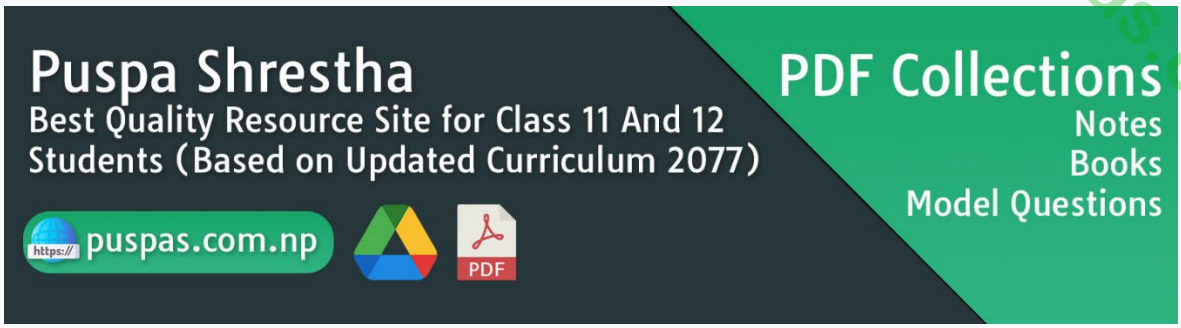
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Model Questions - Solution

Group A

Attempt *any fifteen* questions. **[15×2=30]**

1. Calculate mass in gram of
i. One molecule of nitrogen **[1]**
ii. One atom of carbon **[1]**

i. One molecule of nitrogen in gram
1 mole of N_2 molecule = 28 g
1 mole of N_2 molecule = 6.022×10^{23} N_2 molecule
6.022×10^{23} N_2 molecule = 28 g

$$1 \text{ molecule } N_2 = \frac{28}{6.022 \times 10^{23}} = 4.64 \times 10^{-23} \text{ g}$$

ii. One atom of carbon
We know that,
1 mole of carbon atom = 12 g
1 mole of carbon = 6.022×10^{23} atom
6.022×10^{23} carbon atom = 12 g

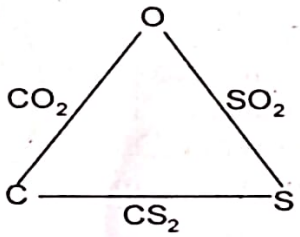
$$1 \text{ carbon atom } = \frac{12}{6.022 \times 10^{23}} = 1.99 \times 10^{-23} \text{ g}$$

Hence, one atom of carbon has mass 1.99×10^{-23} g.

2. State law of equivalent proportions. **[2]**

When two different elements combine separately with the fixed weight of the third elements, the ratio in which they do so will be the same or some simple multiple of the ratio in which they combine together. Example: The three elements carbon, sulphur and oxygen

$C + O_2 = CO_2$, $S + O_2 = SO_2$ and $C + 2S = CS_2$



In CO_2, 12 g of carbon combines with 32 g of oxygen.
In SO_2, 32 g of sulphur combines with 32 g of oxygen.
The ratio of masses of carbon and sulphur which combine with fixed mass of oxygen is
12 : 32 i.e. 3 : 8 ... (i)
In CS_2, 12 g of carbon combines with 64 g of sulphur.
The ratio of masses of carbon and sulphur is
12 : 64 i.e. 3 : 16 ... (ii)

These two ratios are related as $\frac{3}{8} : \frac{3}{16}$ i.e. 1 : 2 Which is simple multiple ratio to each other.

3. Why does boiling point of liquid remain constant even though the heating is continued? **[2]**

The boiling point of liquid remains constant even though the heating is continued. The heat supplied is consumed to make the liquid molecules a part form the attractive force which hold the liquid molecule. Thus, the heat energy goes to compensate the loss of energy due to the escaping of molecules. As a result, there is no change in kinetic energy of the liquid molecules. This cause temperature of boiling liquid constant even through the heating is continued.

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4. Distinguish between crystalline and amorphous solids. [1+1]

Following are the difference

Crystalline solid	Amorphous solid
1. They possess characteristics geometrical shapes.	1. They do not possess characteristics geometrical shape.
2. The constituent particles (atoms, ions or molecules) are arranged in orderly arrangement in a three dimensional pattern.	2. The constituent particle are not orderly arranged in the three dimensional pattern.
3. They have sharp melting point.	3. They do not have sharp m. p.
4. The crystalline solid possess anisotropic nature i.e. the substance whose physical properties like electrical conductivity, refractive index, thermal conductivity, thermal expansion etc. not in all direction are called anisotropic substance and the phenomenon is known as anisotropy.	4. They possess isotropic in nature.

5. An atom of an element has 19 electrons. What is the total number of p-electrons? [2]

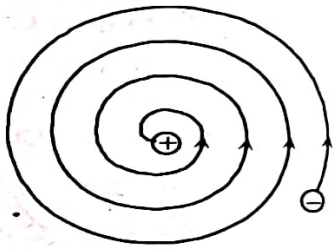
The atom of an element has electron 19 must be potassium because in neutral atom number of proton is equal to number of electron. The electronic configuration of potassium is $K_{19} = 1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$

The total number of p-orbital electron is (6 + 6) =12

6. Give the limitation of Rutherford atomic model? [2]

Following are limitation of Rutherford atomic model:

i. The electron is revolving around the nucleus under the influence of attractive force and loses the energy in the form of electromagnetic radiations. Due to loss of energy, the speed of electron would slow down and its orbit becomes smaller and smaller and finally the electrons would fall into the nucleus. But electrons actually don't fall into the nucleus i.e. atoms are found to be stable.



ii. It doesn't explain atomic spectra of hydrogen.

iii. It doesn't explain how and where electrons are arranged.

7. What is meant by nuclear fusion? Give an example of it. [1+1]

Nuclear reaction in which two lighter nuclei combine with each other to give stable nucleus with higher mass is called nuclear fusion. Here, large amount of energy is liberated.

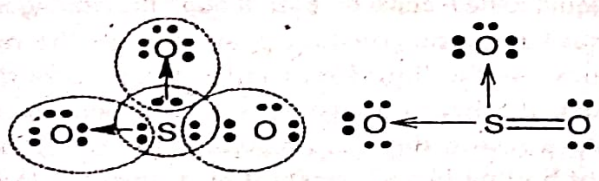
$${}_1H^2 + {}_1H^3 \longrightarrow {}_2He^4 + {}_0n^1 + \text{energy}$$

8. Write down the Lewis structure of : [1+1]

a. SO_3 **b. HPO_4^{--}**

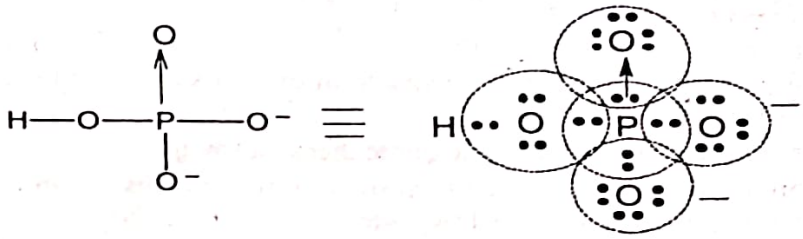
Lewis structure of:

a. SO_3



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b. HPO_4^{--}



9. What are the necessary conditions for the formation of hydrogen bond? [2]

The necessary conditions for the formation of hydrogen bond are:

i. Atom which is attached to hydrogen should have high electronegativity.

ii. Electronegative atom should have small size.

iii. The electronegative atoms are fluorine, oxygen and nitrogen.

10. Mention two important application of dipole moment. [1+1]

Two application of Dipole Moment are:

i. **Distinction of polar and non-polar molecules:** Non-polar molecules have zero dipole moment but polar molecules have some value of dipole moment.

ii. **Shape of a molecules:** CO_2 molecule is linear due to zero dipole moment, H_2O is angular due to 1.84D, NH_3 is trigonal pyramidal due to 1.49D.

11. Calculate the oxidation number of Fe in $Na_4[Fe(CN)_6]$. [2]

Let the O.N. of Fe is x in $Na_4[Fe(CN)_6]$

$4(+1) + x + 6(-1) = 0$

or, $+4 + x - 6 = 0$

or, $x - 2 = 0$

or, $x = +2$

Hence, the oxidation number of Fe is +2.

12. What is the relationship between Kp and Kc for the following reaction? [2]

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

The reversible reaction is given as:

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

The change in number of moles of reactant product and reactant is $(2 - 4) = -2$ i.e. $\Delta n = -2$

For this reaction K_p and K_c are related as

$K_p = K_c(RT)^{\Delta n}$

$K_p = K_c(RT)^{-2}$

13. Write a reaction to show nascent hydrogen is more powerful reducing agent than molecular hydrogen. [2]

The reaction which shows nascent hydrogen is more powerful reducing agent than molecular hydrogen.

Acidified solution of $KMnO_4$ is not reduced by molecular hydrogen but reduced by nascent hydrogen.

$KMnO_4 + H_2SO_4 + H_2 \longrightarrow$ no reaction

$$\underset{\text{Pink}}{2KMnO_4 + 3H_2SO_4 + 10[H]} \xrightarrow{Zn + dil.H_2SO_4} \underset{\text{Colourless}}{K_2SO_4 + 2MnSO_4 + 8H_2O}$$

14. How would you convert Oxygen into Ozone and vice-versa? [1+1]

An oxygen molecule (O_2) is splited by higher frequency UV light into two oxygen atom.

$O_2 + HO \longrightarrow 2O$

Each oxygen atom then quickly combines with an oxygen molecule to form an ozone molecule.

$O + O_2 \longrightarrow O_3$

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The ozone molecule formed above absorb radiation having an appropriate wavelength. Th ozone becomes O_2 and free O-atom

$O_3 + hv\ (240 - 310\ nm) \longrightarrow O_2 + O$

The atomic oxygen produced quickly reacts with another oxygen molecule to reform ozone

$O + O_2 \longrightarrow O_3 + heat$

15. What are the most harmful pollutants present in photochemical smog? [2

The major component of photochemical smog are the oxides of nitrogen, sulphur, carbon hydrogen like NO, NO_2, SO_2, N_2O, CO, H_2O_2 etc.

Effect:

The NO_2 gas cause eye and nose irritation.

Photochemical smog cause headache in human beings

16. What is allotropy? Name the latest allotrope of carbon. [1+1

The two or more forms of the same element having same chemical properties but differen physical properties are called allotropes and phenomenon is known as allotropy. The lates discovered allotropic form of carbon is Buckminister fullerence or Fullerence. It is also calle bucky ball.

17. What is hydrometallurgy? [2

Hydrometallurgy: The process of extraction of metal from an ore by dissolving the ore i aqueous solution of suitable chemical reagent and subsequent precipitation of the metal b other more reactive metal or precipitating reagent.

Example: The silver can be extracted from silver glance by this process:

$$Ag_2S + aq.\ 4NaCN \longrightarrow \underset{\text{Sodium argentocyanide}}{2\ Na[Ag(CN)_2]} + Na_2S$$

$$2Na[Ag(CN)_2] + Zn \longrightarrow \underset{\text{Sodium zincocyanide}}{Na_2[Zn(CN)_4]} + 2Ag$$

18. Write down the balanced chemical reaction for the preparation of:

i. Plaster of paris [1

ii. Bleaching powder [1

i. When gypsum salt i.e. $CaSO_4.2H_2O$ is heated at 120°C, plaster of paris is obtained.

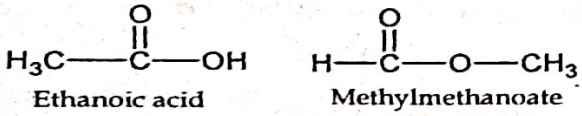
$$\underset{\text{Gypsum salt}}{2CaSO_4.2H_2O} \xrightarrow{120^\circ C} \underset{\text{Plaster of paris}}{(CaSO_4)_2H_2O} + 3\ H_2O$$

ii. When chlorine gas is passed through dry slaked lime at about 40°C then bleaching powder i formed.

$$\underset{\text{Slaked lime}}{Ca(OH)_2} + Cl_2 \xrightarrow{40^\circ C} \underset{\text{Bleaching powder}}{CaOCl_2} + H_2O$$

19. Give two possible isomers of $C_2H_4O_2$ and write their IUPAC name. [1+1

The two possible isomers of $C_2H_4O_2$ are



Ethanoic acid

Methylmethanoate

20. What are electrophiles? Give two examples. [1+1

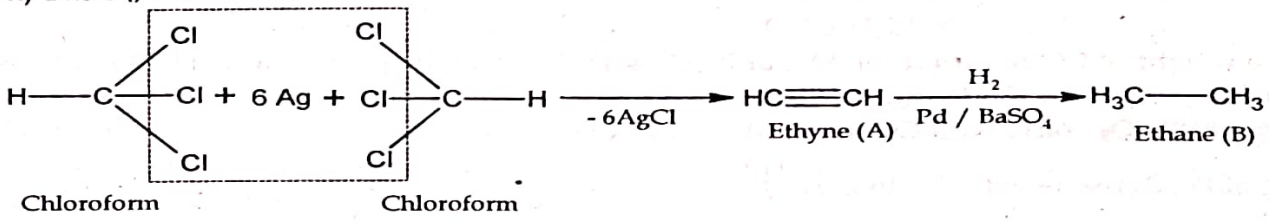
The positively charge species which are able to attract towards the electron is known a electrophile. It is also known as electron loving. Example: Br^+, Cl^+

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21. Identify A and B in the following reaction and give their IUPAC name. **[1+1]**

$$CHCl_3 \xrightarrow[\Delta]{Ag} A \xrightarrow[Pd/BaSO_4]{H_2} B$$

When chloroform is heated with silver powder, ethyne is formed which on reduction with $Pd/BaSO_4$, ethane is formed.



The compounds are

A = Ethyne B = Ethane

22. What is gasoline additive? **[2]**

The chemical compound which reduces the knocking property of fuel when added to the gasoline or petrol or improves the octane number is called anti-knocking agent or gasoline additives. **Example:** Iron carbonyl,Tetraethyl lead (TEL)

Group B

Attempt *any 5* questions. **[5×5=25]**

23. What is the cause of Periodicity of elements in the periodic table? How do the following properties vary in a group? **[1]**

i. Atomic size **[2]**

ii. Ionization energy **[2]**

In the Modern periodic table all the elements are arranged according to the increasing order of atomic number and the elements having similar properties are repeated after regular intervals. This phenomenon is known as periodicity and the properties are known as periodic properties.

i. Variation of atomic size in a group of periodic table:

Ionization energy decreases with increase in atomic size because the larger the distance from the nucleus, the lesser will be the attraction between the nucleus and the valence electrons. Larger the size of atom, lesser the value of Electron affinity.

ii. Variation of ionization energy in a group of periodic table:

When we move from top to bottom, the I.E. gradually decreases. This is due to increase in atomic size.

Increase in number of inner electrons which brings the increase in shielding effect on the outermost electron.

Increase in nuclear charge from top to bottom in a group whose effect is less than the effect of increasing atomic size and shielding effect.

24. Consider a reaction. **[1.5+1.5+2]**

$$Fe_2O_3(s) + 3CO(g) \xrightarrow{\Delta} 2Fe(s) + 3CO_2(g)$$

If the reaction is carried out by mixing 30 g of Fe_2O_3 and 10 g of CO.

i. Find the limiting reactant.

ii. Calculate the weight of iron produced.

iii. What volume of CO_2 is produced at 30°C and 730 mm pressure?
[Atomic Weight of Fe = 56]

The balanced chemical equation is

$$Fe_2O_3(s) + 3CO(g) \xrightarrow[\Delta]{} 2Fe(s) + 3CO_2(g)$$

1 mole	3 mole	2 mole	3 mole
$(2 \times 56 + 3 \times 16)$	$3(12+16)$	2×56	
160 g	84 g	112 g	

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i. 160 g of Fe_2O_3 reacts with 84 g of CO to form product

1 g of Fe_2O_3 reacts with $\frac{84}{160}$ g of CO to form product

30 g of Fe_2O_3 reacts with $\frac{84 \times 30}{160}$ g of CO to form product

$= 15.73$ g CO

The weight of CO required for 30 g of Fe_2O_3 is 15.73 g and the given mass of CO is 10 g. So, th limiting reagent is CO because it finishes first.

ii. 160 g of Fe_2O_3 reacts with CO to give 112 g of iron

1 g of Fe_2O_3 reacts with CO to give $\frac{112}{160}$

30 g of Fe_2O_3 reacts with CO to give $\frac{112 \times 30}{160} = 21$ g Fe

Hence, iron produced is 21 g.

iii. 160 g of Fe_2O_3 reacts with CO to give 3 mole of CO_2

1 g of Fe_2O_3 reacts with CO to give $\frac{3}{160}$

30 g of Fe_2O_3 reacts with CO to give $\frac{3 \times 30}{160} = 0.56$ mol CO_2

Number of moles of CO_2(n) = 0.56 mol

Volume of CO_2 gas (V) = ?

Temperature (T) = (30 + 273) = 303K

Pressure (P) = 730 mm Hg

$= \frac{730}{760} = 0.96$ atm

$R = 0.0821$ L atm K^{-1} mol^{-1}

According to Ideal gas equation,

$PV = nRT$

or $V = \frac{nRT}{P} = \frac{0.56 \times 0.0821 \times 303}{0.96} = 14.51$ litre

Hence, the volume of CO_2 gas required is 14.51 litre.

25. Give the essential postulates of Bohr's atomic model. How is Balmer spectral line originated? [4+1

Neil Bohr, a Danish physicist in 1913 tried to solve the defects of Rutherford model and the aim of modification were:

To overcome the objection labelled against Rutherford's model of atom regarding the stabilit of atom.

To explain the origin of line spectra of hydrogen atom

The basic assumptions of Bohr's atomic model are:

i. An atom consists of +vely charged nucleus in the centre which is surrounded by –vely charge electrons.

ii. There are definite numbers of circular paths or orbit or shell where electrons are revolved. Eac orbit have fixed amount of energy. Such orbits with definite amount of energy are known a stationary energy state or energy level. They are represented by number 1,2,3,4.....or by symbo K, L, M, N ..., etc. The stationary energy defines the stability of an atom.

iii. Only those circular orbits are allowed for the revolution of electrons around the nucleus whic having angular momentum of an electron is whole number multiple of $\frac{nh}{4\pi}$.

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According to Bohr

$$mvr = \frac{nh}{4\pi}$$

Where, m= mass of electron
v = velocity of electron
r = radius of orbit
n = any integer 1, 2, 3 ...
h = Planck's constant

iv. The energy of an orbit or electrons increases with increasing the distance of orbit from the nucleus of atom. $E_2 > E_1$, $E_3 > E_2$

v. The centrifugal force arising from the motion of the electrons and acting away from the nucleus is balanced by the centripetal force acting towards the center of an atom.

vi. Energy is radiated or absorbed only when an electron is jump from one orbit to another. An electron absorb energy when it jumps from low energy level to higher energy level while it radiates energy in the form of electromagnetic waves while it jumps back from higher level to lower level. The magnitude of energy radiated or absorbed is equal to the difference in energy of two different energy level.

$E_2 - E_1 = h\upsilon$, where, E_1 = energy level 1
E_2 = energy level 2

or, $\upsilon = \frac{E_2 - E_1}{h}$

or, $\frac{c}{\lambda} = \frac{E_2 - E_1}{h}$ $\left[\upsilon = \frac{\text{Volecity of light (c)}}{\text{Wave length } (\lambda)}\right]$

Corresponding to the wave length or frequency of each quantum of light radiated gives characteristic line spectra or emission spectra.

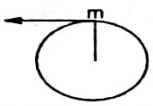


Fig : Electron in Bohr's stationary orbit

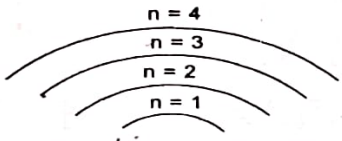


Fig : Distance of the orbits from the nucleus

Main success of Bohr's atomic model

i. It describes the stability of an atom by introducing stationary energy level.

ii. It explains the origin of hydrogen spectra in beautiful manner by the concept of stationary state of electrons.

iii. It gives the idea of quantization of energy.

Limitation of Bohr's atomic model

i. A single line of hydrogen spectrum is found to be composed of several closely packed lines under better resolving instrument. These lines are called hyper lines. The origin of these lines in hydrogen spectra is not explained by Bohr.

ii. It fails to explain the splitting of spectral lines into very fine lines under magnetic field and external electric field.

iii. It fails to explain the splitting of spectral lines for the atoms having large of electrons.

The spectral series which appears visual part of the electromagnetic spectrum is Balmer series. When electron jumps to 2nd orbit from different higher energy levels then Balmer series is originated.

26. How is bromine manufactured from Carnallite? Give a chemical reaction for the test of bromide ion in aqueous solution. [4

Principle: Carnallite contains 0.2% bromine in the form of bromides. Its formula $KCl.MgCl_2.(MgBr_2).6H_2O$ Carnallite is dissolved in water and the resulting solution crystallized when crystals of KCl and $MgCl_2$ separate out. The mother liquor containing main $MgBr_2$ is treated with Cl_2 and steam when bromine vapours are liberated.

$$MgBr_2 + Cl_2 \xrightarrow{\text{Stem}} MgCl_2 + Br_2$$

The vapours are condensed by condenser and liquid bromine is collected. The uncondensed Br_2 vapours are absorbed by iron filings.

$$3Fe + 4Br_2 \longrightarrow Fe_3Br_8 \ (FeBr_2.2FeBr_3)$$

Description:

The mother liquor containing $MgBr_2$ is heated to 60°C and the hot mother liquor is dropped from the top of a tower which is packed with quartz. Cl_2 and steam are introduced in the tower through two pipes. Br_2 vapours are liberated in the tower which escape through the outlet and are condensed by the condenser and the liquid bromine is collected in the receiver. The uncondensed vapours of Br_2 are absorbed in iron fillings in the absorption tower. The spent mother liquor collects in the tank. Any unreacted $MgBr_2$ presence in it, is oxidized by Cl_2 to Br_2 which enters into the tower and collects as liquid bromine in the receiver.

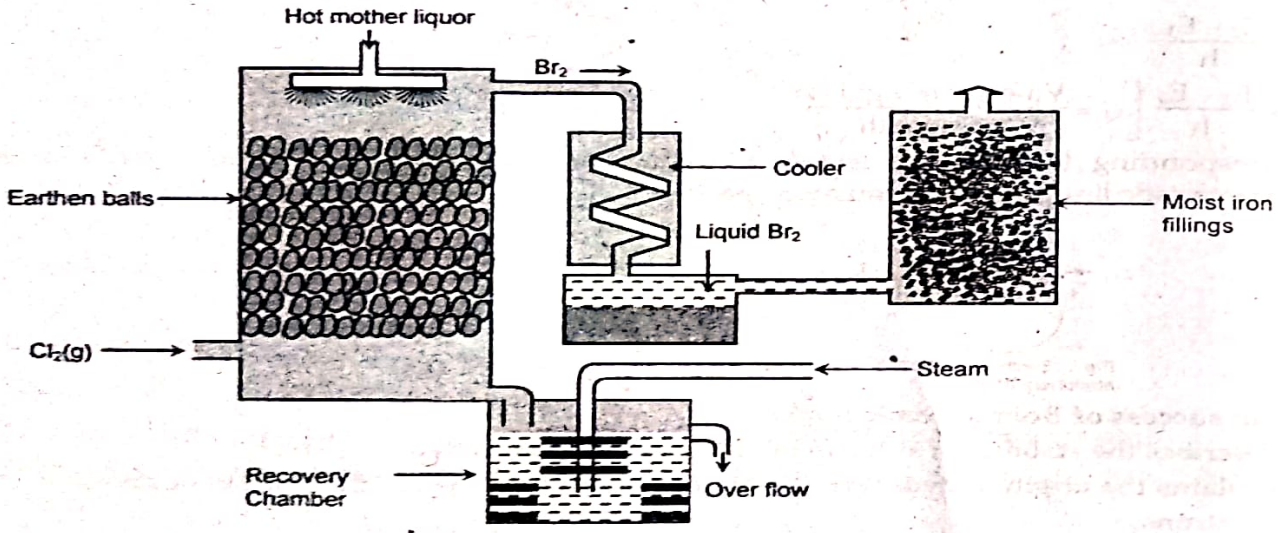


Figure: Manufacture of Bromine from Carnallite

Impurities present in Bromine: Bromine manufactured from carnalite contains the following impurities: (1) Chlorine (2) Iodine

Purification of crude Bromine: The impure Bromine is purified by

a. Distilling with KBr which removes chlorine.

$$2KBr + Cl_2 \longrightarrow 2KCl + Br_2$$

b. Distillation with ZnO which removes I_2

$$2ZnO + 2I_2 \longrightarrow 2\ ZnI_2 + O_2$$

The distillate can be dried by placing it in a desiccators containing conc. H_2SO_4 or anhydrous $CaCl_2$.

Test of Bromide ion (Br^-): In order to test the presence of Br^- ion in a given solution, about mL of solution is taken in clean and dry test tube and is acidified with 1-2 drops of conc. HNO_3. Then the acidified solution is heated and cooled under tap water. 1-2 drops of $AgNO_3$ solution

is added to it. A pale yellow ppt will seen which indicates the presence of Br^- ion in the given solution.

$$Br^-(aq.) + AgNO_3(aq.) \longrightarrow \underset{\text{Pale yellow ppt}}{AgBr\downarrow} + NO_3^-(aq.)$$

For further confirmation, the yellow ppt is dissolved in NH_4OH solution and again reappears by adding few drops of dil. HNO_3 solution.

$$AgBr + 2NH_4OH \longrightarrow [Ag(NH_3)_2]^+ + 2H_2O + Br^-$$

$$[Ag(NH_3)_2]^+ + Br^- + 2HNO_3 \longrightarrow \underset{\text{Pale yellow ppt}}{AgBr\downarrow} + 2NH_4^+ + 2NO_3^-$$

27. What happens when: [5×1=5]

i. Iron wire is dipped in conc. nitric acid?
ii. Magnesium is treated with dilute nitric acid?
iii. Ammonia is passed through copper sulphate solution in excess?
iv. Carbon is boiled with conc. nitric acid?
v. Freshly prepared ferrous sulphate solution is added to a mixture of dil. nitric acid and conc. sulphuric acid?

i. Iron reacts with cold and conc. HNO_3 i.e. about 70% or more and gets oxidized to ferric nitrate and nitrogen dioxide.

$$Fe + 3\,HNO_3 \longrightarrow Fe(NO_3)_2 + 3\,H$$

$$HNO_3 + H \longrightarrow NO_2 + H_2O \quad]\times 3$$

$$Fe + 6\,HNO_3 \longrightarrow Fe(NO_3)_3 + 3\,NO_2 + 3\,H_2O$$

ii. Very dilute nitric acid gives hydrogen gas with Mg metal.

$$2HNO_3 + Mg \longrightarrow Mg(NO_3)_2 + H_2\uparrow$$

Dilute nitric acid gives NO gas with Mg metal.

$$3Mg + 8HNO_3 \longrightarrow 3Mg(NO_3)_2 + 2NO\uparrow + 4H_2O$$

iii. Ammonia gas is passed through copper sulphate solution, bluish white ppt is obtained, but passed in excess then deep blue ppt of tetramine copper sulphate is formed.

$$NH_3 + H_2O \longrightarrow NH_4OH$$

$$CuSO_4 + 2NH_4OH \longrightarrow \underset{\text{Bluish white ppt}}{Cu(OH)_2\downarrow} + (NH_4)_2SO_4$$

$$Cu(OH)_2 + (NH_4)_2SO_4 + 2NH_4OH \longrightarrow \underset{\substack{\text{Deep blue ppt}\\ \text{Tetramine copper sulphate}}}{[Cu(NH_3)_4]SO_4\downarrow} + H_2O$$

iv. When carbon is heated with conc. HNO_3, it is oxidized to CO_2.

$$[2\,HNO_3 \longrightarrow 2NO_2 + H_2O + O] \times 2$$

$$C + 2O \longrightarrow CO_2$$

$$C + 4HNO_3 \longrightarrow CO_2 + 4NO_2 + 2H_2O$$

v. When freshly prepared $FeSO_4$ solution is added to the mixture of conc. HNO_3 and conc. H_2SO_4, a dark brown ring of nitrosyl ferrous sulphate is appeared at the junction of two liquids.

$$HNO_3 \longrightarrow 2\,NO + H_2O + 3[O]$$

$$[2FeSO_4 + H_2SO_4 + [O] \longrightarrow Fe_2(SO_4)_3 + H_2O] \times 3$$

$$6\,FeSO_4 + 2HNO_3 + 3H_2SO_4 \longrightarrow 3Fe_2(SO_4)_3 + 4H_2O + 2NO$$

$$FeSO_4 + NO \longrightarrow \underset{\text{Dark brown ring}}{FeSO_4.NO}\ \text{(Nitrosyl ferrous sulphate)}$$

28. Describe in brief the smelting process in the extraction of metal. [5]

Carbon reduction process (smelting): It is the process of reducing the ore into metal in presence of coke or coal at very high temperature. This process is applied for those metals which have less affinity with oxygen than for carbon. Examples are Fe, Zn, Sn, Pb, Cd, Cu etc. This process is employed because -

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a. Coke or coal reduces metallic oxide to metal and CO, the CO formed in this process als reduces metallic oxide. Therefore C as well as CO acts as reducing agent.

b. Coke or coal burn in air producing heat.

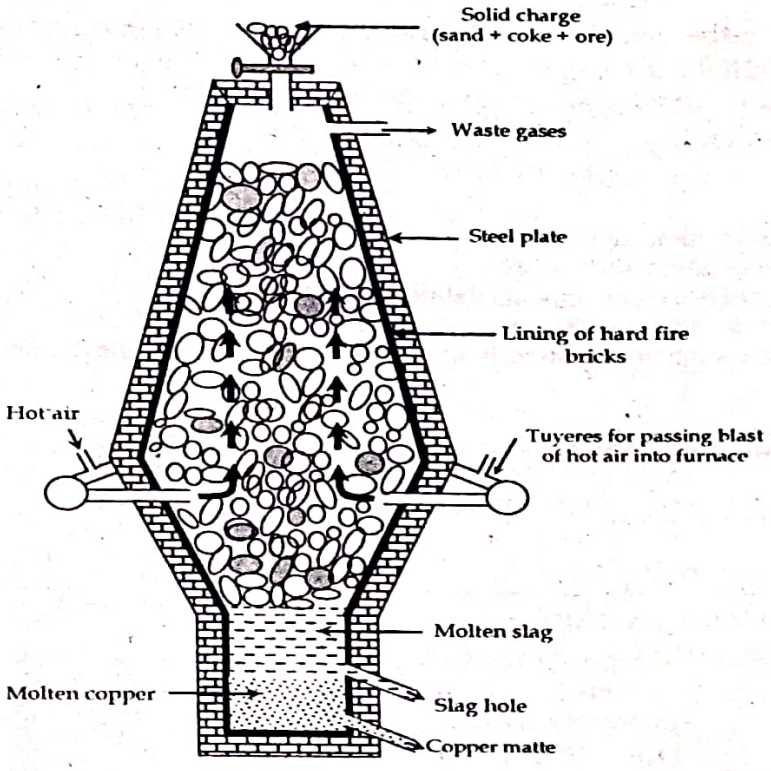


Fig: Blast furnace

c. Carbon has higher affinity with oxygen is cheap and easily available. Example-

$$Fe_2O_3 + 3C \longrightarrow 2Fe + 3CO$$
$$Fe_2O_3 + 3CO \longrightarrow Fe + 3CO_2$$
$$ZnO + C \longrightarrow Zn + CO$$
$$PbO + C \longrightarrow Pb + CO$$

During carbon reduction process, infusible (earthy, rocky) impurities are converted to fusibl mass by adding third chemical substances. This third chemical substance is called flux. Th fusible mass formed is called slag. This forms a molten layer on metal surfaces which can b easily removed.

The flux are of two types:

Acidic flux: SiO_2 and $Na_2B_4O_7.10H_2O$

Basic flux: CaO, MgO, $CaCO_3$, $MgCO_3$

The choice of flux depends upon the nature of impurities. If impurities are basic, Acidic flu should be added or vice-versa.

$$\underset{\text{Acidic flux}}{SiO_2} + \underset{\text{Basic impurities}}{CaO} \longrightarrow \underset{\text{Slag (fusible mass)}}{CaSiO_3}$$

$$\underset{\text{Basic flux}}{MgO} + \underset{\text{Acidic impurities}}{SiO_2} \longrightarrow \underset{\text{Slag (fusible mass)}}{MgSiO_3}$$

29. How is ethene prepared in the laboratory? Give a chemical test to detect the double bond in hydrocarbon.[4

Principle: When ethyl alcohol or ethanol is heated with conc. H_2SO_4, at 170°C, ethylene o ethene gas is formed. To stop frothing some $Al_2(SO_4)_3$ is added to the mixture of C_2H_5OH an

conc. H_2SO_4. Some CO_2 is also formed which is absorbed in NaOH solution and C_2H_4 gas is collected by the downward displacement of water.

Reactants:

Ethanol and conc. H_2SO_4

Reaction:

$$\underset{\text{Ethyl alcohol}}{H_3C-CH_2-O-H} + H-HSO_4 \xrightarrow[\Delta]{100\ ^\circ C} \underset{\text{Ethyl hydrogen sulphate}}{H_3C-CH_2-HSO_4} + H_2O$$

$$\underset{\text{Ethyl hydrogen sulphate}}{H_2C(H)-CH_2(HSO_4)} \xrightarrow[\Delta]{170\ ^\circ C} \underset{\text{Ethene}}{H_2C=CH_2} + H_2SO_4$$

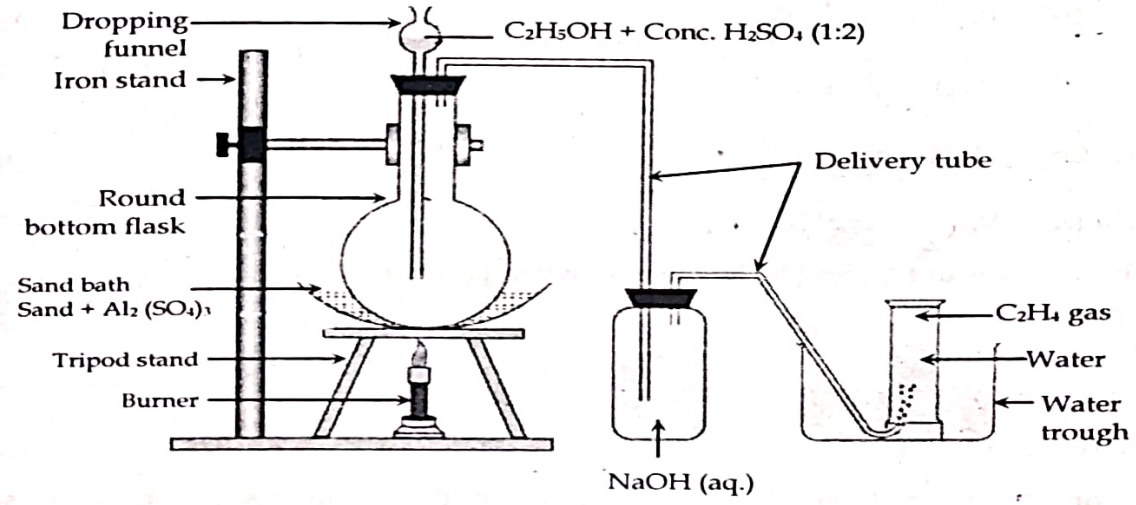


Fig: Laboratory preparation of ethene gas

Procedure: Mixture of ethyl alcohol (50 mL) and conc. H_2SO_4 (100 mL) is taken in Round Bottom flask, fitted with dropping funnel, thermometer and delivery tube. Some sand and anhydrous $Al_2(SO_4)_3$ is added as catalyst and heated in sand bath at 170°C, ethene gas is passed through bottle containing NaOH solution, which absorbs CO_2 and SO_2 only and undissolved pure ethene gas collected in gas jar by downward displacement of water.

Baeyer's test: Alkaline solution of potassium permanganate is called Baeyer's reagent. About 1 mL of organic compound is taken in clean and dry test tube and about 2 – 3 drops of alkaline solution of $KMnO_4$ is added to it. If the pink colour of $KMnO_4$ is discharged, the given organic compound contains double or triples covalent bond between two carbon atoms.

$$\underset{\text{Ethene}}{H_2C=CH_2} + H_2O + O \xrightarrow{KMnO_4\ /\ OH^-} \underset{\text{Ethylene glycol}}{H_2C(OH)-CH_2(OH)}$$

$$\underset{\text{Ethyne}}{HC\equiv CH} \xrightarrow{KMnO_4\ /\ OH^-} \underset{\text{Oxalic acid}}{HO-C(=O)-C(=O)-OH}$$

This test identify the given organic compound is unsaturated hydrocarbon

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Group C

Attempt *any two* questions. [10×2=20]

30. State Charles law. How did this law give the concept of absolute scale of temperature? A perfectly elastic balloon of radius 20 cm was filled with hydrogen gas at sea level. Find the diameter of the balloon when it is risen to a height where the pressure is 0.5 atmosphere. (Assuming no change of temperature and pressure at sea level) [6+4]

In 1787, Jacques Charle's studied the effect of temperature on the volume of gas at a constant pressure and formulated a mathematical relationship between volume and temp. of gas. It states that, "At a constant pressure, the volume of a given mass of a gas increases or decreases by $\frac{1}{273}$ of its volume at 0°C for each degree Celsius rise or fall in temperature"

Let V_o be the volume of given mass of gas at 0°C, then according to Charle's law

Volume of gas at 1°C = $(V_o + V_o \times \frac{1}{273})$ cc.

$= V_o (1 + \frac{1}{273})$ cc.

Volume of gas at 2°C = $V_o (1 + \frac{2}{273})$ cc.

Volume of gas at t°C = $V_o (1 + \frac{t}{273})$ cc.

If V_1 be the volume of gas at t_1°C and V_2 be the volume of gas at t_2°C then

$V_1 = V_o (1 + \frac{t_1}{273})$ ... (i)

$V_2 = V_o (1 + \frac{t_2}{273})$ ... (ii)

From equation (i) and (ii)

$\frac{V_1}{V_2} = \frac{273 + t_1}{273 + t_2}$ or $\frac{V_1}{V_2} = \frac{T_1}{T_2}$ Where T = t + 273 and T is the absolute scale or Kelvin scale temperature

From above expression

$\frac{V_1}{T_1} = \frac{V_2}{T_2}$

or, $\frac{V_1}{T_1} = \frac{V_2}{T_2} = \frac{V_3}{T_3}$ = constant

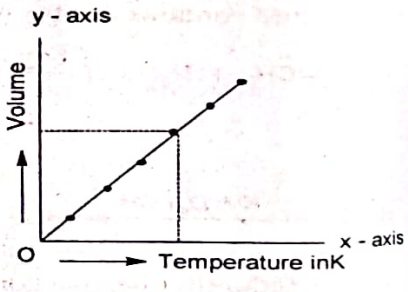
or, $\frac{V}{T}$ = a constant

So, $V \propto T$

Hence, Charle's law can also be stated as: "The volume of a given mass of a gas is directly proportional to the absolute scale of temperature ($V \propto T$) at constant pressure."

Graphical representation of Charle's law

If volume of gases are plotted at different temperature at a constant pressure, a straight line is obtained which is passed through the origin.



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Numerical:

At sea level

Radius of balloon (r_1) = 20 cm

Pressure (P_1) = 760 mm Hg = 1 atm

At altitude

Radius of ballon (r_2) = ?

Pressure (P_2) = 0.5 atm

The volume of a spherical balloon of radius 'r' is given as:

$$V = \frac{4}{3}\pi r^3$$

So, $V_1 = \frac{4}{3}\pi r_1^3$

Similarly,

$V_2 = \frac{4}{3}\pi r_2^3$

According to Boyle's law

$P_1V_1 = P_2V_2$

or, $V_2 = \frac{P_1V_1}{P_2}$

or, $\frac{4}{3}\pi r_2^3 = \frac{P_1 \times \frac{4}{3}\pi r_1^3}{P_2}$

or, $r_2^3 = \frac{P_1 \times r_1^3}{P_2}$

or, $r_2^3 = \frac{1 \times 20^3}{0.5}$

or, $r_2 = \frac{\sqrt[3]{20^3}}{0.5}$

or, $r_2 = \frac{\sqrt[3]{8000}}{0.5}$

or, $r_2 = \sqrt[3]{16000}$

or, r_2 = 379.47 cm

Thus, the diameter of balloon at altitude = 2 × r = 2 × 379.47 cm = 758.94 cm

31. Give the principle for the manufacture of sulphuric acid by Contact process and sketch a self-explanatory diagram. Mention any two important uses of sulphuric acid. [8+2]

Manufacture of Sulphuric acid by Contact Process:

Principle:

Sulphuric acid (H_2SO_4) is manufactured by Contact process. This is modern process. The oxidation of sulphur dioxide SO_2) to sulphur trioxide (SO_3) takes place in contact with the surface of a catalyst during the manucature of acid, so this process is called contact process.

It involves the following steps:

Step: I. Production of Sulphur dioxide (SO_2): Sulphur dioxide is produced by burning sulphur with oxygen or roasting of iron pyrites.

$$S + O_2 \xrightarrow[\Delta]{} SO_2$$

$$4\,FeS_2 + 11\,O_2 \xrightarrow[\Delta]{} 2\,Fe_2O_3 + SO_2$$

Step: II Oxidation of sulphur dioxide to sulphur trioxide: Sulphur dioxide is oxidized to sulphur trioxide at 450°C in the presence of Vanadium pentoxide (V_2O_5) catalyst.

$$2\,SO_2 + O_2 \underset{450\,^\circ C}{\overset{V_2O_5}{\rightleftharpoons}} 2\,SO_3 + 45\ Kcal$$

Step: III Absorption of sulphur trioxide in sulphuric acid: Sulphur trioxide thus produced is absorbed in conc. H_2SO_4 to get fuming sulphuric acid which is called Oleum.

$$SO_3 + \text{Conc. } H_2SO_4 \longrightarrow H_2S_2O_7 \text{ (Oleum)}$$

Step: IV Dillution of Oleum: The oleum is diluted by adding calculated amount of water to obtain conc. H_2SO_4 of desired strength (98%).

$$H_2S_2O_7 \text{ (Oleum)} + H_2O \longrightarrow 2\,H_2SO_4\ (98\%)$$

Favourable condition for maximum yield of H_2SO_4:

The formation of SO_2 to SO_3 is reversible reaction. High concentration of SO_3 leads to high concentration of H_2SO_4. The favourable condition for high concentration of SO_3 is explained by Le-Chatelier's principle.

a. **Concentration:** High concentration of SO_2 and O_2 are used for more production of SO_3.

b. **Temperature:** The formation of SO_3 is exothermic reaction. Low temperature will favour for forward direction. The optimum temperature of about 450°C is supplied.

$$2\,SO_2 + O_2 \underset{450\,^\circ C}{\overset{V_2O_5}{\rightleftharpoons}} 2\,SO_3 + 45\ Kcal$$

c. **Pressure:** Here, 3 volumes of reactants produce 2 volumes of products. High pressure will favour for forward direction. The optimum pressure of about 2 atm is supplied.

$$\underbrace{2\,SO_2 + O_2}_{3\ Volume} \underset{450\,^\circ C}{\overset{V_2O_5}{\rightleftharpoons}} \underbrace{2\,SO_3}_{2\ Volume} + 45\ Kcal$$

d. **Catalyst:** The rate of reaction is increased by the used of positive catalyst like platinum asbestos or vanadium pentoxide (V_2O_5). In comparison to the platinum asbestos, vanadium pentoxide is cheaper and less easily poisoned but slightly less efficient.

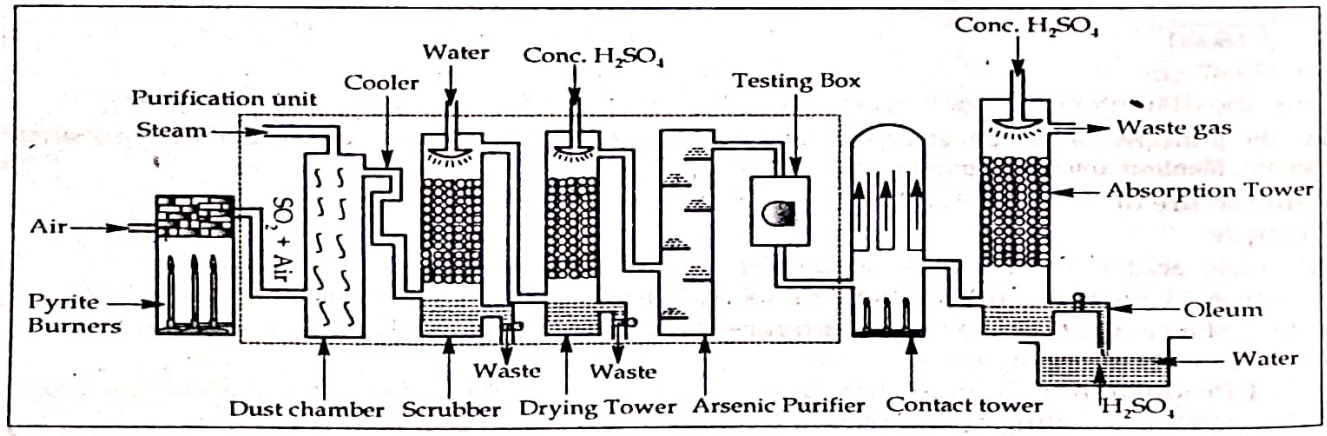


Fig: Manufacture of H_2SO_4 by Contact process

Working plant:

a. **Pyrite burner or Sulphur:** Sulphur dioxide is produced by burning sulphur with oxygen or roasting of iron pyrites in special type of burner made of fire bricks.

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$$S + O_2 \xrightarrow[\Delta]{} SO_2$$

$$4\,FeS_2 + 11\,O_2 \xrightarrow[\Delta]{} 2\,Fe_2O_3 + SO_2$$

Purification unit: The impurities present in the SO_2 formed above are removed in the purification unit.

Dust chamber: The mixtures of gases are passed into dust chamber. The seam is passed from the top of chamber and duct particles are settled down at the bottom.

Water scrubbers: The gas coming out from dust chamber is passed through cooling pipe and cooled gas is passed through scrubber which is packed with quartz. Water is sprayed from the top of tower and gases are made free from acid, mist and any soluble impurities.

Drying tower: The gases coming from scrubber are passed through drying tower which is packed with quartz. Conc. H_2SO_4 is sprayed from the top so that moistures are removed.

Arsenic purifier: This chamber is fitted with many shelves containing $Fe(OH)_3$. Here, oxides of arsenic present in the gases are absorbed by $Fe(OH)_3$.

$$As_2O_3 + 2\,Fe(OH)_3 \longrightarrow 2\,FeAsO_3 + 3\,H_2O$$

Testing box: Strong beam of light is passed into a gas coming from arsenic purifier in testing box. No scattering of light by the beam indicates the absence of dust particles.

Contact tower: The pure and dried gas is passed through contact tower. This tower is made by iron and consists of iron tubes which are packed with V_2O_5. The tower is heated upto 450°C. Here, SO_2 combines with O_2 to give SO_3.

$$2\,SO_2 + O_2 \underset{450\ ^\circ C}{\overset{V_2O_5}{\rightleftharpoons}} 2\,SO_3 + 45\ Kcal$$

Absorption tower: The SO_3 coming from contact tower is passed through absorption tower which is packed with quartz. It meets with stream of conc. H_2SO_4, oleum is formed.

$$SO_3 + \text{Conc. } H_2SO_4 \longrightarrow H_2S_2O_7 \text{ (Oleum)}$$

A calculated amount of water is added to this oleum to get the desired concentration of acid.

$$H_2S_2O_7 \text{ (Oleum)} + H_2O \longrightarrow 2\,H_2SO_4\ (98\%)$$

Uses of sulphuric acid:

a. It is used as an oxidizing agent.
b. It is used as dehydrating agent.

32. Sketch a well labeled diagram for the extraction of sodium by Down's process and explain the principle involved in the process. Explain why? [6]

i. Sodium fire in laboratory should not be extinguished by water. [2]

ii. Alkali metals impart characteristics colour to the flame. [2]

Sodium metal is very reactive and acts as powerful reducing agent. So, cannot be extracted by reduction of oxide in carbon reduction process. Following are the reasons.

At high temperature sodium may combine with carbon to form sodium carbide.

$$4\,Na + C \xrightarrow[\Delta]{} Na_4C$$

The affinity of sodium with oxygen is very high.

$$4\,Na + O_2 \longrightarrow 2Na_2O$$

Sodium metal is extracted from the electrolysis of its fused chlorides using a special electrolytic cell called **Down's cell.**

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Principle: When electricity is passed through fused sodium chloride having graphite as ano and iron ring as cathode. The following reactions occur:

$2NaCl \rightleftharpoons 2Na^+ + 2Cl^-$

Fused

At anode: $2Cl^- \longrightarrow Cl_2 + 2e^-$ (oxidation)

At cathode: $2Na^+ + 2e^- \longrightarrow 2Na$ (reduction)

The net reaction is

$2NaCl \longrightarrow 2Na + Cl_2$

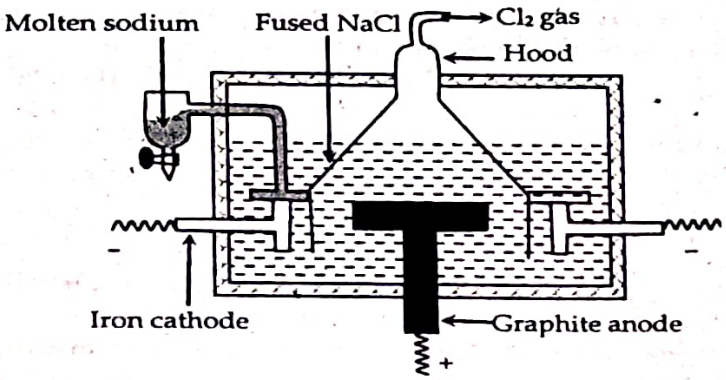


Fig: Down's cell for the extraction of sodium

During electrolysis some $CaCl_2$ is mixed with NaCl to lower down the melting point of Na from 815°C to 640°C. So that working temperature of the cell is lowered to 640°C. At t temperature sodium is liberated smoothly and does not react with iron container. At 640 molten electrolyte (NaCl + $CaCl_2$) does not dissolve molten Na- metal but at 815°C molt electrolyte dissolve sufficient amount of molten Na and its collection becomes difficult. Sodiu collects in kerosene oil.

i. Sodium fire cannot extinguish by adding water because sodium reacts with water to fo inflammable hydrogen gas. Therefore, water is not used to extinguish sodium fire.

ii. Alkali metals have one electron in outermost shell and having low ionization energy. Wh alkali metal is heated, the electron present in their outermost shells get excited and the exci electron, when returns back to the original position, emits electromagnetic radiation wh gives rise to characteristic colour to the flame. So, alkali metals impart characteristics colour the flame.

Metal	Colour to the flame
Lithium (Li)	Crimson
Sodium (Na)	Golden yellow
Potassium (K)	Violet
Rubidium (Rb)	Reddish violet
Cesium (Cs)	Blue violet

33. Write short notes on (any two): [5×2=

i. **Electronic interpretation of oxidation and reduction.**
ii. **Le-Chatelier's principle**
iii. **Homologous Series**
iv. **Detection of nitrogen in organic compound**

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i. Electronic interpretation of oxidation and reduction.

Oxidation: It is defined as the chemical process which involves

a. The loss of electron.
b. The increase in positive charge.
c. The decrease in negative charge.

Oxidation is also known as **de-electronation**. Example:

Loss of electron

$Na \longrightarrow Na^+ + e^-$

$K \longrightarrow K^+ + e^-$

$Ca \longrightarrow Ca^{++} + 2e^-$

Increase in +ve charge.

$Sn^{2+} \longrightarrow Sn^{4+} + 2e^-$

$Fe^{2+} \longrightarrow Fe^{3+} + e^-$

Decrease in –ve charge.

$MnO_4^{--} \longrightarrow MnO_4^- + e^-$

$2Cl^- \longrightarrow Cl_2 + 2e^-$

$S^{2-} \longrightarrow S + 2e^-$

Reduction: It is defined as the chemical process which involves

a. The gain of electrons.
b. The decrease in positive charge.
c. The increase in negative charge.

Reduction is also known as **electronation**. Example:

- Gain of electron resulting in decrease in +ve charge.

$2H^+ + 2e^- \longrightarrow H_2$

$Fe^{3+} + e^- \longrightarrow Fe^{2+}$

$Zn^{2+} + 2e^- \longrightarrow Zn$

- Gain of electron resulting in increase of –ve charge.

$MnO_4^- + e^- \longrightarrow MnO_4^{--}$

$Cl_2 + 2e^- \longrightarrow 2\,Cl^-$

ii. Le-Chatelier's principle

In **1884**, a French chemist **Le-Chatelier** studied the effect of concentration, pressure and temperature on the state of equilibrium. It states that "If a system in equilibrium is subjected to a change in concentration, pressure or temperature then the equilibrium shifts in such a way so as to nullify the effect of the change." That is in an equilibrium reaction:

On increasing the concentration, the equilibrium shift to the direction where the increased concentration is consumed. On doing so, the effect of increased concentration will be minimized.

On increasing the pressure, the equilibrium shifts to the direction where volume is decreased. As we know that when the pressure is increased the volume will decreased. If the equilibrium shifts to the side where volume is increased then the effect of increased pressure will be minimized.

On increasing the temperature, the equilibrium shifts to the direction where heat is absorbed. As we know that the increased temperature raises the heat. If the equilibrium shifts to the side where heat is absorbed then the effect of increased temperature will be minimized.

Application of Le Chatelier's principle in Chemical Equilibria

Let us consider a reaction

Formation of sulphur trioxide (SO_3) from sulphur dioxide (SO_2) and oxygen(O_2)

SO_2 and O_2 react to form SO_3. The reaction is exothermic in nature (ΔH = -ve)

$2SO_2 + O_2 \rightleftharpoons 2SO_3 + 42$ KCal.

2vol 1vol 2vol

Effect of temperature: Since the reaction is exothermic, on increasing the temperature equilibrium shifts to the backward direction i.e. SO_3 decomposes to give SO_2 and O_2

Effect of pressure: Here, total volume of the product is less than that of the reactant. So, increasing pressure the equilibrium shifts to the direction where volume is decreased i.e. forward direction.

Effect of concentration: On increasing the concentration of the reactant i.e. SO_2 and O_2 then equilibrium will shift in forward direction. Thus, the favored condition for formation of SO_3 is # Low temperature # High pressure # High concentration of SO_2 and O_2 **Effect of** catal There is no effect of catalyst on equilibrium

Effect of inert gas: when an inert gas is added to an equilibrium system, the volume of system will be increased. Hence, on adding inert gas the equilibrium will shift to the lar volume side so that the effect of addition is minimized. If volume is maintained constant th there will be no effect of inert gas on equilibrium.

iii. Homologous Series

➢ The series of organic compound having the same general formula and similar chemi properties but different physical properties , one member is differ from other member by sin unit $-CH_2$ is known as Homologous series. Each member of homologous series is call "homologoue" and the phenomenon is known as "homology"

Example: Homologous series of alkene:

Alkenes are represented by the general formula C_nH_{2n}. The series is obtained by putting n = 3, 4....in the general molecular formula of alkenes.

n	Molecular formula	Structural formula	Name
2	C_2H_4	$CH_2=CH_2$	Ethene
3	C_3H_6	$CH_3-CH=CH_2$	Propene
4	C_4H_8	$CH_3-CH_2-CH=CH_2$	But-1-ene
5	C_5H_{10}	$CH_3-CH_2-CH_2-CH=CH_2$	Pent-1-ene
6	C_6H_{12}	$CH_3-(CH_2)_3CH=CH_2$	Hex-1-ene
7	C_7H_{14}	$CH_3-(CH_2)_4CH=CH_2$	Hept-1-ene

Following are the characteristic of homologous series:

i. Each member of homologous series having same functional group.
ii. The general formula of all the members of homologous series are same.
iii. All the member of homologous series have same general method for the preparation.
iv. The physical properties i.e. m.p. and b.p. of homologous series show regular increase w increasing molecular weight.
v. One member of homologous series is differed from other than single unit CH_2.

iv. Detection of nitrogen in organic compound

➢ Presence of nitrogen is detected in an organic compound by Lassaigne's method. In this met the organic compound is fused with a piece of sodium in a fusion tube. After complete fusi the red hot fusion tube is dipped in distilled water contained in a mortar and the whole mas grinded with a pestle. The hot solution is filtered and the filtrate which is called 'sodi extract' is used for the detection of nitrogen.

The reactions occurs during the process of fusion:

If the organic compound contains nitrogen, sodium cyanide is formed which remains dissol in the sodium extract.

$Na + C + N \longrightarrow NaCN$

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Detection of nitrogen:

About 2 mL of sodium extract solution is taken in clean and dry test tube. About 1 mL of freshly prepared ferrous sulphate solution is added to it. The solution is heated and 2 -3 drops of Ferric chloride solution is added. The solution is acidified by adding dil. HCl. The solution becomes bluish green. This indicates the presence of nitrogen in given organic compound.

Reactions:

$$Na + C + N \longrightarrow NaCN$$

$$2NaCN + FeSO_4 \longrightarrow Na_2SO_4 + Fe(CN)_2$$

$$4NaCN + Fe(CN)_2 \longrightarrow \underset{\text{Sodium Ferrocyanide}}{Na_4[Fe(CN)_6]}$$

$$3Na_4[Fe(CN)_6] + 4FeCl_3 \xrightarrow{\text{dil.HCl}} \underset{\substack{\text{Ferric ferrocyanide}\\ \text{Bluish green}}}{Fe_4[Fe(CN)_6]_3} + 12\ NaCl$$

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Unit 1

Langauge of Chemistry

VERY SHORT ANSWER QUESTIONS [2 MARKS]

1. **2075 Set B Q.No. 2** **What is meant by the term basicity? Predict the basicity of H_2SO_4 in the following reaction.** [1+1]
$NaOH + H_2SO_4 \longrightarrow NaHSO_4 + H_2O$

➢ The basicity of an acid is the number of hydrogen (H^+) ions, which can be produced by one molecule of the acid.
In the given reaction: $NaOH + H_2SO_4 \longrightarrow NaHSO_4 + H_2O$
Sodium metal replaces only one hydrogen from sulphuric acid. Hence the basicity of H_2SO_4 is 1

2. **2059 Q.No. 10** **How many electrons and neutrons are present in the symbol $^{27}_{13}Al^{3+}$?**

➢ Atomic no. (Z) = 13 and atomic mass (A) = 27
No. of neutrons = (A – Z) = (27 – 13) = 14
No. of electrons = (13 – 3) = 10
Al atom loses 3 e^- to form Al^{+3}

3. **2056 Q.No. 2** **Define a chemical change and point out its two important characters.**

➢ The permanent change in which one compound is transformed into other compound having different properties is known as chemical change. Example:
$H_2SO_4 + 2\,KOH \longrightarrow K_2SO_4 + 2\,H_2O$
Two important characters are:
a. It is irreversible change.
b. New compound having different properties are formed.

4. **2056 Q.No. 6** **What information can you obtain from the symbol $^{39}_{19}K$?**

➢ Atomic no.(Z) = 19 and Atomic mass (A) = 39
No. of neutron = (A – Z) = (39 – 19) = 20
No. of electrons = Number of protons = Atomic number

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Unit 2

Chemical Arithmetic

2.1 Dalton's Atomic Theory and Laws of Stoichiometry

VERY SHORT ANSWER QUESTIONS [2 MARKS]

1. 2076 Set B Q.No. 1 **Nitrogen reacts with oxygen to give N_2O_3 and N_2O_5 respectively. Which law of stoichiometry do this data illustrate? State the law.** [1+1]

Nitrogen combines with oxygen to form various oxide.

Compound	Combining elements		Ratio of masses		With fixed mass of N	
N_2O_3	N	O	28	48	14	24
N_2O_5	N	O	28	80	14	40

The ratio of different weight of oxygen 24, 40 combining with fixed weight of nitrogen (14) is 24:40 i.e. 3:5 which is simple whole number ratio. The given data illustrate the law of multiple proportions.

Statement:

"When two elements combine to form more than one compound, then the different weight of one element combining with a fixed weight of the other element are in simple numerical ratio with each other."

2. 2076 Set C Q.No. 1 **Why is the law of reciprocal proportion called the law of equivalent proportion?** [2]

Law of reciprocal relates the proportions in which elements combine across a number of different elements. It is also called as equivalent proportion. Example: If element A combines with element B and also with C, if B and C combine together, the proportion by weight in which they do so will be simply related to the weights of B and C which separately combine with a constant weight of A.

3. 2075 Set A Q.No. 2 **State law of definite proportion and give an example to support this law.** [1+1]

Statement: A chemical compound always contains the same elements combined together in the fixed ratio by weight, irrespective of the origin. **Example:** Copper oxide can be prepared by following method.

a. By heating copper hydroxide

$$Cu(OH)_2 \xrightarrow[\Delta]{} CuO + H_2O$$

b. By heating copper carbonate

$$CuCO_3 \xrightarrow[\Delta]{} CuO + CO_2$$

c. By heating copper nitrate

$$2Cu(NO_3)_2 \xrightarrow[\Delta]{} 2CuO + 2NO_2 + 3O_2$$

4. 2074 Supp Q.No. 2 2073 Set C Q. No. 2 **How does Dalton's atomic theory explain the law of conservation of mass?** [2]

According to the Dalton's atomic theory, law of conservation of mass states that " Matter is made up of extremely small indivisible particles which can neither be created nor destroyed."

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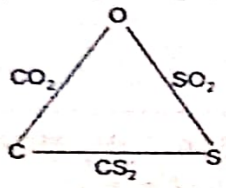
5. 2074 Set A Q.No. 2 **State Gay-Lussac's Law of gaseous volume.**

Ans Under the similar condition of temperature and pressure, gaseous reactants and products al gases, combine in a simple whole number ratio of their volumes.

6. 2074 Set B Q.No. 2 2073 Supp Q.No. 2 2072 Set D Q.No. 2 2069 Set B Q. No. 7 or **State law of Equiva proportion.**

Ans **Statement:** When two different elements combine separately with the fixed weight of the th elements, the ratio in which they do so will be the same or some simple multiple of the rati which they combine together. Example: The three elements carbon, sulphur and oxygen

$$C + O_2 = CO_2, S + O_2 = SO_2 \text{ and } C + 2S = CS_2$$



In CO_2, 12 g of carbon combines with 32 g of oxygen.

In SO_2, 32 g of sulphur combines with 32 g of oxygen.

The ratio of masses of carbon and sulphur which combine with fixed mass of oxygen is 12 i.e. 3 : 8 ... (i)

In CS_2, 12 g of carbon combines with 64 g of sulphur.

The ratio of masses of carbon and sulphur is 12 : 64 i.e. 3 : 16 ... (ii)

These two ratios are related as $\frac{3}{8} : \frac{3}{16}$ i.e. 1: 2 which is simple multiple ratio to each other.

7. 2073 Set D Q. No. 2 2056 Q.No. 1 **State law of constant composition giving a suitable example.**

Ans **Statement:** A chemical compound always contains the same elements combined together in t fixed ratio by weight, irrespective of the origin. **Example:** Copper oxide can be prepared following method.

a. By heating copper hydroxide

$$Cu(OH)_2 \xrightarrow[\Delta]{} CuO + H_2O$$

b. By heating copper carbonate

$$CuCO_3 \xrightarrow[\Delta]{} CuO + CO_2$$

c. By heating copper nitrate

$$2Cu(NO_3)_2 \xrightarrow[\Delta]{} 2CuO + 2NO_2 + 3O_2$$

8. 2071 Supp Q. No. 2 2069 Set A Q. No. 1 2055 Q.No. 7 **State Law of Multiple proportions.**

Ans **Statement:** When two elements combine to form two or more different compounds, then t weight of one of the elements which combines with the constant weight of the other bea simple whole number ratio. **Example:**

Carbon and oxygen combine with each other to form carbon monoxide and carbon-dioxide.

In CO, 12 g of carbon combines with 16 g of oxygen.

In CO_2, 12 g of carbon combines with 32 g of oxygen.

The ratio of mass of oxygen which combines with fixed mass of carbon is 16 : 32 i.e. 1 : 2 wh is whole number ratio.

9. 2071 (Set D) Q.No. 1 **12 g of carbon react with 4 g of hydrogen to produce 16 g of methane. Which chemi law do these data illustrate? State the law.** [1

Ans

C	+	$2H_2$	⟶	CH_4
1 mole		2 mole		1mole
12 g		4 g		16 g

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Total weight of reactant = (12 + 4) = 16 g
Total weight of product = 16 g
Total weight of reactant is equal to the total weight of product so these data show the law of conservation of mass.
Statement: Total sum of mass and energy of system remains constant, but they can be interconverted.

10. 2068 Q.No. 2 12 g of Carbon react with 32 g of Oxygen to produce 44 g of Carbon dioxide. Which Chemical Law do these data illustrate? State the Law. [1+1=2]

$$C + O_2 \longrightarrow CO_2$$
1 mole 1 mole 1mole
12 g 32 g 44 g

Total weight of reactant = (12 + 32) = 44 g
Total weight of product = 44 g
Total weight of reactant is equal to the total weight of product so these data show the law of conversion of mass.
Statement: Total sum of mass and energy of system remains constant, but they can be interconverted.

11. 2067 Q.No. 5 State Law of conservation of mass. Why is this law known as Law of indestructibility of matter? [1 + 1]

Under the similar condition of temperature and pressure, total mass of reactants are equal to the total mass of the products during the chemical combination.
Example: $A + B \longrightarrow C + D$, If x_1 g of A and y_1 g of B combine to form x_2 g of C and y_2 g of D then according to this law.
$x_1 + y_1 = x_2 + y_2$
This law is known as indestructibility of matter because there is no loss of mass when reactant reacts to form the product i.e. total mass of the reactant is equal to total mass of the product.

12. 2066 Q.No. 4 Phosphorous reacts with Oxygen to Produce P_2O_3 and P_2O_5 respectively. Which Chemical law does the data illustrate? State the Law. [1+1]

In P_2O_3: 2 mole of P-atom and 3 mole of O-atom
$2 \times 31 = 62$ g of P combines with $3 \times 16 = 48$ g of O
In P_2O_5: 2 mole of P-atom and 5 mole of O-atom
$2 \times 31 = 62$ g of P combines with $5 \times 16 = 80$ g of O
The ratio of oxygen which combines with fixed weight of P i.e. 62 g is 48 : 80 or 3 : 5. So these data shows the law of multiple proportions.
Statement: When two elements combine to form two or more different compounds, then the weight of one of the elements which combines with the constant weight of the other bear a simple whole number ratio.

13. 2065 Q. No. 13 2063 Q.No. 2 2058 Q.No. 3 2057 Q.No. 1 State the law of reciprocal proportion. [2]

Please refer to 2074 Set B Q.No. 2

14. 2064 Q.No. 12 One-volume of hydrogen reacts with one-volume of chlorine to give two-volume hydrogen chloride gas. Which law of stoichiometry is illustrated? State the law. [2]

According to the question

$$H_2(g) + Cl_2(g) \longrightarrow 2HCl(g)$$
1 vol 1 vol 2 vol

Here, gaseous reactants react together to form gaseous product and reactant and product bear simple whole number ratio i.e. 1:1:2 ratio by volume. So, these data illustrate the law of Gay Lussac's law of gaseous volume.

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15. 2062 Q.No. 5 **H and O react separately to give H_2O_2 and H_2O respectively. What law of stoichiometry illustrated? State the law.**

$2H_2 + O_2 \longrightarrow 2H_2O$

In H_2O: 2 H–atom and 1 O-atom.

∴ 2 g of hydrogen combines with 16 g of oxygen.

$H_2 + O_2 \longrightarrow H_2O_2$

In H_2O_2: 2 H –atom and 2 O- atom

∴ 2 g of hydrogen combines with 32 g of oxygen.

The ratio of oxygen which combines with fixed weight of hydrogen i.e. 2 g is 16 : 32 1 : 2. These data show the law of multiple proportions.

Statement: When two elements combine to form two or more different compounds, then t weight of one of the elements which combines with the constant weight of the other bear simple whole number ratio.

16. 2060 Q.No. 3 **How did the law of multiple proportions encourage Dalton to introduce an atomic theory?** [

In 1803, John Dalton proposed the law of multiple proportion. Law of multiple proportion state that "When two elements combine to form two or more different compounds, then th weight of one of the elements which combine with the constant weight of the other bear simple whole number ratio."

Example:

Carbon and oxygen combine with each other to form carbon monoxide (CO) and carbo dioxide (CO_2).

In CO, 12 g of carbon combines with 16 g of oxygen.

In CO_2, 12 g of carbon combines with 32 g of oxygen.

The ratio of mass of oxygen which combines with fixed mass of carbon is 16 : 32 i.e. 1 : 2 whic is whole number ratio.

The whole number ratio indicates the existence of indivisible smallest particle which Dalto called atom. This encouraged Dalton to introduce an atomic theory.

NUMERICAL PROBLEMS

17. 2066 Q.No. 13 **What volume of CO_2 gas is produced when 20 g of 20% pure $CaCO_3$ is completely heated?** [2

Solution

$CaCO_3 \longrightarrow CaO + CO_2$

1 mole 1 mole 1mole

Molecular weight of $CaCO_3 = (40 + 12 + 48) = 100$ g

Mass of $CaCO_3$ = 20 g of 20% is completely heated.

$$= 20 \times \frac{20}{100} = 4 \text{ g}$$

According to the equation.

100 g of $CaCO_3$ produces 22.4 litre of CO_2 on complete heating.

4 g of $CaCO_3$ produces $\frac{22.4 \times 4}{100} = 0.896$ litre = 896 mL

Hence, the required volume of CO_2 gas is 896 mL.

18. 2060 Q.No. 25 **State the law of Reciprocal proportions.**

a. **0.46 g of a metal produced 0.77 g of metal oxide.**

b. **0.805 g of the same metal displaced 760 cc of H_2 gas at NTP from HCl.**

c. **1.26 g of water was formed by the union of 1.12 g of oxygen with hydrogen.**

Show that these data illustrate the law of reciprocal proportions. [5

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Solution

Statement: When two different elements combine separately with the fixed weight of the third elements, the ratio in which they do so will be the same or some simple multiple of the ratio in which they combine together.

a. Weight of metal = 0.46 g
Weight of metal oxide = 0.77 g
Weight of oxygen = (0.77 – 0.46) = 0.31 g
0.46 g of metal combines with 0.31 g of oxygen.
1 g of metal combines with $\frac{0.31}{0.46} = 0.673$ g

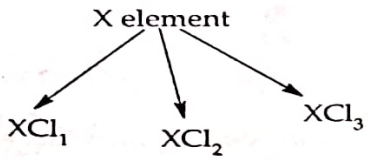
b. Weight of metal = 0.805 g
Volume of hydrogen at NTP = 760 cc
We know that density of H_2 at NTP = 0.000089 g / cc
Mass of hydrogen = d x v = 0.000089 x 760 = 0.06764 g
0.805 g of metal displace 0.06764 g of H_2
1 g of metal displace $\frac{0.06764}{0.805} = 0.084$ g
The ratio of hydrogen and oxygen which combines with the same weight of metal 0.084 : 0.673
$\frac{0.084}{0.084} : \frac{0.673}{0.084}$ or 1 : 8

c. Weight of water = 1.26 g
Weight of oxygen = 1.12 g
Weight of hydrogen = (1.26 – 1.12) = 0.14 g
Ratio of H : O = 0.14 : 1.12
$\frac{0.14}{0.14} : \frac{1.12}{0.14} = 1 : 8$
The given data illustrate the law of reciprocal proportions.

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19. 2054 Q.No. 28 State and explain law of multiple proportion. A certain element X forms three different binary compounds with chlorine, containing 50.68%, 68.95% and 74.75% chlorine, respectively. Show how these data illustrate the law of multiple proportions. [10]

Statement: When two elements combine to form two or more different compounds, then the weight of one of the elements which combines with the constant weight of the other bear a simple whole number ratio.



In XCl_1
% of Cl = 50.68% = 50.68 g
% of X = (100 – 50.68) = 49.32% = 49.32 g
49.32 g X combines with 50.68 g of chlorine.
1 g X combines with $\frac{50.68.}{49.32} = 1.027$ g

In XCl_2
% of Cl = 68.95% = 68.95 g
% of X = (100 – 68.95) = 31.05 % = 31.05 g
31.05 g of X combines with 68.95 g of chlorine.

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1 g of X combines with $\frac{68.95}{31.05} = 2.22$ g

In XCl_3

% of Cl = 7.75 % = 74.75 g

% of X = (100 – 74.75) = 25.25 % = 25.25 g

25.25 g of X combines with 74.75 g of chlorine.

1 g of X combines with $\frac{74.75}{25.25} = 2.96$ g

The ratio of chlorine which combines with fixed weight of X are

1.02 : 2.22 : 2.96 or $\frac{1.02}{1.02} : \frac{2.22}{1.02} : \frac{2.96}{1.02}$ or 1 : 2 : 3

These data show the law of multiple proportions.

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20. 2052 Q.No. 1 Group C A metal X, forms two oxides A and B, 3.00 g of A and B contain 0.720 g and 1.160 g o oxygen respectively. Calculate the masses of metal in gram which combine with one gram of oxygen in eac case. What chemical law do these masses of metal illustrate? State the chemical law. [1

Solution

X metal → A metal oxide
X metal → B metal oxide

In case of A metal oxide

Weight of metal oxide = 3.00 g

Weight of oxygen = 0.72 g

Weight of metal = (3 – 0.72) = 2.28 g

0.72 g of oxygen combines with 2.28 g of metal.

1 g of oxygen combines with $\frac{2.28}{0.72} = 3.16$ g

In case of B metal oxide

Weight of metal oxide = 3.00 g

Weight of oxygen = 1.16 g

Weight of metal = (3 – 1.16) = 1.84 g

1.16 g of oxygen combines with 1.84 g of metal.

1 g of oxygen combines with $\frac{1.84}{1.16} = 1.58$ g

The ratio of metal which combines with fixed weight of oxygen are

3.16 : 1.58 or 2 : 1

These data illustrate the law of multiple proportions.

Statement: Law of Multiple proportions:

When two elements combine to form two or more different compounds, then the weight of on of the elements which combines with the constant weight of the other bear a simple whol number ratio. **Example:**

Carbon and oxygen combine with each other to form carbon monoxide and carbon-dioxide.

In CO, 12 g of carbon combines with 16 g of oxygen.

In CO_2, 12 g of carbon combines with 32 g of oxygen.

The ratio of mass of oxygen which combines with fixed mass of carbon is 16 : 32 i.e. 1 : 2 whic is whole number ratio.

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2.2. Atomic Mass and Molecular Mass

VERY SHORT ANSWER QUESTIONS [2 MARKS]

2076 Set B Q.No. 2 **Mass of 2×10^{21} number of atoms of an element is 0.4g. What is the mass of 0.5 mole of the element?** **[1+1]**

Given,
No. Of atoms of an element = 2×10^{21}
Mass of atoms of an element = 0.4 g
According to the questions
2×10^{21} atoms of an element has mass 0.4 g

6.022×10^{23} atoms of an element has mass $\frac{0.4}{2 \times 10^{21}} \times 6.022 \times 10^{23}$ g

$= 120.44$ g

i.e. 1 mole of atom of an element has mass 120.44 g
Hence, the mass of 0.5 mole of an elements is 0.5×120.44 g = 60.22 g

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2076 Set C Q.No. 2 **2074 Supp Q.No. 1** **How many numbers of moles of CO will be left when 2×10^{21} molecules are removed from 0.28 g of CO?** **[1+1]**

Given,
The given weight of CO = 0.28 g
The molecular weight of CO = 28 g

No. Of mole of CO = $\frac{\text{Given weight}}{\text{Molecular weight}} = \frac{0.28}{28} = 0.01$ mole

We know that
1 mole of CO contains 6.022×10^{23} molecules
0.01 mole of CO contains $0.01 \times 6.022 \times 10^{23}$ molecules
$= 6.022 \times 10^{21}$ molecules
The numbers of molecules left is $(6.022 \times 10^{21} - 2 \times 10^{21}) = 4.022 \times 10^{21}$ molecules.
We know that
6.022×10^{23} molecules of CO = 1 mole of CO

4.012×10^{21} molecules of CO $= \frac{1}{6.022 \times 10^{-3}} \times 4.022 \times 10^{21}$ mole of CO

$= 6.68 \times 10^{23}$

Hence, no. of mole of CO left is 6.68×10^{23}.

2075 GIE Q.No. 1 **Calculate mass in gram of i) two atom of carbon ii) three molecules of hydrogen.** **[1+1]**

Two atom of carbon:
We know that,
1 mole of carbon = 12 g
1 mole of carbon = 6.022×10^{23} carbon atom
Thus,
6.022×10^{23} carbon atom has mass 12 g

2 carbon atom has mass $\frac{12 \times 2}{6.022 \times 10^{23}} = 3.98 \times 10^{-23}$ g carbon.

Three molecules of hydrogen:
We know that,
1 mole of hydrogen molecule = 2 g
1 mole of hydrogen molecule = 6.022×10^{23} hydrogen molecule
Thus,
6.022×10^{23} hydrogen molecule has mass 2 g hydrogen

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1 hydrogen molecule has mass $\frac{2}{6.022 \times 10^{23}}$ g hydrogen

3 hydrogen molecules has mass $\frac{2}{6.022 \times 10^{23}} \times 3$ g hydrogen $= 9.96 \times 10^{-24}$ g

Hence, mass of 3 molecule of hydrogen is 9.96×10^{-24} g.

4. **2075 Set A Q.No. 1 How many grams of sulphur and oxygen are needed to produce 6.023×10^{24} molecule SO_2 according to the reaction?**
$S + O_2 \longrightarrow SO_2$

Solution

The balanced chemical equation is given as:

$$S + O_2 \longrightarrow SO_2$$

1 mole 1 mole 1 mole

32 g 32 g 6.022×10^{23} molecules

According to the reaction

6.022×10^{23} molecules of SO_2 are produced from 32 g sulphur.

SSW1 molecules of SO_2 are produced from $\frac{32}{6.022 \times 10^{23}}$ g sulphur.

6.022×10^{24} molecules of SO_2 are produced from $\frac{32}{6.022 \times 10^{23}} \times 6.022 \times 10^{24}$ g sulphur.

$= 320$ g sulphur

Similarly,

6.022×10^{23} molecules of SO_2 are produced from 32 g oxygen

1 molecules of SO_2 are produced from $\frac{32}{6.022 \times 10^{23}}$ g oxygen

6.022×10^{24} molecules of SO_2 are produced from $\frac{32}{6.022 \times 10^{23}} \times 6.022 \times 10^{24}$ g oxygen

$= 320$ g oxygen

Hence, 320 gram sulphur and oxygen are are needed to produce 6.022×10^{24} molecules of SO_2

5. **2075 Set B Q.No. 1 Calculate the number of hydrogen and oxygen molecules in a solution prepared by mix 45 g of glucose in 36 g of water.** [1

Solution

For glucose:

The molecular weight of glucose ($C_6H_{12}O6$) $= 6 \times 12 + 12 + 6 \times 16 = 180$

The given weight of glucose = 45 g

The no. of mole of glucose $= \frac{\text{Given weight}}{\text{Molecular weight}} = \frac{45}{180} = 0.25$ mole

The number of glucose molecules in 45 g glucose $= 0.25 \times 6.022 \times 10^{23}$ molecules

$= 1.505 \times 10^{23}$ molecules

Thus,

Total number of hydrogen molecules in 45 g glucose $= \frac{1.505 \times 10^{23} \times 12}{2}$

$= 9.033 \times 10^{23}$ molecules

Total number of oxygen molecules in 45 g glucose $= \frac{1.505 \times 10^{23} \times 6}{2}$

$= 4.515 \times 10^{23}$ molecules

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For water:

The molecular weight of water (H_2O) = 2 + 16 = 18

The given weight of water = 36 g

The no. of mole of water = $\frac{36}{18}$ = 2 mole

The number of water molecules in 36 g water = $2 \times 6.022 \times 10^{23}$ molecules

= 1.2044×10^{24} molecules

Thus,

Total number of hydrogen molecules in 36 g water = $\frac{1.2044 \times 10^{24} \times 2}{2}$

= 1.2044×10^{24} molecules

Total number of oxygen molecules in 36 g water = $\frac{1.2044 \times 10^{24} \times 1}{2}$

= 6.022×10^{23} molecules

Hence, total molecules of hydrogen by mixing 45 g glucose in 36 g water

= $9.033 \times 10^{23} + 1.2044 \times 10^{24}$

= 2.1077×10^{24}

Total molecules of oxygen by mixing 45 g glucose in 36 g water

= $4.515 \times 10^{23} + 6.022 \times 10^{23}$

= 1.053×10^{24}

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6. 2074 Set A Q.No. 1 How many number of oxygen molecules are required to produce 220 mg of CO_2 according to the reaction? **[2]**

$C + O_2 \longrightarrow CO_2$

Solution

The balanced chemical equation is given as

$C + O_2 \longrightarrow CO_2$

1mole 1 mole 1 mole

6.022×10^{23} 44 g

Given mass of CO_2 = 220 mg = $\frac{220}{1000}$ = 0.22 g

44 g of CO_2 is produced from 6.022×10^{23} oxygen molecules

0.22 g of CO_2 is produced from $\frac{6.022 \times 10^{23} \times 0.22}{44}$ oxygen molecules

= 3.011×10^{21} oxygen molecules

Hence, 3.011×10^{21} oxygen molecules are required to produce 220 mg of CO_2.

---

7. 2074 Set B Q.No. 1 What mass of nitrogen will be required to produce 6.022×10^{24} molecules of ammonia by the following reaction? **[2]**

$N_2 + 3H_2 \longrightarrow 2NH_3$

Solution

The balanced chemical equation is given as;

$N_2 + 3H_2 \longrightarrow 2NH_3$

28 g $2 \times 6.022 \times 10^{23}$

$2 \times 6.022 \times 10^{23}$ molecules of ammonia is produced from 28 g nitrogen.

6.022×10^{24} molecules of ammonia is produced from $\frac{28 \times 6.022 \times 10^{24}}{2 \times 6.022 \times 10^{23}}$ g nitrogen.

= 1.4×10^{48} g nitrogen

Hence, 1.4×10^{48} g nitrogen is produced from 6.022×10^{24} molecules of ammonia.

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8. 2073 Supp Q.No. 1 Calculate the mass of carbon monoxide having the same number of oxygen atoms as are present in 88 g of carbon dioxide.

Solution

1 mole of carbon dioxide (CO_2) = 44 g

1 mole of CO_2 = 6.022×10^{23} CO_2 molecules

44 g of CO_2 contains 6.022×10^{23} CO_2 molecules

88 g of CO_2 contains $\frac{6.022 \times 10^{23}}{44} \times 88$ CO_2 molecules = $2 \times 6.022 \times 10^{23}$ CO_2 molecules

Now,

6.022×10^{23} CO molecules = 28 g

1 CO molecules = $\frac{28}{6.022 \times 10^{23}}$ g

$2 \times 6.022 \times 10^{23}$ CO molecules = $\frac{28}{6.022 \times 10^{23}} \times 2 \times 6.022 \times 10^{23}$ = 56 g

Hence, 56 g of CO molecules will contain the same number of oxygen atoms as are present in g of CO_2.

9. 2073 Set C Q. No. 1 The cost of per mole of sugar ($C_{12}H_{22}O_{11}$) is Rs. 20. How much a pocket of sugar containing 2 kg would cost?

Given, 1 mole of sugar ($C_{12}H_{22}O_{11}$) = Rs. 20

1 mole of sugar of molecular mass = $(12 \times 12 + 22 \times 1 + 11 \times 16) = 342$ g

Weight of pocket of sugar = 2 kg = 2000 g

Thus,

342 g of sugar has cost 20 rupees.

1 g of sugar has cost $\frac{20}{342}$ rupees.

2000 g of sugar has cost $\frac{20}{342} \times 2000$ rupees = 116.95 rupees.

Hence, the cost of a pocket of sugar containing 2 kg is 116.95 rupees.

10. 2073 Set D Q. No. 1 Calculate the mass of following: [1+1

i. 4 atom of carbon

ii. 3 molecule of hydrogen

Solution

i. 4 atom of carbon:

We know that,

1 mole of carbon = 12 g

1 mole of carbon = 6.022×10^{23} carbon atom

Thus,

6.022×10^{23} carbon atom has mass 12 g

1 carbon atom has mass $\frac{12}{6.022 \times 10^{23}}$ g

4 carbon atom has mass $\frac{12}{6.022 \times 10^{23}} \times 4$ g = 7.97×10^{-23} g carbon.

Hence, the mass of 4 atom of carbon is 7.97×10^{-23} g.

ii. 3 molecule of hydrogen

We know that,

1 mole of hydrogen molecule = 2 g

1 mole of hydrogen molecule = 6.022×10^{23} hydrogen molecule

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Thus,

6.022×10^{23} hydrogen molecule has mass 2 g hydrogen

1 hydrogen molecule has mass $\frac{2}{6.022 \times 10^{23}}$ g hydrogen

3 hydrogen molecules has mass $\frac{2}{6.022 \times 10^{23}} \times 3$ g hydrogen $= 9.96 \times 10^{-24}$ g

Hence, mass of 3 molecule of hydrogen is 9.96×10^{-24} g.

11. 2072 Set C Q.No.1 Calculate the number of molecules of hydrogen and carbon present in 4 g of methane.[1+1]

Solution

The balanced chemical equation is

$C + 2H_2 \longrightarrow CH_4$

1 mole 2 mole 1 mole

16 g

16 g of methane (CH_4) is formed by 2 mole of Hydrogen

$= 2 \times 6.022 \times 10^{23}$ H_2 molecule

4 g of methane is formed by $\frac{2 \times 6.022 \times 10^{23}}{16} \times 4$ H_2 molecule $= 3.011 \times 10^{23}$ H_2 molecule

16 g of methane is formed by 1 mole of carbon $= 6.022 \times 10^{23}$ C molecule

4 g of methane is formed by $\frac{6.022 \times 10^{23}}{16} \times 4 = 1.5 \times 10^{23}$ C molecule

Hence, number of hydrogen molecule is 3.011×10^{23} and number of carbon molecule is 1.5×10^{23}.

12. 2072 Set D Q.No. 1 Why one has higher mass and why? [1+1]

a. 0.5 mole of CO_2 or 16 g of SO_2.

b. 2 g of hydrogen or 6.022×10^{21} number of oxygen molecules.

Solution

a. We know that

1 mole of $CO_2 = 44$ g

0.5 mole of $CO_2 = 44 \times 0.5 = 22$ g

The given mass of $SO_2 = 26$ g

1 mole of $SO_2 = 64$ g

0.25 mole of $SO_2 = 16$ g

Thus, mass of 0.5 mole of CO_2 is higher than 16 g of SO_2 because number of mole of CO_2 is higher than number of mole of SO_2.

b. 1 mole of $H_2 = 2$ g $= 6.022 \times 10^{23}$ H_2

1 mole of $O_2 = 32$ g $= 6.022 \times 10^{23} O_2$

0.01 mole of $O_2 = 6.022 \times 10^{21}$ $O_2 = 0.32$ g

Thus, mass of 2 g H_2 is higher than 6.022×10^{21} O_2 molecule because mole of H_2 is greater than O_2.

13. 2072 Set E Q.No. 1 A vessel containing 32 g of pure CH_4 gas was partially evacuated to remove 6.022×10^{23} molecules of CH_4. How many gram of hydrogen and carbon are left in the vessel. [2]

Solution

1 mole of CH_4 = 16 g

2 mole of CH_4 = 32 g

1 mole of CH_4 = 6.022×10^{23} molecules

The remaining CH_4 is 1 mole

1 mole of CH_4 = 1 mole of C and 4 mole of H = 12 g C and 4 g H

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14. 2071 Supp Q. No. 1 **Calculate the mass in gram of:**
   a. 1×10^{23} **molecule of methane**
   b. **2.5 moles of** Cl_2.

Solution

a. 1 mole of methane = 6.022×10^{23} molecule
   1 mole of methane (CH_4) = 16 g
   6.022×10^{23} methane molecule = 16 g CH_4
   1 methane molecule = $\frac{16}{6.022 \times 10^{23}}$
   1×10^{23} methane molecule = $\frac{16}{6.022 \times 10^{23}} \times 1 \times 10^{23} = 2.65$ g CH_4
   Hence, mass of methane (CH_4) = 2.65 g

b. 1 mole of Cl_2 = 71 g
   2.5 mole of Cl_2 = $71 \times 2.5 = 177.5$ g Cl_2
   Hence, mass of chlorine (Cl_2) = 177.5 g

15. 2071 (Set C) Q.No. 1 **Calculate the mass of water having the same number of hydrogen atoms as are pre in 32 g of methane.**

Solution

1 mole of methane (CH_4) = 16 g
1 mole of methane = 6.022×10^{23} methane molecules
16 g methane contains 6.022×10^{23} methane molecules
32 g methane contains $\frac{6.022 \times 10^{23}}{16} \times 32 = 2 \times 6.022 \times 10^{23}$ methane molecules

Now,
6.022×10^{23} water molecules = 18 g
1 water molecules = $\frac{18}{6.022 \times 10^{23}}$
$2 \times 6.022 \times 10^{23}$ water molecules = $\frac{18}{6.022 \times 10^{23}} \times 2 \times 6.022 \times 10^{23} = 36$ g
Hence, 36 g of water molecules will contain the same number of hydrogen atoms as are pre in 32 g of methane.

16. 2071 (Set D) Q.No. 2 **How many numbers of gold atoms are present in 0.6 g of 18 carat gold. The 24 carat g is taken as 100% pure gold. (Atomic mass of gold = 197).**

Solution

Given,
24 carat gold is 100 % gold
18 carat gold = $\frac{100}{24} \times 18$ % pure gold = 75 % pure gold
Wt. of 18 carat gold = 0.6 g
So, wt. of 18 carat gold = $0.6 \times 75\ \% = 0.6 \times \frac{75}{100} = 0.45$ g
Atomic wt. of gold = 197
No. of mole of gold = $\frac{\text{Given weight}}{\text{Atomic weight}} = \frac{0.45}{197} = 2.28 \times 10^{-3}$ mol

We know that,
1 mole of gold = 6.022×10^{23} atoms
2.28×10^{-3} mole of gold = $6.022 \times 10^{23} \times 2.28 \times 10^{-3} = 1.37 \times 10^{21}$ atoms
Thus, 0.6 g of 18 carat gold contains 1.37×10^{21} atoms.

17. 2070 Supp. Q No. 1 **How many numbers of oxygen molecules are present in 3 liters of CO_2 at STP?** [2]

Solution

We know that,

1 mole of CO_2 gas at STP = 22.4 litre

1 mole of CO_2 gas = 2 mole of oxygen atom = 1 mole oxygen molecule
= 6.022×10^{23} molecule oxygen

22.4 litre of CO_2 = 6.022×10^{23} molecule oxygen

3 litre of CO_2 = $\frac{3 \times 6.022 \times 10^{23}}{22.4}$ = 8.065×10^{22} molecules oxygen

Hence, 8.065×10^{22} molecules oxygen are present in 3 litre of CO_2 at STP.

18. 2070 Supp. Q No. 2 2070 Set C Q No. 2 **6 g of an element X combine with 16 g of another element Y to give 0.5 mole of a compound xy. What is the molecular mass of XY?** [2]

In this question X reacts with y to give XY

X	+	Y	⟶	XY
6 g		16 g		0.5 mole
12 g		32 g		1 mole

According to conservation of mass, total mass of reactants is equal to the total mass of products. The mass of 1 mole of product is (12 + 32) = 44 g i.e. equal to molecular mass. Hence, the molecular mass of XY is 44 g.

19. 2070 Set C Q No. 1 2067 Q No. 2 **How many gram atoms of sulphur and how many grams of oxygen are needed to prepare 6.022×10^{24} molecules of SO_2?** [2]

Solution

S	+	O_2	⟶	SO_2
1mole		1 mole		1 mole

6.022×10^{23} molecules = 1 mole of SO_2

6.022×10^{24} molecules = $\frac{6.022 \times 10^{24}}{6.022 \times 10^{23}}$ = 10 mol

1 mole of SO_2 = 1 mole of S-atom = 32 g

10 mole of SO_2 = 10 mole of S-atom = 320 g

1 mole of SO_2 = 2 mole of O - atom = (2 × 16) = 32 g

10 mole of SO_2 = 20 mole of O - atom = 320 g

20. 2070 Set D Q No. 1 **Which of the following gases has greater number of hydrogen molecule?** [2]
9 g of CH_4 or 10 g of NH_3

Solution

9 g of CH_4

Given,

Mass of CH_4 = 9 g

Molecular mass of CH_4 = 16

No. of mole of CH_4 = $\frac{\text{Given mass}}{\text{Molecular mass}}$ = $\frac{9}{16}$ = 0.56 mol

1 mole of CH_4 contains 4 mole of hydrogen atom

1 mole of CH_4 contains 2 molecules of hydrogen

1 mole of CH_4 contains 2 mole of hydrogen

0.56 mole of CH_4 contains 2 × 0.56 mole of hydrogen = 1.12 mole of hydrogen

Now,

1 mole of H_2 contains 6.022×10^{23} molecule of hydrogen

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1.12 mole of H_2 contains $(1.12 \times 6.022 \times 10^{23})$ molecule of hydrogen
$= 6.744 \times 10^{23}$ molecules of hydrogen

10 g of NH_3

Given,

Mass of $NH_3 = 10$ g

Molecular mass of $NH_3 = 17$

No. of mole of $NH_3 = \frac{\text{Given mass}}{\text{Molecular mass}} = \frac{10}{17} = 0.58$ mol

1 mole of NH_3 contains 3 mole of hydrogen atom

0.58 mole of NH_3 contains (3×0.58) mole of hydrogen atom
$= 1.74$ mole of hydrogen atom

We know that,

2 hydrogen atom = 1 molecule hydrogen

1.74 hydrogen atom = 0.87 molecule hydrogen = 0.87 mole hydrogen molecule

Now,

1 mole of H_2 contains 6.022×10^{23} molecule of hydrogen

0.87 mole of H_2 contains $0.87 \times 6.022 \times 10^{23}$ molecule of hydrogen
$= 5.23 \times 10^{23}$ molecules of hydrogen

Hence, 9 g CH_4 has greater number of hydrogen molecules.

---

21. 2070 Set D Q.No. 2 What mass of H_2 gas will react with 22.4 litres of O_2 at STP to produce 36 gram of water?

Solution

The balanced chemical equation is

$$2H_2 + O_2 \longrightarrow 2H_2O$$

2 mole 1 mole 2 mole

4 g 22.4 litre 36 g

1 mole of oxygen gas contains 22.4 litre oxygen at STP.

Hence, 4 g of H_2 will react with 22.4 litres of O_2 at STP to produce 36 g of water.

---

22. 2069 (Set A) Q. No. 2 Calculate the mass of:

i. one molecule of Nitrogen is gram

ii. a mole of carbon-dioxide

Solution

i. One molecule of nitrogen in gram

1 mole of N_2 molecule = 28 g

1 mole of N_2 molecule = 6.022×10^{23} N_2 molecule

6.022×10^{23} N_2 molecule = 28 g

1 molecule $N_2 = \frac{28}{6.022 \times 10^{23}} = 4.64 \times 10^{-23}$ g

ii. A mole of carbon-dioxide

1 mole of $CO_2 = (12 + 2 \times 16) = 44$ g

---

23. 2067 Q.No. 1 What weight of Na will contain the same number of atoms as are present in 1.2 g of Carbon (C^{12})?

Solution

1 mole of $C^{12} = 12$ g

1 mole of $C^{12} = 6.022 \times 10^{23}$ C^{12} atoms

12 g carbon contains 6.022×10^{23} C^{12} atoms

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1.2 g carbon contains $\frac{6.022 \times 10^{23}}{12} \times 1.2 = 6.022 \times 10^{22}$ C^{12} atoms

Now,

6.022×10^{23} Na- atoms = 23 g

1 Na- atoms = $\frac{23}{6.022 \times 10^{23}}$

6.022×10^{22} Na- atoms = $\frac{23}{6.022 \times 10^{23}} \times 6.022 \times 10^{22} = 2.3$ g

Hence, 2.3 g of Na- atom will contain the same number of atoms as are C^{12} atoms present in 1.2 g

---

24. 2066 Q.No. 1 Which of the followings has larger number of molecules and how? 7 g of nitrogen or 1 g of hydrogen. [2]

Solution

Nitrogen molecule

Given,

Weight of nitrogen = 7 g

Molecular weight of nitrogen = 28 g

No. of moles of nitrogen molecules = $\frac{7}{28} = 0.25$ mol

Hydrogen molecule

Given,

Weight = 1 g

Molecular weight = 2 g

No. of moles of hydrogen molecule = $\frac{1}{2} = 0.5$ mol

The no. of moles of hydrogen is larger than that of nitrogen molecules. So, the number of molecules in hydrogen is larger.

---

25. 2065 Q. No. 1 One atom of an element 'A' weights 6.644×110^{-23} g. Calculate the number of gram atom in 80 kg of its. [2]

Solution

Given,

1 atom of element A = 6.644×10^{-23} g

Given wt. of element 'A' = 80 kg = 80×1000 g

We know that,

1 mole of an element = 6.022×10^{23} atom

So, the weight of 1 mole of an element = $6.022 \times 10^{23} \times 6.644 \times 10^{-23}$

$= 40.01 \approx 40$ g

Hence, atomic weight of element 'A' = 40 g

Number of gram atom = $\frac{\text{Given weight}}{\text{Atomic weight}} = \frac{80 \times 1000}{40} = 2000$

Hence, the number of gram atom in 80 kg of element 'A' is 2000 g atom.

---

26. 2065 Q. No. 2 Calculate the mass of 120 cc of nitrogen at NTP. How many numbers of molecules are present in it? [2]

Solution

At NTP

22.4 litre = 22400 cc of N_2 = 28 g

120 cc of N_2 = $\frac{28 \times 120}{22400} = 0.15$ g

We know that

28 g of N_2 = 1 mole = 6.022×10^{23} molecules

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0.15 g of $N_2 = \frac{6.022 \times 10^{23} \times 0.15}{28} = 3.22 \times 10^{21}$ molecules.

Hence, numbers of molecule present is 3.22×10^{21} molecules.

27. 2064 Q.No. 1 What weight of 60% pure sulphuric acid is required to decompose 25 gram of chalk ($CaCO_3$)?

Solution

The balance chemical equation is

$CaCO_3 + H_2SO_4 \longrightarrow CaSO_4 + H_2O + CO_2$

100 g 98 g

100 g $CaCO_3$ requires 98 g of H_2SO_4 to produce product.

1 g $CaCO_3$ requires $\frac{98}{100}$ g of H_2SO_4 to produce product.

25 g $CaCO_3$ requires $\frac{98 \times 25}{100}$ g of H_2SO_4 to produce product.

$= 24.5$ g

Now,

X of 60 % = 24.5 g

$X \times \frac{60}{100} = 24.5$ g

or, $60X = 100 \times 24.5$

or, $X = \frac{100 \times 24.5}{60} = 40.83$ g

Hence, 40.83 g of 60% H_2SO_4 is required to decompose 25 g chalk.

28. 2064 Q.No. 2(a) Calculate the mass of Two Atom of Nitrogen.

Solution

Two atoms of nitrogen

1 mole of N-atom = 14 g

1 mole of N- atom = 6.022×10^{23} N-atom

6.022×10^{23} N-atom has mass = 14 g

2 N-atom has mass = $\frac{14}{6.022 \times 10^{23}} \times 2 = 4.64 \times 10^{-23}$ g

Hence, two atom of nitrogen weight 4.64×10^{-23} g

29. 2064 Q.No. 2(b) Calculate the mass of One Molecule of Hydrogen.

Solution

One molecule of H_2

1 mole of H_2 = 2 g

1 mole of $H_2 = 6.022 \times 10^{23}$ H_2 molecules

6.022×10^{23} H_2 molecules has mass = 2 g

1 H_2 molecules has mass = $\frac{2}{6.022 \times 10^{23}}$ g $= 3.35 \times 10^{-24}$ g

Hence, mass of one molecule of H_2 is 3.35×10^{-24} g

30. 2064 Q.No. 3 An oxide of trivalent metal contains 32% of oxygen. Calculate the atomic mass of the metal.

Solution

% of O_2 = 32 % i.e. 32 g in weight

Weight of metal oxide = 100 g

Weight of metal = (100 – 32) = 68 g

Valency of metal = 3

32 parts by weight of O_2 combines with 68 parts by wteight of metal to form metal oxide.

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1 parts by weight of O_2 combines with $\frac{68}{32}$

8 parts by weight of O_2 combines with $\frac{68}{32} \times 8 = 17$

So, the equivalent weight of metal = 17

We know that,

Atomic weight = Equivalent weight × valency $= 17 \times 3 = 51$

Hence, atomic mass of metal is 51.

---

1. 2063 Q.No. 1(a) How heavy is one atom of hydrogen? [2]

Solution

We know that,

1 mole of hydrogen atom = 1.008 g

1 mole of hydrogen = 6.022×10^{23} atom

6.022×10^{23} Hydrogen atom = 1.008 g

1 Hydrogen atom $= \frac{1.008}{6.022} \times 10^{-23} = 1.674 \times 10^{-24}$ g.

---

2. 2058 Q.No. 4 2055 Q.No. 2 2051 Q.No. 7 Explain why atomic weights of elements are not whole numbers. [2]

Atomic weight of an element is a number which indicates as to how many times one gram of the element is heavier than $\frac{1}{12}$ of an atom of C-12 isotope. It is average relative weight per atom, not the mass of particular atom of an element due to different isotope. So, it is fraction.

---

3. 2058 Q.No. 5 How many mole of Fe^{2+} can be oxidized to Fe^{3+} by 0.75 mole of Cl_2, according to the following equation? [2]

$Fe^{2+} + Cl_2 \longrightarrow Fe^{3+} + Cl^-$

Solution

The balanced chemical equation is

$2\,Fe^{2+} + Cl_2 \longrightarrow 2\,Fe^{+3} + 2\,Cl^-$

2 mole 1 mole 2 mole 2mole

1 mole of Cl_2 oxidizes 2 mole of Fe^{2+} to Fe^{3+}

0.75 mole of Cl_2 oxidizes 2×0.75 mole of Fe^{2+} to Fe^{3+}

$= 1.5$ mole

So, 1.5 mole of Fe^{2+} can be oxidized to Fe^{3+} by 0.75 mole of Cl_2 according to the given equation.

NUMERICAL PROBLEMS:

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4. 2072 Supp Q. No. 1 6.3 g of concentrated nitric acid is diluted by adding 68 g of pure water. How many oxygen molecules are present in the solution? [2]

For Nitric acid:

Given weight of nitric acid = 6.3 g

Molecular weight of nitric acid (HNO_3) = $(1 + 14 + 3 \times 16) = 63$

No. of mole of nitric acid $= \frac{\text{Given weight}}{\text{Molecular weight}} = \frac{6.3}{63} = 0.1$ mole

We know that,

1 mole of nitric acid contains 3 mole of oxygen atom.

1 mole of nitric acid contains $3 \times 6.022 \times 10^{23}$ oxygen atom.

0.1 mole of nitric acid contains $3 \times 6.022 \times 10^{23} \times 0.1$ oxygen atom.

$= 1.8 \times 10^{23}$ oxygen atom.

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For Water (H_2O):

Given weight of water = 68 g

Molecular weight of water = 18

No. of mole of water = $\frac{\text{Given weight}}{\text{Molecular weight}} = \frac{68}{18} = 3.77$ mole

We know that,

1 mole of water contains 1 mole of oxygen atom.

1 mole of water contains $1 \times 6.022 \times 10^{23}$ oxygen atom.

3.77 mole of water contains $1 \times 6.022 \times 10^{23} \times 3.77$ oxygen atom.

$= 2.27 \times 10^{24}$ oxygen atom.

Thus, the total number of oxygen atom in the solution is $(1.8 \times 10^{23} + 2.27 \times 10^{24}) = 2.45 \times 10^{24}$

We know that 1 molecule of oxygen contains 2 atom of oxygen.

Hence, the number of oxygen molecules in the solution is $\frac{2.45 \times 10^{24}}{2} = 1.225 \times 10^{24}$ oxygen molecules.

---

35. 2068 Q.No. 1 34.2 gram of Sucrose $C_{12}H_{22}O_{11}$ are dissolved in 180 gram of water. Calculate the number oxygen atoms in the solution.

Solution

Given wt. of sucrose = 34.2 g

Molecular wt. of sucrose $(C_{12}H_{22}O_{11}) = (12 \times 12 + 22 + 11 \times 16) = 342$ g

No. of moles of sucrose = $\frac{\text{Given weight}}{\text{Molecualr weight}} = \frac{34.2}{342} = 0.1$ mol

We know that,

1 mole of sucrose contains 11 mole of oxygen atom

1 mole of sucrose contains $11 \times 6.022 \times 10^{23}$ O- atom

0.1 mole of sucrose contains $11 \times 6.022 \times 10^{23} \times 0.1$ O- atom

$= 6.62 \times 10^{23}$ O-atom

Similarly,

Weight of water = 180 g

Molecular weight of water (H_2O) = 18 g

No. of moles of water = $\frac{180}{18} = 10$ mol

1 mole of water contains 1 mole of oxygen atom.

10 mole of water contains 10 mole of O-atom

1 mole of water contains 6.022×10^{23} O- atom.

10 mole of water contains $10 \times 6.022 \times 10^{23}$ O-atom $= 6.022 \times 10^{24}$ O-atom

Thus, the total number of O-atom in the solution is

$(6.62 \times 10^{23} + 6.022 \times 10^{24}) = 6.684 \times 10^{24}$

Hence, number of oxygen atom in the solution is 6.684×10^{24}.

---

36. 2063 Q.No. 1(b) How may moles of CO_2 are there in 4.4 g of carbon dioxide?

Solution

Molecular weight of $CO_2 = (12 + 32) = 44$

44 g of $CO_2 = 1$ mole

4.4 g of $CO_2 = \frac{4.4}{44} = 0.1$ mol

Hence, 0.1 mole of CO_2 are in 4.4 g of CO_2.

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37. 2063 Q.No. 3 **Calculate the volume of 11 g of CO_2 at NTP.** [2]

Solution

1 mole of CO_2 = 44 g

1 mole of CO_2 = 22.4 liter

44 g of CO_2 = 22.4 liter

11 g of $CO_2 = \frac{22.4}{44} \times 11 = 5.6$ liter

Hence, 5.6 liter of CO_2 in 11g CO_2 at NTP.

38. 2062 Q.No. 2 **How many moles of hydrogen are left when 3×10^{21} molecules of hydrogen are removed from a vessel containing 40 mg of hydrogen?** [2]

Solution

1 mole of $H_2 = 6.022 \times 10^{23}$ H_2

Given, number of molecules = 3×10^{21}

No. of moles = $\frac{3 \times 10^{21}}{6.022 \times 10^{23}} = 4.98 \times 10^{45}$ mol

The no. of moles of hydrogen left from vessel = 4.98×10^{-3} mol

We know that,

1 mole of H_2 = 2 g = 2000 mg

Given weight of H_2 = 40 mg

No. of moles of $H_2 = \frac{40}{2000} = 0.02$ mol

So, the no. of moles of H_2 remained in the vessel = $(0.02 - 4.98 \times 10^{-3}) = 0.015$ mol

39. 2061 Q.No. 1 **How many molecules are contained in 0.35 mole of N_2?** [2]

Solution

1 mole of N_2 molecule = 6.022×10^{23} N_2 molecules

0.35 mole of N_2 molecule = $6.022 \times 10^{23} \times 0.35$

$= 2.17 \times 10^{23}$ N_2 molecules

Hence, 2.17×10^{23} N_2 molecules are contained in 0.35 mol.

40. 2061 Q.No. 2 **One atom of an element 'X' weights 6.644×10^{-23} g. Calculate the number of gram atoms in 80 kg. of it.** [2]

Solution

Given,

1 atom of element X = 6.644×10^{-23} g

Given wt. of element 'X' = 80 kg = 80×1000 g

We know that,

1 mole of an element = 6.022×10^{23} atom

So, the weight of 1 mole of an element = $6.022 \times 10^{23} \times 6.644 \times 10^{-23}$

$\approx 40.01 \approx 40$ g

Hence, atomic weight of element 'X' = 40 g

Number of gram atom = $\frac{\text{Given weight}}{\text{Atomic weight}} = \frac{80 \times 1000}{40} = 2000$

Hence, the number of gram atom in 80 kg of element 'X' is 2000 g atom.

41. 2059 Q.No. 11 **What volume would 5.5 g CO_2 occupy at STP?** [2]

Solution

Molecular weight of CO_2 = (12 + 32) = 44

44 g of CO_2 have volume 22.4 liter at NTP

5.5 g of CO_2 have volume $\frac{22.4 \times 5.5}{44}$ = 2.8 liter = 2800 cc. = 2.8L

Hence, 2.8 L of CO_2 occupy 5.5 g at STP.

42. 2058 Q.No. 1 **Make the following conversions.**

a. 2.62 moles of C to grams of C

b. 28.0 grams of N_2 to moles of N_2

Solution

a. We know that,

1 mole of carbon = 12 g carbon

2.62 mole of carbon = (12 × 2.62) = 31.44 g carbon

b. We know that,

1 mole of N_2 = 28 g N_2

Hence, no. of moles of N_2 = 1 mole

43. 2058 Q.No. 2 **Calculate the weight, in grams, of 5.60 litres of chlorine gas (Cl_2) at NTP?**

Solution

1 mole of Cl_2 = (2 × 35.5) = 71 g

1 mole of Cl_2 = 22.4 litre at NTP

22.4 litre of Cl_2 gas = 71 g

5.60 litre of Cl_2 gas = $\frac{71}{22.4} \times 5.60 = 17.75$ g

Hence, weight of 5.60 liter of Cl_2 gas is 17.75 g

44. 2057 Q.No. 2 **Calculate the number of atoms of carbon present in 25 g $CaCO_3$.**

Solution

Mol. Wt. of $CaCO_3$ = (40 + 12 + 3 × 16) = 100

100 g of $CaCO_3$ = 1 mole (1 mole C-atom) = 6.022×10^{23} carbon atom

25 g of $CaCO_3$ = $\frac{6.022 \times 10^{23} \times 25}{100} = 1.5 \times 10^{23}$ carbon atom

Hence, 1.5×10^{23} carbon atom present in 25 g $CaSO_3$.

45. 2057 Q.No. 5 **16 g of a gas at STP occupies 5.6 litre. What is the molecular mass of the gas?**

Solution

5.6 litre of gas has weight 16 g at STP

22.4 litre of gas has weight $\frac{16 \times 22.4}{5.6}$ = 64 g is the molecular mass of gas.

Hence, molecular mass of gas is 64.

46. 2056 Q.No. 3 **How many moles of oxygen molecules are present in 112 mL of O_2 gas at NTP?**

Solution

22.4 litre = 22400 mL of O_2 = 1 mol

112 mL= $\frac{112}{22400}$ = 0.005 mol

Hence, 0.005 mol of oxygen molecule are present in 112 mL of O_2 gas at NTP.

47. 2055 Q.No. 5 **If 32 g of O_2 contains 6.022×10^{23} molecules at NTP, how many molecules under the sa condition 32 g of S will contain?**

Solution

1 mole of oxygen = 32 g

Molecular wt. of oxygen = 32 g = 6.022×10^{23} molecules oxygen

Similarly, 1 mole of S = 32 g = atomic wt. of S = 6.022×10^{23} molecule.

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48. 2055 Q.No. 6 **1 mole of a compound contains 1 mole of C and 1 mole of O. What is the molecular weight of the compound?** [2]

Solution

We know that,

1 mole of carbon = 12 g of carbon

1 mole of oxygen molecule = 32 g of oxygen

Here, 1 mole of compound = 1 mole of C + 1 mole of O_2 = (12 + 32) = 44 g

Hence, the molecular weight of compound is 44 g.

49. 2055 Q.No. 13 **What will be molecular weight of a gas, 11.2 litre of which at NTP weights 14 g?** [2]

Solution

We know that,

1 mole of any gas contains 22.4 litre at NTP

According to question,

11.2 litre of gas at NTP weights 14 g

1 litre of gas at NTP weights $\frac{14}{11.2}$

22.4 litre of gas at NTP weights $\frac{14}{11.2} \times 22.4$ g = 28 g

Hence, the molecular weight of gas is 28.

50. 2054 Q.No. 2 **The cost of table sugar ($C_{12}H_{22}O_{11}$) is Rs. 24 per kg. Calculate its cost per mole.** [2]

Solution

Mol. Wt. of $C_{12}H_{22}O_{11}$ = (12 × 12 + 22 × 1 + 11 × 16) = 342 g

1 mole of sugar = 342 g

1kg = 1000 g

1000 g of sugar cost = Rs. 24

1 g of sugar cost $\frac{24}{1000}$

342 g of sugar cost $\frac{24}{1000} \times 342$ = Rs. 8.20 per mole

Hence, cost of sugar per mole is Rs. 8.20.

51. 2053 Q.No. 1 Group C **A jar containing 0.400 mole of H_2S. Calculate the following:** [10]

a. **How many grams of H_2S?**
b. **How many mole of H and S?**
c. **How many grams of H and S?**
d. **How many molecules of H_2S?**
e. **How many atoms of H and S?**

Solution

Mole of H_2S = 0.400

Molecular wt. of H_2S = (2 + 32) = 34 g

a. 1 mole of H_2S = 34 g
0.400 mole of H_2S = (34 × 0.400) = 13.6 g

b. 1 mole of H_2S = 2 mole H
0.400 mole of H_2S = (2 × 0.400) = 0.8 mole H
1 mole of H_2S = 1 mole S
0.400 mole of H_2S = 0.400 mole S

c. 1 mole of H_2S = 2 g H
0.400 mole of H_2S = (2 × 0.400) = 0.8 g H
1 mole of H_2S = 32 g S
0.400 mole of H_2S = (32 × 0.400) = 12.8 g S

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d. 1 mole of $H_2S = 6.022 \times 10^{23}$ molecules
0.400 mole of $H_2S = (6.022 \times 10^{23} \times 0.400) = 2.4088 \times 10^{23}$ molecules

e. 1 mole of $H_2S = 2 \times 6.022 \times 10^{23}$ H atoms
0.400 mole of $H_2S = (0.400 \times 2 \times 6.022 \times 10^{23}) = 4.81 \times 10^{23}$ H atoms
1 mole of $H_2S = 6.022 \times 10^{23}$ S atoms
0.400 mole of $H_2S = (0.400 \times 6.022 \times 10^{23}) = 2.40 \times 10^{23}$ S atoms

52. 2053 Q.No. 7 Group A Calculate the weight of 11.2 litres of CO_2 gas at STP. (Molecular weigh $CO_2 = 44$).

Solution

1 mole of $CO_2 = 44$ g
1 mole of CO_2 gas at NTP = 22.4 litre
22.4 litre of $CO_2 = 44$ g
11.2 litre of $CO_2 = 22$ g
Hence, weight of 11.2 liter of CO_2 gas is 22 g.

53. 2052 Q.No. 4 Group A Copper has a density of 8.92 g / cm³. If 1 mole of copper were shaped into a cube, w would be the length of the side of the cube (Atomic weight of copper = 63.5)?

Solution

Given,
Density of copper = 8.92 g /cm³
No. of mole of copper = 1 mol
Atomic weight of copper = 63.5
1 mole of copper = 63.5 g
Length of side of cube (l) = ?
Volume of copper (V) = ?

We know that,

$$d = \frac{m}{v}$$

or, $v = \frac{m}{d} = \frac{63.5}{8.92} = 7.12\ cm^3$

We know that, $V = l^3$

or, $l = \sqrt[3]{V} = \sqrt[3]{7.12} = 1.92$ cm
So, the length of side of cube = 1.92 cm

54. 2052 Q.No. 10 Group A How many moles of atoms is contained in 15 g of Zn?

Solution

Given,
Mass of Zn = 15 g
Atomic mass of Zn = 65
We know that,

$$\text{No. of moles of atom} = \frac{\text{Given mass}}{\text{Atomic mass}} = \frac{15}{65} = 0.23 \text{ mol}$$

Hence, 0.23 mol of Zn atom is contained in 15 g of Zn.

55. 2052 Q.No.20 Group A What is the weight (in g) of 0.5 atom of oxygen?

Solution

1 mole of O-atom = 16 g
1 mole of O-atom = 6.022×10^{23} O-atom
6.022×10^{23} O-atom = 16 g

$$0.5 \text{ O-atom} = \frac{16}{6.022 \times 10^{23}} \times 0.5 = 1.33 \times 10^{-23} \text{ g}$$

Hence, weight of 0.5 atom of oxygen is 1.33×10^{-23} g

5. **2052 Q.No. 3 Group B** **Define atomic mass of an element Chlorine naturally is made up of 75%, Cl-35 and 25% Cl-37. Calculate the atomic mass of element chlorine.** **[5]**

The atomic weight of an element is a number which indicates as to how many times one atom of the element is heavier than one-twelth weight of an atom of the carbon-12 isotope.

Atomic mass of an element = average weight per atom of element $\frac{1}{12}^{th}$ weight of one atom of C^{12}

The average atomic mass of chlorine element = $\frac{(35 \times 75 + 37 \times 25)}{100} = 35.5$

Hence, atomic mass of chlorine element is 35.5.

7. **2051 Q.No. 6 Group A** **How many molecules are contained in 0.35 mole of N_2?** **[2]**

Solution

1 mole of N_2 contains 6.022×10^{23} molecules

0.35 mole of N_2 contains $0.35 \times 6.022 \times 10^{23}$ molecules = 2.10×10^{23} molecules.

Hence, 2.10×10^{23} molecules of N_2 are contained in 0.35 mole of N_2.

8. **2051 Q.No. 1 Group C**

a. **How many grams of H_2S are contained in 0.400 mole of H_2S?** **[2]**
b. **How many gram-atoms of H and of S are contained in 0.400 mole of H_2S?** **[2]**
c. **How many grams of H and of S are contained in 0.400 mole of H_2S?** **[2]**
d. **How many molecules of H_2S are contained in 0.400 mole of H_2S?** **[2]**
e. **How many atoms of H and of S of are contained in 0.400 mole of H_2S?** **[2]**

Solution

1 mole of $H_2S = (2 + 32) = 34$ g

0.400 mole of $H_2S = (34 \times 0.400) = 13.6$ g

1 mole of H_2S = 2 mole of H

0.400 mole = $(2 \times 0.400) = 0.800$ mole or gram atom of H

1 mole of H_2S = 1 mole of S

0.400 mole = 0.400 mole of S

1 mole of H_2S = 2 g of H

0.400 mole = 0.800 g of H

1 mole of H_2S = 32 g of S

0.400 mole of $H_2S = (32 \times 0.4) = 12.8$ g S

1 mole of $H_2S = 6.022 \times 10^{23}$ molecules

0.4 mole of $H_2S = (0.4 \times 6.022 \times 10^{23}) = 2.4 \times 10^{23}$ molecules

1 mole of $H_2S = 2 \times 6.022 \times 10^{23}$ H – atom

0.4 mole of $H_2S = (0.4 \times 2 \times 6.022 \times 10^{23}) = 4.8 \times 10^{23}$ H-atom

1 mole of $H_2S = 6.022 \times 10^{23}$ S –atom

0.4 mole of $H_2S = (0.4 \times 6.022 \times 10^{23}) = 2.4 \times 10^{23}$ S-atom.

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2.3. Empirical, Molecular Formula ar Limiting Reactants

VERY SHORT ANSWER QUESTIONS [2MARKS]

1. 2060 Q.No. 2 **What is a limiting reactant? Why is it essential in stoichiometric calculations?**

In many chemical reactions, one of the reactant is in fewer amounts while other is in excess. reactant which is in less, exhausted first while other still remains in excess. The reactant w is in less and exhausted first is called limiting reactant or the reactant which is compl consumed during reaction.

Following are the reason due to which limiting reagent is essential in stoichiometric calculat

i. It gives the information about the given chemical reaction and helps in a numbe chemical calculations
ii. It helps for the calculation of the amount of reactant which is required for the chen reaction with respect to another.
iii. It is not possible to solve the calculation of chemical reaction without limiting reagent.

SHORT ANSWER QUESTIONS [5 MARKS]

2. 2076 Set B Q.No. 29b 2076 Set C Q.No. 29b **16.8 g of $NaHCO_3$ when heated produces 9 g of Na_2CO_3 acco to the following reaction:**

$$2NaHCO_3 \xrightarrow{\Delta} Na_2CO_3 + H_2O + CO_2$$

i. **Find the percentage purity of the $NaHCO_3$**
ii. **How much volume of CO_2 will be produced at 1 atmospheric pressure and 27°C temperatures?**

The balanced equation is given as:

$$NaHCO_3 \xrightarrow{\Delta} Na_2CO_3 + H_2O + CO_2$$

168 g 106 g 1 mole

The given weight of $NaHCO_3$ is 16.8 g

The given weight of Na_2CO_3 is 9 g

i. From the balanced chemical equation

106 g Na_2CO_3 is produced from 168 g $NaHCO_3$

9 g Na_2CO_3 is produced from $\frac{168 \times 9}{106}$ g $NaHCO_3$

$= 14.26$ g $NaHCO_3$

Hence, the percentage purity of $NaHCO_3$ is $\frac{14.26 \times 100}{16.8} = 84.88\%$

ii. From the balanced chemical equation

168 g $NaHCO_3$ gives 1 mole of CO_2

14.26 g $NaHCO_3$ gives $\frac{1 \times 14.26}{168}$ mole of CO_2

$= 0.084$ mole of CO_2

Given,

No. Of mole of CO_2 (n) = 0.084 mole

Temperature of CO_2 (T) = 27°C = 27 + 273 = 300K

Pressure of CO_2 (P) = 760 mm Hg = 1 atm

Universal gas constant (R) = 0.0821 L atm $K^{-1}mol^{-1}$

Volume of CO_2 (V) = ?

We know that

$PV = nRT$

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or, $V = \frac{nRT}{P} = \frac{0.084 \times 0.0821 \times 300}{1} = 2.09$ Litre

Hence, the volume of CO_2 produced is 2.09 Litre

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3. 2075 GIE Q.No. 24 **You are given**

$Fe_2O_3 + 3CO \longrightarrow 2Fe + 3CO_2$

The reaction is carried out by mixing 130 g of Fe_2O_3 and 50 g of CO.

i. **Calculate the limiting reactant.**
ii. **How much mass of iron is produced?**
iii. **How many number of moles of unreacted reactant left over?**
iv. **Calculate the volume of CO_2 produced at 25°C and 2 atmospheric pressure. (Given: Atomic weight of Fe = 56)** **[1+1+1+2]**

Sol The balanced chemical equation is

Fe_2O_3	+	3CO	⟶	2Fe	+	$3CO_2$
160 g		84 g		112 g		3 mole

160 g of Fe_2O_3 reacts with 84 g of CO

130 g of Fe_2O_3 reacts with $\frac{84 \times 130}{160}$ g of CO = 68.25 g of CO.

The given mass of CO is 50 g but calculated mass of CO is 68.25 g. Here, CO is in less amount and finished first. So, CO is limiting reagent.

i. 84 g CO reacts with Fe_2O_3 to give 112 g Fe

50 g CO reacts with Fe_2O_3 to give $\frac{112 \times 50}{84}$ g Fe = 66.66 g Fe

iii. The mass of unreacted reactant left over = 68.25 – 50 = 18.25 g

The number of mole = $\frac{18.25}{28}$ = 0.65 mol.

iv. 84 g CO reacts with Fe_2O_3 to give 3 mole CO_2

50 g CO reacts with Fe_2O_3 to give $\frac{3 \times 50}{84}$ mole CO_2 = 1.78 mole CO_2

Given, T = 25°C = (25 + 273) = 298 K

P = 2 atm

n = 1.78 mole

R = 0.0821 L atm K^{-1} mol^{-1}

V = ?

We know that,

PV = nRT

or, $V = \frac{nRT}{P} = \frac{1.78 \times 0.0821 \times 298}{2} = 43.54$ Litre.

Hence, the volume of CO_2 gas is 43.54 Litre.

---

4. 2075 Set B Q.No. 26 2072 Set E Q.No. 26 **2 g of magnesium is burnt in a closed vessel containing 3 g of oxygen.**

i. **Which one is limiting reactant?**
ii. **Calculate the mole of reactant left over.**
iii. **How many gram of MgO are produced?**
iv. **What is the mass of H_2SO_4 required to neutralize MgO formed in the reaction?** **[1+1+1+2]**

Sol The balanced chemical equation is

2Mg	+	O_2	⟶	2MgO
2×24		32 g		2 × (24+16)
48 g		32 g		80 g

i. 48 g of Magnesium reacts with 32 g of oxygen

1 g of Magnesium reacts with $\frac{32}{48}$ g of oxygen

2 g of Magnesium reacts with $\frac{32}{48} \times 2$ g of oxygen = 1.33 g

Thus, 2 g of magnesium requires 1.33 g of oxygen for complete reaction. The given mass oxygen is 3 g. So, the reactant magnesium is finished first and limits the reaction. Therefore, is limiting reactant.

ii. The mass of reactant left over = (3 – 1.33) g = 1.66 g

The number of mole of reactant left over = $\frac{1.66}{80}$ = 0.052 mol

iii. 48 g of magnesium reacts with oxygen to produce 80 g MgO

1 g of magnesium reacts with oxygen to produce $\frac{80}{48}$ g MgO

2 g of magnesium reacts with oxygen to produce $\frac{80}{48} \times 2$ g MgO = 3.33 g MgO

Hence, the mass of MgO produced is 3.33 g.

iv. Now, the MgO produced reacts with H_2SO_4 as

$MgO + H_2SO_4 \longrightarrow MgSO_4 + H_2O$

40 g 98 g

40 g of MgO reacts with 98 g of H_2SO_4

1 g of MgO reacts with $\frac{98}{40}$ g of H_2SO_4

3.33 g of MgO reacts with $\frac{98}{40} \times 3.33$ g of H_2SO_4 = 8.15 g of H_2SO_4

Hence, the mass of H_2SO_4 which is required to neutralize MgO is 8.15 g.

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5. **2071 Supp Q. No. 24** **3.00 g of H_2 react 29.00 g of O_2 to yield H_2O.**

a. Which is the limiting reactant?

b. Calculate the maximum amount of H_2O that can be formed.

c. Calculate the amount of reactants which remains unreacted.

Solution

a. The balanced chemical equation is

$2H_2 + O_2 \longrightarrow 2H_2O$

4 g + 32 g 36 g

4 g of hydrogen reacts with 32 g of oxygen to form water.

1 g of hydrogen reacts with $\frac{32}{4}$

3 g of hydrogen reacts with $\frac{32}{4} \times 3$ = 24 g of oxygen

Thus, 24 g of oxygen is required for complete reaction of 3 g of hydrogen. But given weight oxygen is 29 g. So, hydrogen is limiting reagent.

b. 4 g of hydrogen reacts with oxygen to form 36 g of water

1 g of hydrogen reacts with oxygen

3 g of hydrogen reacts with oxygen $\frac{36}{4} \times 3$ = 27 g of water

c. The mass of unreacted reactant = (29 –24)g = 5 g

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2068 Q.No. 25 **A chemical reaction was carried out by mixing 25 g of pure Calcium Carbonate and 0.75 mole of pure hydrochloric acid to give $CaCl_2$, H_2O and CO_2.** **[1.5+1+1+1.5=5]**

i. **Which one is limiting reactant and why?**
ii. **Calculate the mass of $CaCl_2$ produced.**
iii. **How many number of water molecules are formed?**
iv. **What mass of NaOH is required to absorb the whole CO_2 produced in the reaction?**

Solution

The balanced chemical equation is

$$\underset{1\text{ mole}}{CaCO_3} + \underset{2\text{ mole}}{2HCl} \longrightarrow \underset{1\text{ mole}}{CaCl_2} + \underset{1\text{ mole}}{CO_2} + \underset{1\text{ mole}}{H_2O}$$

$$\underset{100\text{ g}}{} \qquad \underset{(2\times 36.5 = 73)}{} \qquad \underset{111\text{ g}}{}$$

100 g of $CaCO_3$ reacts with 2 mole of HCl

25 g of $CaCO_3$ reacts with $\frac{2}{100} \times 25 = 0.5$ mol HCl

Thus, 25 g of calcium carbonate requires 0.5 mole of HCl but given mass of HCl is 75 mole. So, $CaCO_3$ is the limiting reactant.

i. 100 g of $CaCO_3$ produces 111 g of $CaCl_2$

25 g of $CaCO_3$ produces $\frac{111}{100} \times 25$ g of $CaCl_2 = 27.75$ g of $CaCl_2$

ii. 100 g of $CaCO_3$ produces 1 mole $H_2O = 6.022 \times 10^{23}$ H_2O molecules

25 g of $CaCO_3$ produces $= \frac{6.022 \times 10^{23}}{100} \times 25 = 1.5 \times 10^{23}$ H_2O molecules

iv. No. of mole of $CaCO_3 = \frac{25}{100} = 0.25$ mol

1 mole of $CaCO_3$ produces 1 mole of CO_2
0.25 mole of $CaCO_3$ produces 0.25 mole
Now, the CO_2 produced reacts with NaOH as

$$CO_2 + 2NaOH \longrightarrow Na_2CO_3 + H_2O$$

1 mole of CO_2 is absorbed by 2 mole of NaOH
0.25 mole of CO_2 is absorbed by $(2 \times 0.25) = 0.5$ mol of NaOH

We know that,
1 mole of NaOH = 40 g
0.5 mole of NaOH = 20 g
Hence, 20 g of NaOH is required to absorb all the CO_2 produced by the above reaction.

---

7. **2064 Q.No. 25** **10.6 g of pure Na_2CO_3 if treated with 7.9 g of HCl to produce NaCl, H_2O and CO_2.** **[2+2+1]**

a. **Find the limiting reagent and calculate mole of unreacted reagent left over.**
b. **What volume of CO_2 gas is produced at NTP?**
c. **Calculate mass of NaCl formed.**

Solution

a. The balanced chemical equation is

$$\underset{1\text{ mole}}{Na_2CO_3} + \underset{2\text{ mole}}{2HCl} \longrightarrow \underset{2\text{ mole}}{2NaCl} + \underset{1\text{ mole}}{H_2O} + \underset{1\text{ mole}}{CO_2}$$

$$\underset{106\text{ g}}{} \qquad \underset{2\times 36.5}{} \qquad \underset{2\times 58.5}{} \qquad \underset{22.4\text{ liter}}{}$$

106 g of Na_2CO_3 requires $2 \times 36.5 = 73$ g of HCl for the complete reaction.

1 g of Na_2CO_3 requires $= \frac{73}{106}$ g of HCl for the complete reaction.

10.6 g of Na_2CO_3 requires $= \frac{73}{106} \times 10.6$ g of HCl for the complete reaction.

$= 7.3$ g of HCl

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Thus, 7.3 g of HCl is required for complete reaction with 10.6 g of Na_2CO_3. But HCl provided is 7.9 g. So, Na_2CO_3 is consumed first and is limiting reagent.

Here,

Weight of HCl consumed = 7.3 g

Weight of HCl provided = 7.9 g

Weight of HCl remained unreacted = (7.9 – 7.3) = 0.6 g

No. of moles of unreacted HCl = $\frac{0.6}{36.5}$ = 0.016 mol

b. 106 g of Na_2CO_3 produces 22.4 liter of CO_2 gas at NTP

1 g of Na_2CO_3 produces = $\frac{22.4}{106}$ liter of CO_2 gas at NTP

10.6 g of Na_2CO_3 produces = $\frac{22.4}{106} \times 10.6$ = 2.24 liter of CO_2 gas at NTP

c. 106 g of Na_2CO_3 produces (2 x 58.5) = 117 g of NaCl

1 g of Na_2CO_3 produces = $\frac{117}{106}$ g of NaCl

10.6 g of Na_2CO_3 produces = $\frac{117}{106} \times 10.6$ =11.7 g of NaCl

NUMERICAL PROBLEMS:

8. 2073 Supp Q.No. 29 2 g of magnesium is burnt in a closed vessel containing 1.2 g of oxygen to produ Magnesium oxide.

i. Find the limiting reagent.

ii. Calculate the number of molecules of unreacted reagent left over.

iii. What mass of MgO is produced?

iv. How many grams of pure HCl are required to neutralize whole MgO produced? **[2+1+1**

The balance chemical equation is

$$2\,Mg + O_2 \longrightarrow 2\,MgO$$

2 mole	1 mole	2 mole
48 g	32 g	80 g
	22.4 L	

i. 48 g magnesium reacts with 32 g of oxygen to form magnesium oxide.

1 g magnesium reacts with $\frac{32}{48}$ g of oxygen to form magnesium oxide.

2 g magnesium reacts with $\frac{32}{48} \times 2$ g of oxygen to form magnesium oxide.

= 1.33 g of oxygen

The given mass of oxygen is 1.2 g but the calculate mass of oxygen is 1.33 g. The oxyger finished first in the reaction. Therefore, oxygen is limiting reagent.

ii. The mass of unreacted reactant = (1.33 -1.2) = 0.13 g

No. of moles of unreacted reactant = $\frac{0.13}{32}$ = 0.004 mole oxygen.

1 mole oxygen contains 6.022×10^{23} oxygen molecules.

0.004 mole oxygen contains $0.004 \times 6.022 \times 10^{23}$ oxygen molecules.

$= 2.40 \times 10^{21}$ oxygen molecules.

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ii. 32 g oxygen reacts with magnesium to form 80 g of magnesium oxide.

1 g oxygen reacts with magnesium to form $\frac{80}{32}$ g of magnesium oxide.

1.2 g oxygen reacts with magnesium to form $\frac{80}{32} \times 1.2$ g of magnesium oxide = 3g MgO.

Hence, the mass of magnesium oxide (MgO) is 3 g.

v. The balance equation between MgO and HCl is

$$MgO + 2\,HCl \longrightarrow MgCl_2 + H_2O$$
$$40\text{ g} \quad 73\text{ g}$$

40 g MgO reacts with 73 g of HCl to form magnesium chloride.

1g MgO reacts with $\frac{73}{40}$ g of HCl to form magnesium chloride.

3 g MgO reacts with $\frac{73}{40} \times 3$ g of HCl to form magnesium chloride.

= 5.475 g HCl

Hence, the mass of HCl which is required to neutralize whole MgO is 5.475 g.

---

9. 2073 Set C Q. No. 29 | 2073 Set D Q. No. 29 **For a reaction:** **[2+1+2]**

$2\,NaHCO_3 \xrightarrow{\Delta} Na_2CO_3 + H_2O + CO_2$

2.5 g of a sample $NaHCO_3$ when strongly heated gives 310 cc of CO_2 gas at 27°C and 760 mm Hg pressure.

i. Calculate the percentage purity of the sample ($NaHCO_3$)

ii. How many moles of water are produced?

iii. What mass of pure HCl is required to neutralize Na_2CO_3 produce in the reaction?

The balanced chemical equation is

$$2\,NaHCO_3 \xrightarrow{\Delta} Na_2CO_3 + H_2O + CO_2$$
$$2(23+1+12+48) \quad (2\times23+12+48) \quad 1\text{ mole} \quad 22.4\text{ L or }22400\text{ cc}$$
$$168\text{ g} \qquad 106\text{ g}$$

Given, weight of $NaHCO_3$ = 2.5 g

At RTP

Volume of CO_2 gas (V_1) = 310 cc

Temperature of gas (T_1) = 27°C = (27 + 273) = 300 K

Pressure of gas (P_1) = 760 mm Hg

At STP

Volume of CO_2 gas (V_2) = ?

Temperature of gas (T_2) = 273 K

Pressure of gas (P_2) = 760 mm Hg

We know from combined gas equation,

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

Or, $$V_2 = \frac{P_1V_1T_2}{P_2T_1}$$

Or, $$V_2 = \frac{760 \times 310 \times 273}{760 \times 300} = 282.1\text{ cc of carbon dioxide}$$

i. From the above balanced chemical equation

22400 cc of CO_2 is produced from 168 g $NaHCO_3$

1 cc of CO_2 is produced from $\frac{168}{22400}$ g $NaHCO_3$

282.1 cc of CO_2 is produced from $\frac{168}{22400} \times 282.1$ g $NaHCO_3 = 2.11$ g $NaHCO_3$

The percentage purity of $NaHCO_3 = \frac{2.11}{2.5} \times 100 = 84.4\%$

ii. 168 g of $NaHCO_3$ gives 1 mole of H_2O

1 g of $NaHCO_3$ gives $\frac{1}{168}$ mole of H_2O

2.11 g of $NaHCO_3$ gives $\frac{1}{168} \times 2.11$ mole of $H_2O = 0.0125$ mole of H_2O

iii. 168 g of $NaHCO_3$ gives 106 g of Na_2CO_3

1 g of $NaHCO_3$ gives $\frac{106}{168}$ g of Na_2CO_3

2.11 g of $NaHCO_3$ gives $\frac{106}{168} \times 2.11$ g of $Na_2CO_3 = 1.33$ g of Na_2CO_3

The reaction of Na_2CO_3 and HCl

$Na_2CO_3 + 2\,HCl \longrightarrow 2\,NaCl + H_2O + CO_2$

106 g 73 g

106 g Na_2CO_3 neutralizes with 73 g of HCl

1 g Na_2CO_3 neutralizes with $\frac{73}{106}$ g of HCl

1.33 g Na_2CO_3 neutralizes with $\frac{73}{106} \times 1.33$ g of HCl $= 0.91$ g of HCl

Hence, the mass of HCl is required to neutralize Na_2CO_3 is 0.91 g.

---

10. 2072 Set C Q.No. 26 2072 Set D Q.No. 26 **Consider a reaction** [1+1+

$Fe_2O_3 + 3CO \longrightarrow 2Fe + 3CO_2$

10 g of Fe_2O_3 is reacted with 9 g of CO.

i. Find the limiting reagent.

ii. How many mole of unreacted reactant left over?

iii. Calculate the mole of CO consumed in the reaction.

iv. What mass of NaOH is required to absorb whole CO_2 produced?

The balanced chemical equation is

$Fe_2O_3 + 3CO \longrightarrow 2Fe + 3CO_2$

$(2\times56+3\times16)$ 3 mole 3 mole

160 g 3 (12+16)

84 g

i. 160 g Fe_2O_3 reacts with 84 g CO to form product

10 g Fe_2O_3 reacts with $\frac{84}{160} \times 10$ g CO $= 5.25$ g CO

The given mass of CO is 9 g but calculated mass of CO is 5.25 g. Here, CO is in excess amo and Fe_2O_3 is finished first. Hence, Fe_2O_3 is limiting reagent.

ii. Given mass of CO = 9 g

Reacted mass of CO = 5.25 g

Unreacted mass of CO = (9 – 5.25) g = 3.75 g

The molecular mass of CO = 28

We know that

Number of mole of unreacted reactant $= \frac{\text{Given mass}}{\text{Molecular mass}} = \frac{3.78}{28} = 0.133$ mol

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Here, number of mole of unreacted reactant is 0.133 mol.

iii. 160 g of Fe_2O_3 reacts with 3 mole of CO

10 g of Fe_2O_3 reacts with $\frac{3}{160} \times 10$ mole of CO = 0.1875 mole of CO

Hence, mole of CO consumed in the reaction is 0.1875 mol.

iv. NaOH reacts with CO_2 to give Na_2CO_3

$2NaOH + CO_2 \longrightarrow Na_2CO_3 + H_2O$

2×40 1 mole

80 g

160 g of Fe_2O_3 reacts with CO to give 3 mole of CO_2

10 g of Fe_2O_3 reacts with CO to give $\frac{3}{160} \times 10 = 0.1875$ mole of CO_2.

Here,

1 mole of CO_2 requires 80 g of NaOH

0.1875 mole of CO_2 requires $80 \times 0.1875 = 15$ g NaOH

Hence, the mass of NaOH which is required to absorb whole CO_2 is 15 g.

---

11. 2071 (Set C) Q.No. 24 (a) What volume of oxygen will be produced by heating 245 kg of pure $KClO_3$ at STP? (atomic weight of K = 39) **[2]**

Solution

The balanced chemical equation is

$3KClO_3 \xrightarrow{\Delta} 2KCl + 3O_2$

2 mole 2 mole 3 mole

$2 \times (39+35.5+3\times16)$ 3×22.4 liter

$2 \times (122.5)$

245 g

Given,

Weight of $KClO_3 = 245$ kg $= (245 \times 1000) = 245000$ g

From balanced chemical equation:

245 g of $KClO_3$ will give 3×22.4 liter oxygen gas.

1 g of $KClO_3$ will give $= \frac{3 \times 22.4}{245}$ liter oxygen gas.

245000 g of $KClO_3$ will give $= \frac{3 \times 22.4}{245} \times 245000$ liter oxygen gas.

$= 67200$ liter

Hence, 67200 litre of oxygen will produce by heating 245 kg of pure $KClO_3$ at STP.

---

12. 2071 (Set C) Q.No. 24 (b) How much sulphuric acid containing 80% H_2SO_4 by weight is needed to produce 500 kg of 80% HCl by weight?

$2\,NaCl + H_2SO_4 \longrightarrow Na_2SO_4 + 2\,HCl$ **[3]**

Solution

500 kg of 80% HCl $= 500 \times 1000 \times \frac{80}{100} = 400000$ g HCl

The balanced chemical equation is

$2NaCl + H_2SO_4 \longrightarrow Na_2SO_4 + 2HCl$

2 mole 1 mole 1 mole 2 mole

98 g $(2 \times 36.5) = 73$ g

From the equation,

73 g of HCl is obtained from 98 g of H_2SO_4

400000 g of HCl is obtained from $\frac{98 \times 400000}{73} = 536986.30$ g of H_2SO_4

The purity of H_2SO_4 is 80% by weight
i.e. 80 g of pure H_2SO_4 is obtained from 100 g of H_2SO_4
536986.30 g of pure H_2SO_4 is obtained from $\frac{100 \times 536986.30}{80}$
$= 671232.87g = 671.23$ kg of H_2SO_4
So, 671.23 kg of 80% H_2SO_4 is required to prepare 500 kg of 80% HCl by weight.

13. 2071 (Set D) Q.No. 24 8 g of pure calcium is treated with 50 g of pure HCl to give $CaCl_2$ and H_2: [1+1+1
a. Which is limiting reactant?
b. Calculate the mass of unreacted left over.
c. What mass of $CaCl_2$ will be formed?
d. How many moles of water will be produced if the whole H_2 formed in the reaction react with O_2?

Solution

The balanced chemical equation is

Ca	+	2 HCl	⟶	$CaCl_2$	+	H_2
1 mole		2 mole		1 mole		1 mole
40 g		(2 × 36.5) 73 g		111 g		

a. 40 g of calcium reacts with 73 g of HCl to form product
1 g of calcium reacts with $\frac{73}{40}$ g of HCl to form product
8 g of calcium reacts with $\frac{73 \times 8}{40}$ g of HCl to form product =14.6 g HCl
Thus, 8 g of calcium requires 14.6 g of HCl for complete reaction. The amount of HCl given is g. So, the reactant Calcium is finished first in the reaction and limits the reaction. Therefo Calcium is limiting reactant.

b. The unreacted HCl left = (50 – 14.6) = 35.4 g

c. 40 g of calcium reacts with HCl to produce 111 g $CaCl_2$
1 g of calcium reacts with HCl to produce $\frac{111}{40}$
8 g of calcium reacts with HCl to produce $\frac{111 \times 8}{40} = 22.2$ g $CaCl_2$
Hence, 22.2 g of $CaCl_2$ will be produced.

d. Given,
40 g of calcium reacts with HCl to give 1 mole of H_2
1 g of calcium reacts with HCl to give $\frac{1}{40}$
8 g of calcium reacts with HCl to give $\frac{8}{40} = 0.2$ mol of H_2
Hydrogen reacts with oxygen to form water

$2H_2$	+	O_2	⟶	$2H_2O$
2 mole				2 mole

2 mole of hydrogen reacts with oxygen to give 2 mole of water
0.2 mole of hydrogen reacts with oxygen to give 0.2 mol of water
Hence, 0.2 mol of water will be produced.

14. 2070 Supp. Q.No. 25 2.4 g of magnesium is treated with 0.2 mole of sulphuric acid to yield $MgSO_4$ and H_2 [1
i. Which one is limiting reactant and why?
ii. Calculate the mass of excess reactant.
iii. How many moles of $MgSO_4$ are produced?
iv. What mass of water will be produced if the whole H_2 gas formed in the reaction react with O_2?

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Solution

The balanced chemical equation is

$Mg + H_2SO_4 \longrightarrow MgSO_4 + H_2$

1 mole 1 mole 1 mole 1 mole

24 g 98 g 120 g

i. 24 g of magnesium is completely reacted with 1 mole of H_2SO_4

1 g of magnesium is completely reacted with $\frac{1}{24}$ mole of H_2SO_4

2.4 g of magnesium is completely reacted with $\frac{1 \times 2.4}{24}$

$= 0.1$ mol of H_2SO_4

The required mole of sulphuric acid is 0.1 mole but the given mole of sulphuric acid is 0.2. So, H_2SO_4 is in excess amount and Mg is limiting reactant.

ii. 1 mole of H_2SO_4 reacts with 24 g of Mg

0.2 mole H_2SO_4 reacts with $24 \times 0.2 = 4.8$ g Mg

The mass of excess Mg = (4.8 – 2.4) = 2.4 g

iii. Given,

24 g of Mg reacts with sulphuric acid to give 1 mole of $MgSO_4$

2.4 g of Mg reacts with sulphuric acid to give $\frac{2.4}{24} = 0.1$ mole of $MgSO_4$

iv. 24 g of Mg reacts with sulphuric acid to give 2 gm of H_2

2.4 g of Mg reacts with sulphuric acid to give $\frac{2 \times 2.4}{24} = 0.2$ g H_2

Hydrogen reacts with oxygen to form water.

$2H_2 + O_2 \longrightarrow 2H_2O$

4 g $(2 \times 18) = 36$ g

4 g of hydrogen reacts with oxygen to form 36 g of water.

0.2 g of hydrogen reacts with oxygen to form $\frac{36 \times 0.2}{4} = 1.8$ g water.

Hence, 1.8 g of water will be produce if the whole H_2 gas formed in the reaction react with O_2.

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15. 2070 Set C Q.No. 28 20 g of 40% pure $CaCO_3$ if reacted with 5 g of HCl to produce $CaCl_2$, H_2O and CO_2.

a. Find which one is limiting reactant and why?

b. Calculate mass of $CaCl_2$ formed.

c. How many number of water molecules are produced?

d. Calculate the volume of CO_2 produced at 27° C and 0.5 atm pressure. **[1+1+1+2]**

Solution

20 g of 40% $CaCO_3 = 20 \times \frac{40}{100} CaCO_3 = 8$ g $CaCO_3$

The balanced chemical equation is

$CaCO_3 + 2HCl \longrightarrow CaCl_2 + H_2O + CO_2$

1 mole 2 mole 1 mole 1 mole 1 mole

100 g 73 g 111 g 22.4 litre

Given,

a. 100 g $CaCO_3$ reacts with 73 g of HCl to produce product

1 g $CaCO_3$ reacts with $\frac{73}{100}$ g of HCl to produce product

8 g $CaCO_3$ reacts with $\frac{73 \times 8}{100}$ g of HCl to produce product = 5.84 g HCl

The amount of HCl required is 5.84 g but given mass of HCl is 5 g. So, the limiting react HCl which limit the reaction.

b. 73 g HCl reacts with $CaCO_3$ to form 111 g of $CaCl_2$

1 g HCl reacts with $CaCO_3$ to form $\frac{111}{73}$ g of $CaCl_2$

5 g HCl reacts with $CaCO_3$ to form $\frac{111 \times 5}{73} = 7.60$ g $CaCl_2$

c. 73 g of HCl produces 1 mole of water

1 g of HCl produces $\frac{1}{73}$ mol of water

5 g of HCl produces $\frac{5}{73} = 0.068$ mol water

We know that,

1 mole water = 6.022×10^{23} water molecules

0.068 mole water = $0.068 \times 6.022 \times 10^{23}$ water molecule

$= 4.09 \times 10^{22}$ water molecule

Hence, 4.09×10^{22} water molecules are produced.

d. Given,

73 g HCl reacts with $CaCO_3$ to produce 1 mole of CO_2

1 g HCl reacts with $CaCO_3$ to produce $\frac{1}{73}$ mole of CO_2

5 g HCl reacts with $CaCO_3$ to produce $\frac{5}{73} = 0.068$ mol of CO_2

Hence, no. of mole of CO_2 (n) = 0.068 mole

Volume of CO_2 (V) =?

Temperature (T) = 27°C = (27 + 273) = 300 K

Pressure (P) = 0.5 atm

R = 0.0821 L atm $K^{-1}mol^{-1}$

We know that,

$PV = nRT$

or, $V = \frac{nRT}{P} = \frac{0.068 \times 0.0821 \times 800}{0.5} = 3.34$

or, V = 3.34 litre

Hence, 3.34 litre of CO_2 gas is produce at 27°C and 0.5 atm pressure.

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16. 2070 Set D Q.No. 23 **For a reaction,**

$Ca(OH)_2 + 2NH_4Cl \longrightarrow CaCl_2 + 2NH_3 + 2H_2O$

(aq.) (aq.) (aq.) (g) (l)

The reaction is carried out by mixing 7 g of pure $Ca(OH)_2$ and 7 g of pure NH_4Cl.

a. Find the limiting reactant.

b. Calculate the mole of unreacted reactant left over.

c. How many gram of $CaCl_2$ are formed?

d. What volumes of NH_3 gas are produced at 27°C and 1.5 atmospheric pressure? [1+1+

Solution

The balanced chemical equation is

$Ca(OH)_2$	+	$2NH_4Cl$	$\longrightarrow$	$CaCl_2$	+	$2NH_3$	+	$2H_2O$
1 mole		2 mole		1 mole		2 mole		2 mole
74 g		107 g		111 g				

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Given,
74 g $Ca(OH)_2$ reacts with 107 g of NH_4Cl

1 g $Ca(OH)_2$ reacts with $\frac{107}{74}$ g of NH_4Cl

7 g $Ca(OH)_2$ reacts with $\frac{107 \times 7}{74}$ g of NH_4Cl $= 10.12$ g NH_4Cl

The required mass of NH_4Cl is 10.12 g but the given mass of NH_4Cl is 7 gm. So, NH_4Cl is limiting reagent which limit the reaction.

Given,
107 g NH_4Cl is completely react with 74 g of $Ca(OH)_2$

1 g NH_4Cl is completely react with $\frac{74}{107}$

7 g NH_4Cl is completely react with $\frac{74 \times 7}{107} = 4.84$ g $Ca(OH)_2$

The mass of unreacted reactant = (7 – 4.84) = 2.16 g

The no. of mole of unreacted reactant $Ca(OH)_2 = \frac{2.16}{74} = 0.029$ mol

Given,
107 g NH_4Cl is completely reacted with $Ca(OH)_2$ to produce 111 g $CaCl_2$

1 g NH_4Cl is completely reacted with $Ca(OH)_2$ to produce $\frac{111}{107}$

7 g NH_4Cl is completely reacted with $Ca(OH)_2$ to produce $\frac{111 \times 7}{107}$

$= 7.26$ g

Hence, 7.26 g of $CaCl_2$ is produced.

Given,
107 g NH_4Cl is completely reacted with $Ca(OH)_2$ to produce 2 mole of NH_3

1 g NH_4Cl is completely reacted with $Ca(OH)_2$ to produce $\frac{2}{107}$

7 g NH_4Cl is completely reacted with $Ca(OH)_2$ to produce $\frac{2 \times 7}{107}$

$= 0.13$ mol NH_3

Hence, no. of mole of NH_3 (n) = 0.13 mole
Volume of NH_3(V) = ?
Pressure (P) = 1.5 atm
Temperature (T) = 27°C = (27 + 273) =300 K
R = 0.0821 L atm $K^{-1}mol^{-1}$
We know that,
$PV = nRT$

$\therefore V = \frac{nRT}{P}$

$\therefore V = \frac{0.13 \times 0.0821 \times 300}{1.5}$

$\therefore V = 2.13$ litre

Hence, 2.13 litre of NH_3 gas is produce at 27°C and 1.5 atm pressure.

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17. **2069 (Set B) Q. No. 1** **73 g of conc. HCl was diluted by adding 144 g of water. How many gram at hydrogen are present in the dilute acid?**

Solution

Molecular wt. of HCl = (35.5 + 1) = 36.5 g

1 mole of HCl = 36.5 g

1 mole of HCl = 1 H gram atom

36.5 g of HCl = 1 H gram atom

73 g of HCl = 2 H gram atom

Similarly,

1 mole if H_2O = 18 g

1 mole of H_2O = 2 gram atom H

18 g of H_2O = 2 gram atom H

144 g of $H_2O = \frac{2}{18} \times 144$ gram atom H = 16 gram atom

So, the total number of gram atom present in dilute acid = (16 + 2) = 18 gram atom H

18. **2069 (Set B) Q. No. 2** **Calculate the amount of lime (CaO) that can be prepared by heating 200 kg of lime s ($CaCO_3$) that is 95% pure.**

Solution

Molecular mass of lime stone ($CaCO_3$) = (40 + 12 + 4 × 16) = 100

Given mass of $CaCO_3$ = 200 kg = 200000 g

% purity $CaCO_3 = 200000 \times 95\% = 200000 \times \frac{95}{100} = 190000$

The balance chemical equation

$$CaCO_3 \longrightarrow CaO + CO_2$$

100 g 56 g

100 g of $CaCO_3$ produces 56 g of CaO

1 g of $CaCO_3$ produces $\frac{56}{100}$ g of CaO

190000 g of $CaCO_3$ produces $\frac{56}{100} \times 190000 = 106400$ g = 106.4 kg

Thus, the mass of CaO that can be produced by the heating 200 kg of lime stone is 106.4 kg.

19. **2067 Q.No. 23**

i. **How much sulphuric acid containing 90% H_2SO_4 by weight is needed for the production of 1000 k hydrochloric acid containing 42% HCl by weight in the following reaction.**
2 NaCl (aq.) + H_2SO_4(aq.) ⟶ Na_2SO_4(aq.) + 2 HCl (aq.)

ii. **If the above reaction is carried out by mixing 11.7 g of pure NaCl and 10 g of pure H_2SO_4, find the limi reactant.** [3

Solution

i. The balanced equation

$2NaCl$	+	H_2SO_4	⟶	Na_2SO_4	+	$2HCl$
2 mole		1 mole		1 mole		2 mole
2 × 58.5		98 g		142 g		2 × 36.5 = 73 g

1000 kg of 42 % HCl can be prepared i.e. $\frac{42}{100} \times 1000 = 420$ kg = 420000 g

From the equation

73 g of HCl is obtained from 98 g of H_2SO_4

420000 g of HCl is obtained from $\frac{98 \times 420000}{73} = 563835.61$ g of H_2SO_4

The purity of H_2SO_4 is 90% by wt.

i.e. 90 g of pure H_2SO_4 is obtained from 100 g of H_2SO_4

563835.61 g of pure H_2SO_4 is obtained from $\frac{100 \times 563835.61}{90}$

$= 626484 \text{ g} = 626.48 \text{ kg}$ of H_2SO_4

So, 626.48 kg of 90% H_2SO_4 is required to prepare 1000 kg of of 42% HCl by wt.

i. The balance equation is

$2NaCl$	+	H_2SO_4	⟶	Na_2SO_4	+	$2HCl$
2 mole		1 mole		1 mole		2 mole
2×58.5		98 g				
117 g						

117 g pure NaCl reacts with 98 g of pure H_2SO_4

11.7 g pure NaCl reacts with $\frac{98}{117} \times 11.7 = 9.8$ g

Wt. of H_2SO_4 given is 10 g but only 9.8 g H_2SO_4 is used i.e. H_2SO_4 is in excess and NaCl is finished first. So, NaCl is limiting reactant.

2066 Q.No. 23 **17 g of ammonia is completely reacted with 45 g of oxygen to produce NO and H_2O.**

i. Which is limiting reagent?

ii. Calculate the number of moles of unreacted reactant left over.

iii. What volume of NO are produced at NTP?

iv. Calculate the mass of water produced. **[2+1+1+1]**

olution

Given mass of ammonia = 17 g

Given mass of oxygen = 45 g

The balance chemical equation is

$4NH_3$	+	$5O_2$	⟶	$4NO$	+	$6H_2O$
4 mole		5 mole		4 mole		6 mole
4×17		5×32		4×30		6×18
4×22.4		5×22.4		4×22.4		6×22.4

4 mole of NH_3 reacts with 5 mole of O_2

(4×17) g of NH_3 reacts with (5×32) g of O_2

68 g of NH_3 reacts with 160 g of O_2

1 g of NH_3 reacts with $\frac{160}{68}$ g of O_2

17 g of NH_3 reacts with $\frac{160}{68} \times 17$ g of $O_2 = 40$ g of O_2

Thus, 17 g of NH_3 requires 40 g of O_2 for complete reaction. The amount of O_2 given is 45 g. So, the reactant NH_3 is finished first in the reaction and limit the reaction. Therefore, NH_3 is limiting reactant.

Mass of unreacted reactant = (45 – 40) = 5 g

Molecular mass of $O_2 = 32$ g

No. of moles of unreacted O_2 left over = $\frac{5}{32} = 0.156$ mol

ii. 68 g of NH_3 produces 4×22.4 liter of NO gas at NTP

1 g of NH_3 produces $\frac{4 \times 22.4}{68}$ liter of NO gas at NTP

17 g of NH_3 produces $\frac{4 \times 22.4}{68} \times 17 = 22.4$ liter of NO gas at NTP

v. 68 g of NH_3 produces 6×18 g of H_2O at NTP

1 g of NH_3 produces $\frac{6 \times 18}{68}$ g of H_2O at NTP

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17 g of NH_3 produces $\frac{6 \times 18}{68} \times 17$ g of H_2O at NTP = 27 g

Hence, the mass of water produced is 27 g.

21. 2065 Q. No. 23 **200 g of 90% pure $CaCO_3$ is completely reacted with excess HCl to produce $CaCl_2$, H_2O CO_2.** [1+1+

a. Which one is limiting reagent?
b. Calculate the mass of $CaCl_2$ formed.
c. How many moles of water are produced?
d. What volumes of CO_2 are produced if the reaction is carried out at 27°C temperature 760 mm Hg pressure?

Solution

a. The amount of $CaCO_3$ is 200 g of 90% = $200 \times \frac{90}{100} = 180$ g

The $CaCO_3$ is reacted with excess of HCl. So, $CaCO_3$ will finish first and limit the reaction $CaCO_3$ is limiting reactant.

b. The balanced equation

$$CaCO_3 + 2HCl \longrightarrow CaCl_2 + CO_2 + H_2O$$

1 mole 2mole 1 mole 1 mole 1mole
100 g (2×36.5) 111 g 44 g 18 g

100 gm $CaCO_3$ gives 111 gm of $CaCl_2$

180 g $CaCO_3$ gives $\frac{111 \times 180}{100} = 199.8$ g $CaCl_2$ will be formed.

c. 100 g of $CaCO_3$ gives 1 mole of water

180 g of $CaCO_3$ gives $\frac{180}{100} = 1.8$ mol

d. 100 g of $CaCO_3$ gives 1 mole of CO_2

180 g of $CaCO_3$ gives $\frac{180}{100} = 1.8$ mol CO_2

Given,

P = 760 mm Hg = 1 atm
T = 27°C = 27 + 273 = 300K
n = 1.8 mole
R = 0.0821 liter atm $K^{-1}Mol^{-1}$
V = ?

We know that,

PV = nRT

or $V = \frac{nRT}{P} = \frac{1.8 \times 0.0821 \times 300}{1} = 44.33$ liter of CO_2 will be formed.

Hence, 44.33 litre of CO_2 gas will be formed.

22. 2063 Q.No. 24 **10 grams of impure zinc reacts with excess of dilute sulphuric acid to yield zinc sulphate hydrogen. (Zn = 65, S = 32, O = 16)**

a. Calculate the number of moles of H_2SO_4 consumed.
b. Calculate the mass of $ZnSO_4$ formed.
c. What volume of hydrogen is evolved at NTP? [2+1.5

Solution

$$Zn + \text{dil. } H_2SO_4 \longrightarrow ZnSO_4 + H_2$$

1 mole 1 mole 1 mole 1 mole
65 g 98 g 161 g

a. 65 g of Zn reacts with 1 mole of H_2SO_4 to form product.

1 g of zinc reacts with $\frac{1}{65}$ mole of H_2SO_4 to form product

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10 g of Zn reacts with $\frac{10}{65}$ = 0.153 mole of H_2SO_4

65 g of zinc react with H_2SO_4 to give 161 g of $ZnSO_4$.

1 g of zinc reacts with H_2SO_4 to give $\frac{161}{65}$

10 g of zinc reacts with H_2SO_4 to give $\frac{161}{65} \times 10 = 24.76$ g $ZnSO_4$

Hence, 24.76 g $ZnSO_4$ is formed.

65 g of zinc reacts with H_2SO_4 to give 1 mole of H_2 gas

1 g of zinc reacts with H_2SO_4 to given $\frac{1}{65} \times 10 = 0.153$ mol H_2 gas

We know that,

1 mole of H_2 gas have volume 22.4 liter at NTP

0.154 mole of H_2 gas have volume $22.4 \times 0.154 = 3.4496$ liter = 3449.6 mL H_2 gas

Hence, 3449.6 mL of H_2 gas will be produced at NTP.

---

3. **2062 Q.No. 23** **5 g of pure $CaCO_3$ if treated with 5 g of HCl to produce $CaCl_2$, H_2O and CO_2:** **[5]**
   a. **Find which one is limiting reactant and why?**
   b. **Calculate mass of $CaCl_2$ formed.**
   c. **How many number of water molecules are produced?**
   d. **Calculate the volume of CO_2 produced at NTP.**

Balanced chemical equation

$$CaCO_3 + 2\,HCl \longrightarrow CaCl_2 + CO_2 + H_2O$$

1 mole	2 mole	1 mole	1 mole	1 mole
100 g	2×36.5	111 g	44 g	18 g

1 mole of $CaCO_3$ requires 2 mole of HCl for complete reaction.

100 g of $CaCO_3$ requires $(2 \times 36.5) = 73$ g of HCl for complete reaction.

5 g of $CaCO_3$ requires = $\frac{73 \times 5}{100} = 3.65$ g of HCl

The amount of HCl added to $CaCO_3$ is 5 g which is more than required. So, the $CaCO_3$ is limiting reactant.

1 mole of $CaCO_3$ produces 1 mole of $CaCl_2$

100 g of $CaCO_3$ produces 111 g mole of $CaCl_2$

5 g of $CaCO_3$ produces $\frac{111 \times 5}{100} = 5.55$ g of $CaCl_2$ will be formed.

1 mole of $CaCO_3$ produces 1 mole of H_2O

100 g of $CaCO_3$ produces 1 mole of H_2O.

5 g of $CaCO_3$ produces $\frac{1 \times 5}{100} = 0.05$ mol of H_2O

We know that,

1 mole H_2O contains 6.022×10^{23} molecules

0.05 mole H_2O contains $(0.05 \times 6.022 \times 10^{23}) = 3.011 \times 10^{22}$ molecules of H_2O will be formed.

1 mole of $CaCO_3$ gives 1 mole of CO_2 gas

100 g of $CaCO_3$ gives 1 mole of CO_2

5 g of $CaCO_3$ gives $\frac{5}{100} = 0.05$ mol of CO_2

We know that,

1 Mole of CO_2 occupies 22.4 liter at NTP

0.05 mole of CO_2 occupies $(22.4 \times 0.05) = 1.12$ liter CO_2 at NTP will be produced.

Hence, 1.12 liter of CO_2 is produced at NTP.

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24. 2056 Q.No. 33 Given, $CaCO_3(s) + 2HCl(aq.) \longrightarrow CaCl_2(aq.) + H_2O(l) + CO_2(g)$
If 10 grams of pure $CaCO_3$ are added in a solution containing 7.665 grams of HCl,
a. Find the limiting reactant.
b. Calculate the number of moles excess reactant left over unreacted.
c. Calculate the volume of CO_2 gas produced at NTP.
d. Calculate the number of grams of NaOH required to absorb whole of the CO_2 gas as Na_2CO_3. (At. mass of Ca = 40, C = 12, O = 16, Cl = 35.5, Na = 23 and H = 1)

Solution

a. $CaCO_3 + 2HCl \longrightarrow CaCl_2 + CO_2 + H_2O$
1 mole 2mole 1 mole 1 mole 1 mole
100 g (2×36.5)
1 mole $CaCO_3$ = 100 g of $CaCO_3$ needs 2 mole of HCl = (2×36.5) = 73 g of HCl for reaction.
10 g of $CaCO_3$ needs = $\frac{73 \times 10}{100}$ = 7.3 g of HCl
The amount of HCl added in the reaction is 7.665 g which is more than needed for $CaCO_3$. Th
$CaCO_3$ is limiting reactant and finished first.

b. Mass of HCl needed = 7.3 g
Mass of HCl present = 7.665 g
The mass of unreacted HCl = (7.665 – 7.3) = 0.365 g
We know that,
No. of moles = $\frac{\text{Given weight}}{\text{Molecular weight}} = \frac{0.365}{36.5}$ = 0.01 mol of HCl is left unreacted.

c. 1 mole of $CaCO_3$ = 100 g of $CaCO_3$ gives 1 mole of CO_2 gas
10 g of $CaCO_3$ gives $\frac{10}{100}$ = 0.1 mole CO_2 gas
We know that,
1 mole of CO_2 gas occupies 22.4 liter volume at STP
0.1 mole of CO_2 gas occupies $0.1 \times 22.4 = 2.24$ liter

d. NaOH reacts with CO_2 gives Na_2CO_3
$2NaOH + CO_2 \longrightarrow Na_2CO_3 + H_2O$
2 mole 1 mole
1 mole of CO_2 reacts with 2 mole of NaOH
0.1 mole of CO_2 reacts with 0.2 mole of NaOH
We know that,
1 mole of NaOH = 40 g
0.2 mole of NaOH = $(0.2 \times 40) = 8$ g
So, 8 g of NaOH is required to absorb whole of the CO_2 gas.

25. 2055 Q.No. 29 Give the equation:
$4NH_3(g) + 5O_2(g) \longrightarrow 4NO(g) + 6H_2O(g)$
a. How many moles of NH_3 must react to produce 5.0 moles of NO?
b. How many moles of O_2 must react to produce 5.0 moles of NO?
c. How many litres of NH_3 and O_2 must react to produce 100 litres of NO?
d. How many litres of O_2 will react with 100 g of NH_3?
e. How many litres of NO are formed by reacting 10 moles of NH_3 with 10 moles of O_2?

Solution

The balance chemical equation is
$4\ NH_3(g) + 5\ O_2(g) \longrightarrow 4\ NO(g) + 6\ H_2O(l)$
4 mole 5 mole 4 mole 6 mole
$(4 \times 22.4$ litre) $(5 \times 22.4$ litre) $(4 \times 22.4$ litre)
4 (14 + 3)
(4×17)
68 g

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4 mole of NO gas is produced from 4 mole of NH_3 gas

5 mole of NO gas is produced from $\frac{4 \times 5}{4} = 5$ mol

4 mole of NO is produced from 5 mole of O_2 gas.

5 mole of NO is produced from $\frac{5 \times 5}{4} = 6.25$ mol

4×22.4 litre of NO is produced from 4×22.4 litre of NH_3

100 litre of NO is produced from $\frac{4 \times 22.4 \times 100}{4 \times 22.4} = 100$ litre of NH_3

4×22.4 litre of NO is produced from 5×22.4 litre of O_2

100 litre of NO is produced from $\frac{5 \times 22.4 \times 100}{4 \times 22.4} = 125$ litre of O_2

$4 \times 17 = 68$ m of NH_3 reacts with 5×22.4 litre of O_2

100 g of NH_3 reacts with $\frac{5 \times 22.4 \times 100}{68} = 164.70$ litre

4 mole of NH_3 reacts with 5 mole of O_2

10 mole of NH_3 reacts with $\frac{5 \times 10}{4} = 12.5$ mole of O_2

Only 10 mole of O_2 is given. So, O_2 is limiting reactant and the product formed should calculate with respect to O_2.

5 mole of O_2 gives 4 mole of NO

10 mole of O_2 gives $\frac{4 \times 10}{5} = 8$ mole NO

1 mole of NO = 22.4 litre

8 mole of NO = $8 \times 22.4 = 179.2$ litre

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2.4. Avogadro's Hypothesis & Its Applications

VERY SHORT ANSWER QUESTIONS [2 MARKS]

1. 2072 Set E Q.No. 2 A trivalent metal oxide contain 68.4 percentage of oxygen. What is the atomic mass of metal?

Solution

Given,

Valency of metal = 3

Let Weight of metal oxide = 100 g

Weight of oxygen = 68.4 g

Weight of metal = (100 – 68.4) = 31.6 g

68.4 parts by weight of oxygen combines with 31.6 parts by weight of metal to form metal ox

1 parts by weight of oxygen combines with $\frac{31.6}{68.4}$ parts by weight of metal to form metal oxid

8 parts by weight of oxygen combines with $\frac{31.6}{68.4} \times 8$ parts by weight of metal to form m

oxide = 3.69

Hence, equivalent weight of metal = 3.69

We know that,

Atomic weight = Equivalent weight × Valency

= 3.69 × 3 = 11

Hence, atomic weight of metal is 11.

2. 2069 (Set A) Q. No. 4 Calculate the wt. of 11.2 liters of CO_2 gas at STP (molecular weight of CO_2 = 44).

1 mole of CO_2 = 44 g

1 mole of CO_2 gas at NTP = 22.4 liter

22.4 liter of CO_2 = 44 g

11.2 liter of CO_2 = 22 g

Hence, the weight of 11.2 litre of CO_2 is 22 g.

3. 2067 Q.No. 4 In what way has Avogadro's hypothesis given support to Dalton's atomic theory?

Avogadro's hypothesis removed the difference between atom and molecules and emphas on indestructibility of atom during the chemical change in support of Dalton's atomic theor

4. 2066 Q.No. 2 What volume of CO_2 will be delivered at NTP to extinguish fire from a Cylinder of 10 l Capacity containing 5 kg of CO_2 gas?

Solution

Given,

Mass of CO_2 = 5 kg = 5000 g

We know that,

44 g of CO_2 = 22.4 liter at NTP

5000 g $CO_2 = \frac{22.4}{44} \times 5000 = 2545.45$ liter

Given, capacity of cylinder = 10 liter

So, the volume of gas delivered = (2545.45 – 10) = 2535.45 liter

5. 2065 Q.No. 9 2054 Q.No. 10 State Avogadro's Hypothesis.

Statement: "Equal volume of all gases and vapours under similar conditions of temperature pressure, contains the same number of molecules."

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Example:

H_2 + Cl_2 ⟶ 2HCl

1 Volume 1Volume 2 Volume

Applying Avogadro's hypothesis

H_2 +	Cl_2 ⟶	2HCl
n molecule	n molecule	2n molecule
1 molecule	1 molecule	2 molecule
$\frac{1}{2}$ molecule	$\frac{1}{2}$ molecule	1 molecule

This means that 1 molecule of HCl gas is formed by combination of $\frac{1}{2}$ molecule of H_2 and $\frac{1}{2}$ molecules of Cl_2. Since molecule may have two atoms. So, combination between fractions of molecule is possible.

2064 Q.No. 11 An oxide of nitrogen contains its half-volume of nitrogen and its vapour density is 15. Determine its molecular formula. [2]

Given,

1 volume of an oxide of nitrogen contains $\frac{1}{2}$ volume of nitrogen.

According to Avogadro's hypothesis, 1 volume of gas contains n molecules of gas.

Hence,

n molecules of an oxide of nitrogen contains $\frac{n}{2}$ molecules of nitrogen.

1 molecules of an oxide of nitrogen contains $\frac{1}{2}$ molecules of nitrogen.

1 molecules of an oxide of nitrogen contains 1 atom of nitrogen. [Nitrogen is diatomic gas]

Therefore, the formula of nitrogen oxide may be N_1O_x [Where, x = No. of oxygen atom]

Vapour density (V.D.) = 15

Molecular mass (M) = ?

Molecular formula =?

We know that,

$M = 2 \times V.D. = 2 \times 15 = 30$

According to questions

$N_1O_x = 30$

Or, $14 + 16x = 30$

Or, $16x = 30 - 14$

Or, $16x = 16$

Or, $x = 1$

Hence, the molecular formula of oxide of nitrogen is NO.

SHORT ANSWER QUESTIONS

7. 2076 Set B Q.No. 29a A trivalent metal oxide contains 31.6% of oxygen. What is the atomic mass of the metal? [2]

Given,

Valency of metal = 3

Let weight of metal oxide = 100 g

Weight of oxygen = 31.6 g

Weight of metal = (100 – 31.6) = 68.4 g

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We know that

31.6 parts by weight of oxygen combines with 68.4 parts by weight of metal to form metal oxide

1 parts by weight of oxygen combines with $\frac{68.4}{31.6}$ parts by weight of metal to form metal oxide

8 parts by weight of oxygen combines with $\frac{68.4}{31.6} \times 8$ parts by weight of metal to form metal oxide

$= 17.31$

Hence, the equivalent weight of metal = 17.31

We know that

Atomic weight of metal = Equivalent weight of metal × Valency

$= 17.31 \times 3$

$= 51.93$ amu

Hence, atomic weight of metal = 51.93 amu

8. **2076 Set C Q.No. 29a A divalent metal oxide contains 40% of oxygen. What is the atomic weight of metal?**

Ans Given, Valency of metal = 2

Let wight of metal oxide = 100 g

Weight of oxygen = 40 g

Weight of metal = 100 – 40 = 60 g

We know that

40 parts by weight of oxygen combines with 60 parts by weight of metal to form metal oxide

1 parts by weight of oxygen combines with $\frac{60}{40}$ parts by weight of metal to form metal oxide

8 parts by weight of oxygen combines with $\frac{60}{40} \times 8$ parts by weight of metal to form metal oxide

$= 12$

Hence, the equivalent weight of metal = 12

We know that

Atomic weight of metal = Equivalent weight of metal × Valency

$= 12 \times 2$

$= 24$ amu

Hence, atomic weight of metal = 24 amu

9. **2075 Set A Q.No. 25 How would you apply Avogadro's hypothesis to show the molecular weight of gas is two times of its vapour density? An oxide of nitrogen contains same of its own volume of nitrogen and has vapour density equal to 22. Determine molecular formula of the nitrogen oxide.**

Ans Statement: "Equal volume of all gases and vapours under similar conditions of temperature and pressure, contains the same number of molecules."

Molecular weight of a substance is the weight of one molecule of the substance as compared to the weight of an atom of hydrogen.

$$\text{Molecular Weight} = \frac{\text{Weight of 1 molecule of the gas}}{\text{Weight of 1 atom of hydrogen}}$$

Vapour density of a substance is defined as the number which shows how many times a certain volume of its vapour is heavier than the same volume of hydrogen gas at same temperature and pressure.

$$\text{V.D.} = \frac{\text{Weight of certain volume of gas}}{\text{Weight of same volume of hydrogen gas}} = \frac{\text{Weight of V cc of gas}}{\text{Weight of V cc of hydrogen}}$$

Let, V cc be the volume of gas contain 'n' molecules

$$\text{V.D.} = \frac{\text{Weight of n molecule of the gas}}{\text{Weight of n molecule of hydrogen}}$$

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$$= \frac{\text{Weight of 1 molecule of the gas}}{\text{Weight of 1 molecule of hydrogen}} \text{ [for 1 molecule of gas]}$$

$$= \frac{\text{Weight of 1 molecule of the gas}}{\text{Weight of 2 atom of hydrogen}} \text{ [hydrogen is diatomic]}$$

$$= \frac{\text{Weight of 1 molecule of the gas}}{2 \times \text{Weight of 1 atom of hydrogen}}$$

Therefore, Molecular Weight = 2 × V.D.

Numerical:

Vapour density (V.D.) = 22

Molecular mass (M) = ?

Molecular formula = ?

We know that,

M = 2 × V.D.

M = 2 × 22 = 44

Nitrogen contains same of its own volume of nitrogen. The formula of oxide of nitrogen is

$N_2O_x = 44$

or, 2 × 14 + 16x = 44

or, 28 + 16x = 44

or, 16x = 44 – 28

or, 16x = 16

or, x = 1

Hence, the molecular formula of oxide of nitrogen is N_2O.

---

10. **2074 Supp Q.No. 27 Apply Avogardo's hypothesis to derive the relationship between vapour density and molecular mass of a gas. An oxide on nitrogen contains same of its own volume of nitrogen whose vapour density is 54. Determine the molecular formula of nitrogen oxide. [3+2]**

Derivation of relationship between vapour density (V.D.) and molecular mass (M): Please refer to 2075 Set A Q.No. 25

Numerical:

Vapour density (V.D.) = 54

Molecular mass (M) = ?

Molecular formula = ?

We know that,

M = 2 × V.D.

M = 2 × 54 = 108

Nitrogen contains same of its own volume of nitrogen

The formula of oxide of nitrogen is

$N_2Ox = 108$

or, 2 × 14 + 16x = 108

or, 28 + 16x = 108

or, 16x = 108 – 28

or, 16x = 80

or, $x = \frac{80}{16}$

or, x = 5

So, the molecular formula of oxide of nitrogen is N_2O_5

---

11. **2074 Set A Q.No. 26 Deduce the relationship between molecular mass and vapour density of a gas using Avogadro's hypothesis. An oxide of nitrogen contains half of its own volume of nitrogen and has vapour density equal to 15. Determine molecular formula of the nitrogen oxide. [3+2]**

Relationship between molecular mass (M) and vapour density (V.D.):

Please refer to 2075 Set A Q.No. 25

Numerical:

Given,

1 volume of an oxide of nitrogen contains $\frac{1}{2}$ volume of nitrogen.

According to Avogadro's hypothesis, 1 volume of gas contains n molecules of gas.
Hence,

n molecules of an oxide of nitrogen contains $\frac{n}{2}$ molecules of nitrogen.

1 molecules of an oxide of nitrogen contains $\frac{1}{2}$ molecules of nitrogen.

1 molecules of an oxide of nitrogen contains 1 atom of nitrogen. [Nitrogen is diatomic gas]
Therefore, the formula of nitrogen oxide may be N_1O_x [Where, x = No. of oxygen atom]
Vapour density (V.D.) = 15
Molecular mass (M) = ?
Molecular formula =?
We know that,
$M = 2 \times V.D. = 2 \times 15 = 30$
According to questions
$N_1O_x = 30$
Or, $14 + 16x = 30$
Or, $16x = 30 - 14$
Or, $16x = 16$
Or, $x = 1$
Hence, the molecular formula of oxide of nitrogen is NO.

---

12. 2074 Set B Q.No. 25 **How would you apply Avogadro's hypothesis to deduce the relationship be molecular weight and vapour density of gas? An oxide of nitrogen contains half of its own volu nitrogen and vapour density is 23. Determine its molecular formula.** [1+

Relationship between molecular mass (M) and vapour density (V.D.):

Please refer to 2075 Set A Q.No. 25

Numerical:

Given,

1 volume of an oxide of nitrogen contains $\frac{1}{2}$ volume of nitrogen.

According to Avogadro's hypothesis, 1 volume of gas contains n molecules of gas.
Hence,

n molecules of an oxide of nitrogen contains $\frac{n}{2}$ molecules of nitrogen.

1 molecules of an oxide of nitrogen contains $\frac{1}{2}$ molecules of nitrogen.

1 molecules of an oxide of nitrogen contains 1 atom of nitrogen. [Nitrogen is diatomic gas]
Therefore, the formula of nitrogen oxide may be N_1O_x [Where, x = No. of oxygen atom]
Vapour density (V.D.) = 23
Molecular mass (M) = ?
Molecular formula =?
We know that,
$M = 2 \times V.D. = 2 \times 23 = 46$
According to questions

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$N_1O_x = 46$

r, $14 + 16x = 46$

r, $16x = 46 - 14$

r, $16x = 32$

r, $x = 2$

Hence, the molecular formula of oxide of nitrogen is NO_2.

. 2069 (Set B) Q. No. 23 **Define Avogadro's hypothesis. How is this hypothesis applied to show that molecular mass of volatile substance is twice of its vapour density? A oxide of nitrogen contains same of its own volume of nitrogen and its vapour density is 54. Determine its molecular formula.** **[1+2+2]**

First Part: Please refer to 2075 Set A Q.No. 25

Numerical: Please refer to 2074 Supp Q.No. 27

. 2057 Q.No. 23 2061 Q.No. 23 **State Avogadro's hydrothesis. Show that molecular weight = 2 × vapour density.[5]**

Please refer to 2075 Set A Q.No. 25

. 2055 Q.No. 24 **1 litre of hydrogen at STP weights 0.09 g. If 2 litres of a gas at STP weights 2.880 g, calculate the vapour density and the molecular weight of the gas.** **[5]**

olution

1 litre of H_2 gas at STP = 0.09 g

2 litre of a gas at STP = 2.88 g

1 litre of a gas at STP = 1.44 g

Ve know that ,

$$\text{Vapour density} = \frac{\text{Weight of 1 litre of a gas at STP}}{\text{Weight of 1 litre of } H_2 \text{ gas at STP}} = \frac{1.44}{0.09} = 16$$

We know that, molecular mass = 2 × V.D. = (2 × 16) = 32

. 2054 Q.No. 31(a) **State and explain Avogadro's hypothesis. How this theory can be used to determine the molecular weight of a gas?** **[5]**

Please refer to 2075 Set A Q.No. 25

RITE SHORT NOTES ON

. 2069 (Set A) Q. No. 33b **Avogadro's hypothesis and its relation with molecular mass of volatile substance.**

Please refer to 2075 Set A Q.No. 25

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2.5. Equivalent Masse

VERY SHORT ANSWER QUESTIONS [2 MARKS]

1. 2075 GIE Q.No. 2 **What is meant by equivalent weight of an acid? Calculate the equivalent weight of H_2S the reaction given below.**
$NaOH + H_2SO_4 \longrightarrow NaHSO_4 + H_2O$

Solution

Equivalent weight of an acid: The number of parts by mass of it which contains 1.008 part mass of replaceable hydrogen atom is called equivalent weight of an acid.

$$\text{Equivalent mass of acid} = \frac{\text{Molecular mass of acid}}{\text{Number of replaceable hydrogen atom}}$$

In the given reaction one hydrogen atom is replaced by Na, the equivalent weight of H_2S We same as molecular mass i.e. 98.

2. 2072 Set C Q.No.2 **Calculate the equivalent weight of underlined elements:** [0.5
i. $\underline{Fe_2}O_3$ ii. $\underline{Mg}Cl_2$ iii. $\underline{C}H_4$ iv. $\underline{N}H_3$
(Given that Atomic weight of Fe = 56)

Solution

i. $\underline{Fe_2}O_3$
Atomic weight of Fe = 56
Valency of Fe = 3
Equivalent weight of Fe = ?
We know that,

$$\text{Equivalent weight} = \frac{\text{Atomic weight}}{\text{Valency}} = \frac{56}{3} = 18.66$$

Hence, equivalent weight of Fe = 18.66

ii. $\underline{Mg}Cl_2$
Atomic weight of Mg = 24
Valency of Mg = 2
Equivalent weight of Mg = ?
We know that,

$$\text{Equivalent weight} = \frac{\text{Atomic weight}}{\text{Valency}} = \frac{24}{2} = 12$$

Hence, equivalent weight of Mg = 12

iii. $\underline{C}H_4$
Atomic weight of C = 12
Valency of C = 4
Equivalent weight of C = ?
We know that,

$$\text{Equivalent weight} = \frac{\text{Atomic weight}}{\text{Valency}} = \frac{12}{4} = 3$$

Hence, equivalent weight of carbon = 3

iv. $\underline{N}H_3$
Atomic weight of N = 14
Valency of N = 3
Equivalent weight of N = ?
We know that,

$$\text{Equivalent weight} = \frac{\text{Atomic weight}}{\text{Valency}} = \frac{14}{3} = 4.66$$

Hence, equivalent weight of nitrogen = 4.66

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2071 (Set C) Q.No. 2 **A divalent metal oxide contains 60% of metal. What is atomic weight of metal?** **[2]**

olution

% of Metal = 60 % i.e. 60 g in weight
Weight of metal oxide = 100 g
Weight of oxygen = (100 – 60) = 40 g
Valency of metal = 2
40 parts by weight of O_2 combines with 60 parts by wt. of metal to form metal oxide.
1 parts by weight of O_2 combines with $\frac{60}{40}$
8 parts by weight of O_2 combines with $\frac{60}{40} \times 8 = 12$
So, the equivalent weight of metal = 12

Ve know that,
Atomic weight = Equivalent weight × Valency = 12 × 2 = 24
Hence, atomic weight of metal is 24.

. **2067 Q.No. 3** **4 g of a divalent metal reacts with chlorine to produce 11.1 g of its metal chloride. Calculate the atomic mass of metal.** **[2]**

Solution

Valency = 2
Weight of metal = 4 g
Weight of metal chloride = 11.1 g
Weight of chlorine = (11.1 – 4) = 7.1 g
7.1 g chlorine combines with 4 g of metal to form metal chloride.
35.5 g chlorine combines with $\frac{4 \times 35.5}{7.1} = 20$
So, the equivalent weight of metal = 20
Atomic weight of metal = Equivalent weight × Valency = 20 × 2 = 40 amu.
Hence, the atomic mass of metal is 40 amu.

5. **2065 Q. No. 3** **Define equivalent weight of an element. A divalent metal has atomic weight 24. What is its equivalent weight?** **[2]**

The equivalent weight of an element is that parts by weight of it which combines with or displace from a compound 1.008 part by weight of hydrogen or 8 part by weight of oxygen or 35.5 part by weight of chlorine.

Numerical:
Given,
For divalent metal, valency of metal= 2
Equivalent weight of metal = $\frac{\text{Atomic weight}}{\text{Valency}} = \frac{24}{2} = 12$
Hence, equivalent weight of divalent metal is 12.

6. **2059 Q.No. 5** **Why is hydrogen displacement method not applicable to determine the equivalent mass of copper?** **[2]**

In electrochemical series, copper lies below hydrogen i.e. copper is less electropositive than hydrogen. So, copper cannot displace hydrogen from non-oxidizing agent like dil. HCl or dil. H_2SO_4. Therefore, equivalent weight of copper cannot be determined by hydrogen displacement method.

7. **2057 Q.No. 4** **Equivalent weight of an element is 32.5. What does it mean?** **[2]**

Equivalent wt. of an element is 32.5 means that 32.5 parts by weight of it combines or displaces completely for 1 gram equivalent of any reacting species.

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NUMERICAL PROBLEMS

8. 2072 Supp Q. No. 3 24 g of divalent metal A requires 16 g of oxygen to form its oxide. What is the weight of the metal A?

Solution

Given, weight of metal = 24 g
Valency of metal = 2
Weight of oxygen = 16 g
16 parts by weight of oxygen combines with 24 parts by weight of metal (A) to form metal
1 parts by weight of oxygen combines with $\frac{24}{16}$ parts by weight of metal (A) to form metal
8 parts by weight of oxygen combines with $\frac{24}{16} \times 8$ parts by weight of metal (A) to form
oxide = 12
Hence, equivalent weight of metal (A) = 12
We know that,
Atomic weight = Equivalent weight × Valency = 12 × 2 = 24
Hence, atomic weight of metal (A) is 24.

9. 2066 Q.No. 3 Calculate the equivalent wt of following underlined elements:

i. $\underline{C}Cl_4$ ii. $\underline{Fe_2}O_3$ (Atomic weight of Carbon = 12, Atomic weight of Iron = 56)

Solution

i. $\underline{C}Cl_4$
The valency of C = 4 Atomic mass of C = 12

$$\text{Equivalent weight} = \frac{\text{Atomic mass}}{\text{Valency}} = \frac{12}{4} = 3$$

ii. $\underline{Fe_2}O_3$
Valency of Fe = 3 Atomic mass of Fe = 56

$$\text{Equivalent weight} = \frac{\text{Atomic mass}}{\text{Valency}} = \frac{56}{3} = 18.66$$

10. 2069 (Set A) Q. No. 9 Calculate the equivalent weight of underlined element.

i. $\underline{C}Cl_4$ ii. $\underline{Mg}O$ iii. $\underline{Fe_2}O_3$ iv. $\underline{Al}Cl_3$

Solution

i. $\underline{C}Cl_4$
The valency of C = 4 Atomic mass of C = 12

$$\text{Equivalent weight} = \frac{\text{Atomic mass}}{\text{Valency}} = \frac{12}{4} = 3$$

ii. $\underline{Mg}O$
Valency of Mg = 2
Atomic weight of Mg =24

$$\text{Equivalent weight} = \frac{\text{Atomic mass}}{\text{Valency}} = \frac{24}{2} = 12$$

iii. $\underline{Fe_2}O_3$
Valency of Fe = 3
Atomic mass of Fe = 56

$$\text{Equivalent weight} = \frac{\text{Atomic mass}}{\text{Valency}} = \frac{56}{3} = 18.66$$

iv. $\underline{Al}Cl_3$
Valency of Al = 3
Atomic weight of Al = 27

$$\text{Equivalent weight} = \frac{\text{Atomic mass}}{\text{Valency}} = \frac{27}{3} = 9$$

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Unit 3

State of Matter

3.1 Gaseous State

VERY SHORT ANSWER QUESTIONS [2 MARKS]

1. 2076 Set B Q.No. 4i 2076 Set C Q.No. 4b **Give reasons: Gases do not settle at the bottom of the vessel** [1]

We know that there is no effect of gravity on gas molecules and the force of attraction and repulsion between gas molecule is negligible. Due to this reason, gases do not settle down on the bottom of container.

2. 2072 Set C Q.No.3ii **Explain, why Gases do not settle on the bottom of container?** [1]

Please refer to 2076 Set B Q.No. 4i

3. 2071 Supp Q. No. 4 **On the basis of Boyle's law, explain why mountaineers carry oxygen cylinders with them.** [2]

On the basis of Boyle's law, the volume of fixed mass of gas is inversely proportional to the pressure at constant temperature.

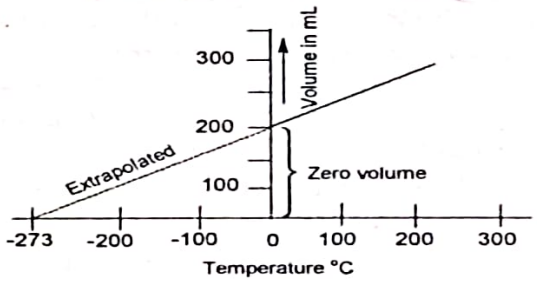
$$V \propto \frac{1}{P} \text{ (at constant T)}$$

Higher the pressure lower the volume of gas and vice-versa. At the high altitude, atmospheric pressure is decreased due to this the volume of gas is increased. At high altitude the volume of gas is increased. At high altitude the percentage of oxygen which require for breathing human beings is minimum. Hence, the mountaineers carry oxygen cylinder for breathing at high altitude.

4. 2071 Set C Q.No. 4 **Draw a volume Vs temperature (°C) graph and find out the temperature correspondingly to zero volume.** [2]

The relation between volume (V) and temperature (t°C) of gas at constant pressure is given as

The volume of gas becomes zero at -273°C and this temperature is called absolute zero temperature.



5. 2060 Q.No. 1 **Find the number of moles of molecules present in 50 mL of an ideal gas exerting a pressure of 770 mm at 25°C (R = 0.082 L atm mole $^{-1}$K^{-1}).** [2]

Given,

V = 50 mL = 0.05 liter

P = 770 mm Hg = 1.01 atm

T = 25°C = 25 + 273 = 298 K

$R = 0.0821$ liter atm K^{-1} mol^{-1}
No. of moles (n) = ?
We know that, $PV = nRT$

$$n = \frac{PV}{RT} = \frac{1.01 \times 0.05}{0.0821 \times 298} = 2.06 \times 10^{-3} \text{ mol}$$

Hence, no. of mole of molecule present in 50 mL an ideal gas is 2.06×10^{-3} mol.

6. 2059 Q.No. 3 **State Dalton's law of partial pressure.**

Statement: "The total pressure exerted by the mixture of two or more non-reacting gas is e to the sum of the partial pressure at a constant temperature."
If $p_1, p_2, p_3, \ldots$ are the partial pressure of different non-reacting gases and P_T is the total pres of the mixture at the same temperature then,
$P_T = p_1 + p_2 + p_3 \ldots$

7. 2059 Q.No. 8 **What is universal gas constant?**

From ideal gas equation
$PV = nRT$

$$R = \frac{PV}{nT} = \frac{\left(\frac{\text{Force}}{\text{Area}}\right) \times \text{Volume}}{\text{Mole} \times \text{degree (K)}} = \frac{\text{Force}}{l^2} \times \frac{l^3}{\text{Moles} \times \text{degree (K)}}$$

$$= \frac{\text{Force} \times l}{\text{Moles} \times \text{degree}} = \frac{\text{Work done}}{\text{Moles} \times \text{degree (K)}}$$

Thus, the universal gas constant is the work done when the temperature of 1 mole of ga increased by 1° in Kelvin scale.

8. 2058 Q.No. 7 **What is an ideal gas? Under what conditions will a gas behave nearly like an ideal gas?**

Ideal gas: The gas which obeys the ideal gas equation $PV = n RT$ and the gas laws i.e. Boyl Charle's law, Graham's law of diffusion and Dalton's law of partial pressure at all temperat and pressure is known as ideal gas. It is free from intermolecular force. All the gas shows id behaviour at low pressure and high temperature. Hence, the concept of ideal gas is a theoretical or hypothetical.
At high temperature and low pressure, any real gas will behaves nearly like an ideal gas.

9. 2054 Q.No. 9 **Sketch the diagram for the variation of volume of a given mass of ideal gas with temperatu at constant pressure. Indicate the absolute zero in the diagram.**

Please refer to 2071 Set C Q.No. 4

10. 2054 Q.No. 15 **What do you mean by ideal gas and real gas?**

Ideal gas: The gas which obeys the ideal gas equation $PV = n RT$ and the gas laws i.e. Boyl Charle's law, Graham's law of diffusion and Dalton's law of partial pressure at all temperati and pressure is known as ideal gas. It is free from intermolecular force. All the gas shows id behaviour at low pressure and high temperature. Hence, the concept of ideal gas is a theoretical or hypothetical.
Real gas: The gas which does not obey the ideal gas equation and all gas laws at all temperati and pressure is called real gas.

11. 2052 Q.No. 7 Group A **Draw volume (V) and temperature (t°C) relationship of gases at constant press Indicate the temperature at which the volume occupied by the gas pressure. Indicate the temperatur which the volume occupied by the gas becomes zero. Name that temperature.**

Please refer to 2071 Set C Q.No. 4

12. 2051 Q.No. 1 Group A **At what condition the value of P × V is always constant?**

At constant temperature the product of P × V of gas is always constant. i.e. PV = Constant const. T

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ONG ANSWER QUESTIONS: [10 MARKS]

. **2071 Supp Q. No. 30** **State Boyle's and Charle's Law. Derive PV = nRT**
When 2g of a gas (A) is introduced into an evacuated flask kept at 25°C, the pressure is found to be one atmosphere. If 3 g of another gas (B) is added to the same flask, the total pressure becomes 1.5 atmospheres at the same temperature. Assuming ideal behaviour of gases. Calculate the ratio of molecular masses. **[2+3+5]**

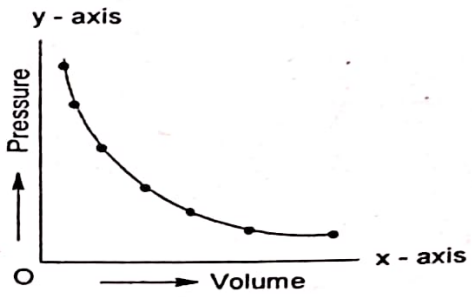
. **Boyle's Law:** In 1662, **Robert Boyle** studied the effect of pressure on fixed mass of gas at constant temperature. It states that, "The volume of a given mass of a gas is inversely proportional to its pressure at constant temperature"

$V \alpha \frac{1}{P}$ (at constant temperature) Where, V is the volume and P is the pressure of the given mass of gas.

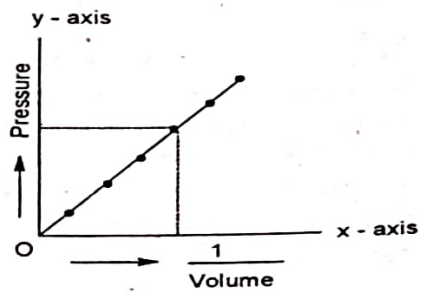
r, PV = K,
Where,
K = proportionality const.
= depends upon mass of gas and temperature
If P_1 and V_1 be the pressure and volume of gas in one condition and P_2 and V_2 be the pressure and volume of gas in another condition, then Boyle's law becomes.
$P_1V_1 = K$ and $P_2V_2 = K$ Hence, $P_1V_1 = P_2V_2$
This equation is the mathematical expression of Boyle's law.

Graphical Representation of Boyle's law

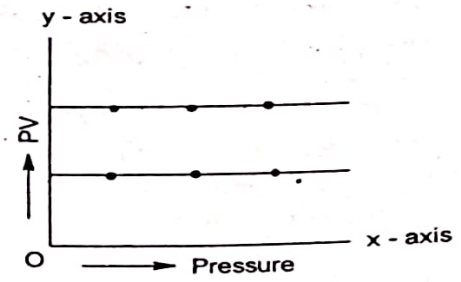
. **Volume Vs pressure graph:** When the volume of a certain mass of gas is plotted against pressure, a hyperbolic curve is obtained. The curve is called P-V isotherm.



. **Pressure Vs $\frac{1}{V}$ graph:** When pressure of gas is plotted against reciprocal of volume, a straight line is obtained which is passed through the origin.



. **Pressure x Volume Vs pressure graph:** When the pressure-volume product (PV) for a certain mass of gas is plotted against pressure, a straight line is obtained which is parallel to pressure axis.



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Charle's law: In 1787, Jacques Charle's studied the effect of temperature on the volume of at a constant pressure and formulated a mathematical relationship between volume temperature of gas. It states that, "At a constant pressure, the volume of a given mass of a increases or decreases by $\frac{1}{273}$ of its volume at 0°C for each degree Celsius rise or fal temperature"

Let V_o be the volume of given mass of gas at 0°C, then according to Charle's law

Volume of gas at 1°C = $(V_o + V_o \times \frac{1}{273})$ cc. = $V_o (1 + \frac{1}{273})$ cc.

Volume of gas at 2°C = $V_o (1 + \frac{2}{273})$ cc.

Volume of gas at t°C = $V_o (1 + \frac{t}{273})$ cc.

If V_1 be the volume of gas at t_1°C and V_2 be the volume of gas at t_2°c then

$V_1 = V_o (1 + \frac{t_1}{272})$ ... (i)

$V_2 = V_o (1 + \frac{t_2}{272})$ ... (ii)

From equation (i) and (ii)

$\frac{V_1}{V_2} = \frac{273 + t_1}{273 + t_2}$ or $\frac{V_1}{V_2} = \frac{T_1}{T_2}$, Where, T = t + 273 and T is the absolute scale or Kelvin temperature

From above expression

$\frac{V_1}{T_1} = \frac{V_2}{T_2}$

or, $\frac{V_1}{T_1} = \frac{V_2}{T_2} = \frac{V_3}{T_3}$ = constant

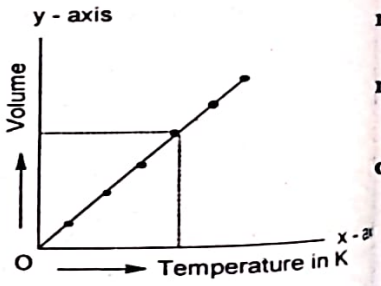
or, $\frac{V}{T}$ = a constant

So, $V \alpha T$

Hence, Charle's law can also be stated as: "The volume of a given mass of a gas is dire proportional to the absolute scale of temperature ($V \alpha T$) at constant pressure."

Graphical representation of Charle's law:

If volume of gases is plotted at different temperature at a constant pressure, a straight line is obtained which is passed through the origin.



According to Charle's law, volume of fixed mass of gas is directly proportional to the absolute temperature at constant pressure.

$V \alpha T$

According to the kinetic theory of gas, the average kinetic energy of gas is directly proportional to the absolute temperature

K.E. α T

When temperature of gas is increased then its kinetic energy of molecule is also increased to this bombardment of gas molecules on the wall of container is increased. This will caus increase in volume of gas.

K.E. α V

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Derivation of PV = nRT

The mathematical equation which is obeyed by the gas at ideal condition is known as Ideal gas equation.

Derivation of Ideal gas equation

Boyle's law

$V \alpha \frac{1}{P}$ (at constant temperature) ... (i)

Charle's law

$V \alpha T$ (at constant pressure) ... (ii)

Avogadro's law

"Equal volume of all gases contains equal number of molecules/moles under the condition of same temperature and pressure."

$V \alpha n$ (at constant temperature and pressure) ... (iii)

Combining the equation (i),(ii) and (iii) We get

$V \alpha \frac{nT}{P}$

r, PV = n RT Where, R = Universal gas constant
= Molar gas constant (if 1 g mole of gas is taken)
= It depends upon the number of moles of gas

lumerical:

For gas 'A'

Given,

Weight of gas (m) = 2 g

Temperature (T) = 25°C = (25 + 273) K = 298 K

Pressure (P) = 1 atm

Volume of two flasks is same

R = 0.0821 L atm K^{-1} mol^{-1}

Molecular mass (M) = ?

We know, that

PV = nRT

r, $PV = \frac{m}{M} RT$

r, $M = \frac{mRT}{PV}$

r, $M = \frac{2 \times 0.0821 \times 298}{1 \times 1} = 48.93$

Hence, the molecular mass of gas (M_A) = 48.93

or gas 'B'

Weight of gas (m) = 3 g

Temperature (T) = 25°C (25 + 273)K = 298 K

Pressure (P) = 0.5 atm

R = 0.0821 L atm K^{-1} mol^{-1}

Molecular mass (M) = ?

Volume of two flasks is same

We know that,

PV = nRT

r, $PV = \frac{m}{m} RT$

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or, $M = \frac{mRT}{PV}$

$M = \frac{3 \times 0.0821 \times 298}{0.5 \times 1} = 146.79$

Hence, the molecular mass of gas B = (M_B) = 146.79

Ratio of molecular mass of A and B gas = $M_A : M_B = 48.93 : 146.79 = 1:3$

Hence, the ratio of molecular mass of gas A and B is 1 : 3.

---

14. 2071 Set C Q.No. 30 Write down the postulates of Kinetic molecular theory of gases. Why do gases show deviations from ideal behaviour at low temperature and high pressure? A saturated hydrocarbon has molecular formula C_nH_{2n+2} diffuses through a porous membrane twice as fast as sulphur dioxide. Calculate the volume occupied by the hydrocarbon at 27°C and 2 atmospheric pressure. [4+

Ans Postulates of kinetic molecular theory:

In order to explain the kinetic and molecular behaviour of the gaseous molecules, a theoretical model was proposed, which is known as Kinetic molecular theory of gases or Kinetic theory of gases. It was put forward by Bernoulli in 1738 and extended by Clausis (1857), Maxwell (1 and Boltzmann.

The main postulates of kinetic theory are given below.

a. All gases are made up of a very large number of small particles which is called molecules.
b. Volume occupied by the individual molecule is negligible in compared to the total volume gas.
c. The molecules of a gas are in a continuous random motion. During motion, they collide each other or with the wall of the container.
d. All molecular collisions are perfectly elastic i.e. there is no loss of energy during collisions.
e. Gases exert pressure when the molecules are bombarded against the wall of the vessel.
f. The average kinetic energy of the gaseous molecule is directly proportional to the absolute temperature (K.E. α T)
g. There is no effect of gravity on the gaseous molecules.

At low temperature and high pressure, gas molecules are come close to each other and the attraction force between gases molecule. So, gases show deviation from ideal behavior.

Numerical:

Given,

For sulphur dioxide SO_2

$r_1 = r$

$M_1 = (32 + 2 \times 16) = 64$

For saturated hydrocarbon

$r_2 = 2r$

$M_2 = ?$

Volume occupied (V) = ?

Temperature (T) = 27°C = (27 + 273) = 300 K

Pressure (P) = 2 atm

Number of mole (n) = ?

From Graham's law of diffusion

$\frac{r_1}{r_2} = \sqrt{\frac{M_2}{M_1}}$

or, $\frac{r}{2r} = \sqrt{\frac{M_2}{64}}$

or, $\frac{r^2}{4r^2} = \frac{M_2}{64}$

or, $64r^2 = 4r^2M_2$

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$$\text{or, } M_2 = \frac{64r^2}{4r^2} = 16$$

Molecular mass of Saturated hydrocarbon having molecular formula (C_nH_{2n+2}) $M_2 = 16$

Hence,

$C_nH_{2n+2} = 16$

or, $(12n + 2n + 2) = 16$

or, $14n = (16 - 2)$

or, $14n = 14$

$$\text{or, } n = \frac{14}{14} = 1$$

Therefore, the molecular formula of saturated hydrocarbon = CH_4

Molar mass of the hydrocarbon is 16 which is mass of 1 mole of the hydrocarbon.

From ideal gas equation,

$PV = nRT$

$$\text{or, } V = \frac{nRT}{P} = \frac{1 \times 0.0821 \times 300}{2} = 12.31 \text{ litre}$$

Hence, the volume occupied by the saturated hydrocarbon CH_4 is 12.31 litre.

---

5. 2071 (Set D) Q.No. 32 **What are the postulates of Kinetic molecular theory of gas? Distinguish between an ideal gas and a real gas. An evacuated glass vessel weighs 50 g when empty, 148 g when filled with a liquid of density 0.98 g / cc and 50.5 g when filled with an ideal gas at 760 mm Hg at 27°C. Calculate the volume of the ideal gas STP.** **[4+2+4]**

Postulate of kinetic theory of gas: Please refer to 2071 (Set C) Q.No. 30

Distinguish between an ideal gas and a real gas

Ideal Gas	Real Gas
1. Ideal gas cannot be liquefied since it has no intermolecular attraction.	1. Real gas can be liquefied since it has intermolecular attraction which helps to coalesce the gas molecules.
2. Coefficient of thermal expansion (α) depends on temperature (T) and does not depends on the nature of the gas.	2. Coefficient of thermal expansion (α) is found to vary from gas to gas i.e. α depends on the nature of gas.
3. Coefficient of compressibility (β) depends on the pressure of gas and will be same for all gases.	3. Coefficient of compressibility (β) is found to depend on the nature of the gas.
4. If P is plotted against V, a rectangular hyperbola curve is obtained at constant T.	4. If P is plotted against V, a rectangular hyperbola is obtained at high temperature.
5. It has no definite volume and mass.	5. It has definite volume and mass.

Numerical:

Weight of liquid = (148 – 50) g = 98 g

Density of liquid (d) = 0.98 g / cc

Weight of the ideal gas = (50.5 – 50) = 0.5 g

Pressure (P_1) = 760 mm Hg = 1 atm

Temperature (T_1) = (27 + 273) = 300K

For liquid,

$$\text{Density (d)} = \frac{\text{Mass}}{\text{Volume}}$$

$$\text{r, } 0.98 = \frac{98}{\text{volume}}$$

r, Volume = 100 cc

Now, volume of ideal gas is the same as the volume occupied by liquid.

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Hence, the volume of ideal gas $(V_1) = \frac{100}{1000} = 0.1$ litre

At STP
Volume $(V_2) = ?$
Pressure $(P_2) = 1$ atm.
Temperature $(T_2) = 273$ K
From Combined gas equation

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

or, $V_2 = \frac{P_1V_1T_2}{P_2T_1}$

or, $V_2 = \frac{1 \times 0.1 \times 273}{1 \times 300}$

or, $V_2 = 0.091$ litre
or, $V_2 = 91$ cc
Hence, the volume of the ideal gas at STP is 91 cc.

---

16. 2070 Supp. Q.No. 32 State and explain Graham's law of diffusion. What are the applications of Grahar Through the two ends of a glass-tube of length 2 meters, hydrogenchloride (HCl) and ammonia (NH are allowed to enter. At what distance ammonium chloride will first appear?

Thomas Graham, in 1829 studied the effect of density on the rate of diffusion of a gas a forward a mathematical relationship between density of gas and its rate of diffusion. I that, "Under similar condition of temperature and pressure, the rates of diffusion of ga inversely proportional to the square root of their densities."

Diffusion: The intermixing of two or more than two gases irrespective of density relati and without the help of any external agency.

Derivation
Mathematically,

$$\text{Rate of diffusion (r)} \alpha \frac{1}{\sqrt{\text{Density of gas (d)}}}$$

or, $r \alpha \frac{1}{\sqrt{d}}$

or, $r = \frac{K}{\sqrt{d}}$ Where, K = a constant

If r_1 and r_2 are the rate of diffusion of two gases and their densities are d_1 and d_2 respec then

$$r_1 = \frac{K}{\sqrt{d_1}} \quad \ldots \text{(i)}$$

$$\text{and } r_2 = \frac{K}{\sqrt{d_2}} \quad \ldots \text{(ii)}$$

Dividing equation (i) by (ii), we get

$$\frac{r_1}{r_2} = \frac{\sqrt{d_2}}{\sqrt{d_1}}$$

or, $\frac{r_1}{r_2} = \sqrt{\frac{d_2}{d_1}}$ ... (iii)

We know that,
Molecular weight of a gas is twice of its vapour density i.e.
$M = 2 \times V.D.$

or, $V.D. = \frac{M}{2}$ Where, V.D. = vapour density or density of gas

$d = \frac{M}{2}$.

$= \frac{M_1}{2}$ and $d_2 = \frac{M_2}{2}$

tting the value of d_1 and d_2 in the above equation (iii) then we get

So, $\frac{r_1}{r_2} = \sqrt{\frac{M_2}{M_1}}$ ... (iv)

Therefore, Graham's law can also be stated as, the rate of diffusion of a gas is inversely proportional to square root of its molecular weight at constant temperature and pressure.

Again, rate of diffusion is defined as the volume of gas diffused per unit time.

i.e. $r = \frac{\text{Volume diffused}}{\text{Time taken}} = \frac{V}{t}$

If the volume of gas are equal

$r_1 = \frac{V}{t_1}$ and $r_2 = \frac{V}{t_2}$

Putting the value of r_1 and r_2 in the above equation (iii) then we get

$$\frac{\frac{V}{t_1}}{\frac{V}{t_2}} = \sqrt{\frac{d_2}{d_1}} = \sqrt{\frac{M_2}{M_1}}$$

So, $\frac{t_2}{t_1} = \sqrt{\frac{d_2}{d_1}} = \sqrt{\frac{M_2}{M_1}}$ ... (v)

Thus, Graham's law of diffusion can also be stated that time taken by equal volume of gas to diffuse is directly proportional to square root of its density or molecular weight.

If gases are allowed to diffuse in equal time i.e. $t_1 = t_2 = t$ then,

$$\frac{\frac{V}{t_1}}{\frac{V}{t_2}} = \sqrt{\frac{d_2}{d_1}} = \sqrt{\frac{M_2}{M_1}}$$

$\frac{V_1}{V_2} = \sqrt{\frac{d_2}{d_1}} = \sqrt{\frac{M_2}{M_1}}$ ... (vi)

Thus, Graham's law of diffusion can also be stated that volume of gas diffused at the same time is inversely proportional to square root of its density or molecular weight.

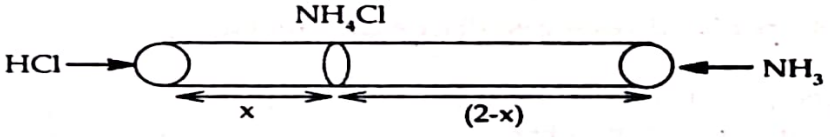
Application of Graham's law of diffusion:

Following are the main application

i. It is used to determine the rate of diffusion of gas.
ii. It is used to determine the density of gas.
iii. It is used to determine the molecular mass of gas.
iv. It is used to separate the isotopes of gases whether lighter isotopes diffuse faster.
v. It is used to separate the mixture of gases.

olution

Let, x m = distance from HCl end, NH_4Cl forms



For HCl

$M_1 = 36.5$

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$$r_1 = \frac{\text{Distance travelled}}{\text{Time taken}} = \frac{x}{t}$$

For NH_3

$M_2 = 17$

$$r_2 = \frac{\text{Distance travelled}}{\text{Time taken}} = \frac{(2-x)}{t}$$

According to Graham's law of diffusion

$$\frac{r_1}{r_2} = \sqrt{\frac{M_2}{M_1}}$$

$$\text{or, } \frac{x/t}{(2-x)/t} = \sqrt{\frac{17}{36.5}}$$

$$\text{or, } \frac{x}{(2-x)} = 0.682$$

$$\text{or, } x = (0.682 \times 2) - 0.682x$$

$$\text{or, } x + 0.682x = 0.682 \times 2$$

$$\text{or, } x(1 + 0.682) = 1.364$$

$$\text{or, } x = \frac{1.364}{1.682}$$

$$\text{or, } x = 0.8109$$

Hence, the distance from NH_3 end at which NH_4Cl forms is

$2 - x = (2 - 0.8109) = 1.189$ m

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17. 2070 Set C Q.No. 31 **Derive PV = nRT. How did Charle's law give the concept of absolute s temperature? Two vessel of capacity 1.5 litres and 2 litres contain hydrogen gas and oxyg respectively under a pressure of 750 mm and 100 mm. The gases are mixed together in a 5 litre vess will be the final pressure of mixture?**

a **Derivation of PV = nRT:** Please refer to 2071 Supp Q. No. 30

Charle's law: Please refer to 2071 Supp Q. No. 30

Solution

Two vessels contains hydrogen and oxygen gas

For hydrogen gas

Volume of hydrogen (V_1) = 1.5 litre

Pressure of hydrogen (P_1) = 750 mm Hg

Total volume of gas (V_2) = 5 litre

Pressure (P_2) = ?

We know that,

$$P_1V_1 = P_2V_2$$

$$\text{or, } P_2 = \frac{P_1V_1}{V_2}$$

$$\text{or, } P_2 = \frac{750 \times 1.5}{5}$$

$$\text{or, } P_2 = 225 \text{ mm Hg}$$

Hence, the partial pressure of hydrogen gas (PH_2) = 225 mm Hg

For oxygen gas

Volume of hydrogen (V_1) = 2 litre

Pressure of hydrogen (P_1) = 100 mm Hg

Total volume of gas (V_2) = 5 litre

Pressure (P_2) = ?

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e know that,

$P_1V_1 = P_2V_2$

$P_2 = \frac{P_1V_1}{V_2}$

$P_2 = \frac{100 \times 2}{5}$

$P_2 = 40$ mm Hg

ence, the partial pressure of oxygen gas (PO_2) = 40 mm Hg

ow, the total pressure of gaseous mixture = $PH_2 + PO_2$

= (225 + 40)= 265 mm Hg

2070 Set D Q.No. 32 Explain, how Charle's law gave the concept of absolute scale of temperature. Derive the relation PV = nRT. A hydrocarbon CxHy has mass ratio between hydrogen and carbon 1 : 10.5. One litre of the hydrocarbon at 127°C and 1 atm pressure weights 2.8 g, find the molecular formula of the hydrocarbon. [2+4+4]

Charle's law: Please refer to 2071 Supp Q. No. 30

Derivation of PV = nRT: Please refer to 2071 Supp Q. No. 30

olution

iven,

Volume (V) = 1 litre

Pressure (P) = 1 atm

Temperature (T) = 127°C = (127 + 273) = 400K

Given mass of gas (m)= 2.8 g

Molecular mass (M) = ?

Universal gas constant (R) = 0.0821 L atm $K^{-1}mol^{-1}$

e sc
xyge
esse

/e know that,

$PV = nRT$

$PV = \frac{mRT}{M}$

$\therefore M = \frac{mRT}{PV}$

$\therefore M = \frac{2.8 \times 0.0821 \times 400}{1 \times 1}$

$\therefore M = 91.952$

Hence, molecular mass of hydrocarbon (C_xH_y) = 91.952 amu.

The ratio of Carbon and hydrogen = 10.5 : 1

The relative no. of moles of C : H = $\frac{10.5}{12} : \frac{1}{1}$ = 0.875 : 1

The simplest ratio of moles of C : H = 1.75 : 2

So, the empirical formula of carbon and hydrogen = $C_{1.75}H_2$

/e know that,

(Empirical formula weight)$_n$ = Molecular formula weight

$(12 \times 1.75 + 2)_n = 91.952$

r, $(21 + 2)n = 91.952$

r, $23\ n = 91.952$

r, $n = \frac{91.952}{23}$

r, $n = 4$

low, Molecular formula = (empirical formula)$_n$ = $(C_{1.75}H_2)_4$ = C_7H_8

lence, the molecular formula of hydrocarbon C_xH_y is C_7H_8.

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19. 2067 Q.No. 30 State and explain Dalton's Law of partial pressure. What is the main application of this l vessel Contains 12 g of an ideal gas at t°C temperature and 1 atm pressure. When the tempera increased by 10°C at the same volume, the pressure increases by 10 %. Calculate the volume and temperature.(molecular mass of gas = 120)

Dalton's law of partial pressure:

In 1807, John Dalton put forwarded a mathematical as well as theoretical relationship be partial pressure of different non-reacting gas and total pressure exerted by the mixture enclosed in vessel.

Partial pressure: The pressure exerted by the individual component of the non-reacting ga mixture, if present alone in the vessel.

Statement: "The total pressure exerted by the mixture of two or more non-reacting gas is to the sum of the partial pressure at a constant temperature."

If $p_1, p_2, p_3, \ldots$ are the partial pressure of different non-reacting gases and P_T is the total pre of the mixture at the same temperature then

$$p_T = p_1 + p_2 + p_3 \ldots$$

Derivation of Dalton's law of partial pressure

Let a vessel contains three different gases A,B,C having n_1, n_2, n_3 moles respectively and th number of moles of the mixture is n_T, then

$$n_T = n_1 + n_2 + n_3$$

From Ideal gas equation

$$PV = n\,RT$$

$$\text{or, } P = \frac{n}{V}RT$$

So, $p_1 = \frac{n_1}{V}RT$, $p_2 = \frac{n_2}{V}RT$, $p_3 = \frac{n_3}{V}RT$. **Where, p_1, p_2, p_3 are the partial pressure of the gas C respectively.**

Adding all the given three equation, we get

$$p_1 + p_2 + p_3 = \frac{n_1}{V}RT + \frac{n_2}{V}RT + \frac{n_3}{V}RT = \left(\frac{n_1 + n_2 + n_3}{V}\right)RT = \frac{n_T}{V}RT = P_T$$

i.e. $P_T = p_1 + p_2 + p_3$

This is the mathematical expression of Dalton's law of partial pressure.

Again, if we divide the partial pressure of a particular component of gas by the total press the mixture of gases then we get

$$\frac{p_1}{p_T} = \frac{\frac{n_1}{V}RT}{\frac{n_T}{V}RT} = \frac{n_1}{n_T}$$

So, $p_1 = \frac{n_1}{n_T} \times P_T$ **i.e. partial pressure = mole fraction of gas × total pressure of gas.**

Application of Dalton's law of partial pressure: When the gas is collected over the wa becomes moist due to presence of small quantity of water vapour, then

Pressure exerted by moist gas = pressure exerted by dry gas + pressure of water va (aqueous tension)

$$P_{\text{moist gas}} = P_{\text{dry gas}} + P_{\text{water vapour}}$$

The partial pressure of water vapour in a moist gas is called aqueous tension and denoted

So, $P_{\text{dry gas}} = P_{\text{moist gas}} - f$

Numerical:

Given,

Given mass of gas (w) = 12 g

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Initial temperature (T_1) = t°C = (t + 273)K
Final temperature (T_2) =(t°C + 10°C) = (t + 10 + 273) = (t + 283)K
Initial pressure (P_1) = 1 atm

Final pressure (P_2)=(10% of 1 atm + 1atm)= $(\frac{10}{100} \times 1 \text{ atm} + 1 \text{ atm}) = (0.1+1) \text{ atm} = 1.10 \text{ atm}$

From combined gas equation,

At constant volume, $\frac{P_1}{T_1} = \frac{P_2}{T_2}$

or, $\frac{1}{t + 273} = \frac{1.10}{t + 283}$

or, $t + 283 = 1.10\ t + 300.3$

or, $0.1\ t = -17.3$

or, $t = \frac{-17.3}{0.1}$

or, $t = -173$

or, $t = -173°C$

or, $t = (-173 + 273)K$

or, $t = 100\ K$

Hence, initial temperature is 100 K

From Ideal gas equation,

$PV = nRT$

or, $V = \frac{nRT}{P}$

or, $V = \frac{wRT}{MP} = \frac{12 \times 0.0821 \times 100}{120 \times 1} = 0.821$ litre

Hence, volume of gas at 100 K is 0.821 litre.

---

20. 2064 Q.No. 30

a. State and explain Graham's law of diffusion of gases. [5]

b. 5 gram of hydrogen diffused through a porous membrane in 30 minutes. Find the time required to diffuse the same amount of SO_2 gas at identical conditions. [5]

a. **Graham's law of diffusion:** Please refer to 2070 Supp. Q.No. 32

b. Given,

Mass of H_2 = 5 g = mass of SO_2
Diffusion time for H_2 (t_1) = 30 minute
Diffusion time for SO_2 (t_2) = ?
Molecular mass of H_2 (M_1) = 2
Molecular mass of SO_2 (M_2) = 64
Density of H_2 (d_1) = 1
Density of SO_2 (d_2) = 32

We know that, $\frac{r_1}{r_2} = \sqrt{\frac{M_2}{M_1}} = \sqrt{\frac{64}{2}} = 5.65$

or, $r_1 = 5.65\ r_2$ ... (i)

We know that, $r = \frac{V}{t}$

So, the above equation (i) becomes

$\frac{V_1}{t_1} = 5.65 \frac{V_2}{t_2}$

We know that, $d = \frac{M}{V}$

or, $V = \frac{M}{d}$

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or, $\frac{mH_2}{dH_2 \times t_1} = 5.65 \times \frac{mSO_2}{dSO_2 \times t_2}$ [mass of H_2 = mass of SO_2 = 5 g]

or, $dSO_2 \times t_2 = 5.65 \times dH_2 \times t_1$

We also know that, $d = \frac{M}{2}$

So, $\frac{\text{Molecular weight of } SO_2}{2} \times t_2 = 5.65 \times \frac{\text{Molecular weight of } H_2}{2} \times t_1$

or, $\frac{64}{2} \times t_2 = 5.65 \times \frac{2}{2} \times 30$

or, $t_2 = \frac{5.65 \times 30 \times 2}{64} = 5.29$ minute

Hence, the time required to diffuse SO_2 gas is 5.29 minutes.

21. 2063 Q.No. 30(a) 2060 Q.No. 33 (d) **Write the postulates of Kinetic theory of gas.**

Please refer to 2071 (Set C) Q.No. 30

22. 2063 Q.No. 30(b) **State and explain Charle's law. How is Charle's law explained qualitatively in the ligh Kinetic theory of gas?**

Please refer to 2071 Supp Q. No. 30

23. 2055 Q.No. 23 **Give the postulates of Kinetic Molecular Model of gas.**

Please refer to 2071 (Set C) Q.No. 30

24. 2053 Q.No. 2 Group C

a. State and explain Dalton's law of partial pressure.

b. A 1.00 L sample of dry gas at 25°C has the following compositions:

0.8940 g of N_2, 0.2741 g of O_2 0.0152 g of Ar

0.00107 g of CO_2 Given R = 0.0821 L atm mol^{-1} k^{-1}

What are the partial pressures for each components gas in the mixture? What is the total pressure?

Dalton's law of partial pressure: Please refer to 2067 Q.No. 30

Solution

Given,

Volume of dry gas (V) = 1.0 L

Temperature (T) = 25°C = (25 + 273) = 298K

Universal gas constant (R) = 0.0821 liter $K^{-1}mol^{-1}$

For Nitrogen gas

Given mass of N_2 = 0.8904 g

Molecular mass of N_2 = 28

No. of mole of N_2 (n_N) = $\frac{0.8904}{28} = 0.032$ mol

We know that,

PV = nRT

Partial pressure of N_2 (P_N) = $\frac{n_N RT}{V} = \frac{0.032 \times 0.0821 \times 298}{1} = 0.78$ atm

For Oxygen gas

Given mass of O_2 = 0.2741 g

Molecular mass of O_2 = 32

No. of mole of O_2 (n_O) = $\frac{0.2741}{32} = 0.0086$ mol

We know that,

PV = nRT

Partial pressure of O_2 (P_O) = $\frac{n_O RT}{V} = \frac{0.0086 \times 0.0821 \times 298}{1} = 0.21$ atm

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or Argon gas

Given mass of Ar = 0.0152 g

Molecular mass of Ar = 40

No. of mole of Ar (n_{Ar}) = $\frac{0.0152}{40}$ = 0.00038 mol

We know that,

PV = nRT

Partial pressure of Ar (P_{Ar}) = $\frac{n_{Ar}RT}{V} = \frac{0.00038 \times 0.0821 \times 298}{1}$ = 0.0092 atm

or Carbondioxide gas

Given mass of CO_2 = 0.00107 g

Molecular mass of CO_2 = 44

No. of mole of CO_2 (nCO_2) = $\frac{0.00107}{44}$ = 2.43×10^{-5} mol

We know that,

PV = nRT

Partial pressure of CO_2 (PCO_2) = $\frac{n_{Ar}RT}{V} = \frac{2.43 \times 10^{-5} \times 0.0821 \times 298}{1}$ = 5.94×10^{-4} atm

Hence, total pressure of gas (P_T) = $P_N + P_O + P_{Ar} + PCO_2$

= $(0.78 + 0.21 + 0.0092 + 5.94 \times 10^{-4}) = 0.9997$ atm

5. 2052 Q.No. 3 Group C [10]

a. State and explain Boyle's law.

b. A carbon dioxide fire-extinguisher of 3 litres capacity contains 4.4 kg of carbon dioxide. What volume of gas could this extinguisher deliver at NTP?

Boyle's Law: Please refer to 2071 Supp Q. No. 30

Given,

Mass of CO_2 = 4.4 kg = 4400 g

Molecular mass of CO_2 = 44

Capacity of fire extinguisher = 3 litre

We know that,

1 mole of CO_2 gas contains 22.4 litre at STP

1 mole of CO_2 gas has mass = 44

44 g of CO_2 = 22.4 litre

1 g of CO_2 = $\frac{22.4}{44}$

4400 g of CO_2 = $22.4 \times \frac{4400}{44}$ = 2240 litre

Hence, the volume of CO_2 gas that will be delivered from the fire extinguisher is (2240 – 3) = 2237 litre.

. 2051 Q.No. 3 Group B **What are the main points of kinetic theory of gases?** [5]

Please refer to 2071 (Set C) Q.No. 30

UMERICAL PROBLEMS

. 2076 Set B Q.No. 31 **State Boyle's Law and draw (i) P vs V, (ii) V vs $\frac{1}{P}$ and (iii) PV vs P graphs to support Boyle's law. What is the practical significance of this law? A toy balloon blown up at 10°C, has a volume 960 cc, At this stage the balloon is distended to $\frac{7}{8}$ of its maximum stretching capacity. Will the balloon brust, if it is brought to a room having temperature 25°C? If not, calculate the temperature at which the balloon brust.** [2+3+1+4]

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Boyle's law: Please refer to 2071 Supp Q. No. 30

Significance of Boyle's law: According to Boyle's law, at constant temperature the density of directly proportional to pressure. This is because density depends on volume, smaller the v higher the density. So, when pressure is applied, volume is reduced i.e. density is increased. Thus, at higher altitudes, as the atmospheric pressure is low, the air is less dense. As a resu oxygen is available for breathing. That is why mountaineers have to carry oxygen cylinder them.

Numerical:

Initial volume of air $(V_1) = \frac{7}{8} \times 960 \text{ cc} = 840 \text{ cc}$

Initial temperature $(T_1) = 10^oC = (10 + 273) = 283 \text{ K}$

Final temperature $(T_2) = 25^oC = (25 + 273) = 298 \text{ K}$

Final volume $(V_2) = ?$

We know that

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

or, $$V_2 = \frac{V_1 T_2}{T_1} = \frac{840 \times 298}{283} = 884.52 \text{ cc}$$

Hence, the volume of air is 884.52 cc

AT 25°C, the balloons will not brust because the volume of air in balloon at 25°C is 884.52 cc w less than 960cc.

Calculation of temperature:

Initial volume $(V_1) = 840$ cc — Final volume $(V_2) = 960$ cc

Initial temperature $(T_1) = 283\text{K}$ — Final temperature $(T_2) = ?$

We know that

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

or, $$T_2 = \frac{V_2 T_1}{V_1} = \frac{960 \times 283}{840} = 323.43 \text{ K} = (323.43 - 273) = 50.42^oC$$

Hence, the temperature at which the balloons will brust is 50.42°C.

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28. 2076 Set C Q.No. 31 State and explain Graham's Law of diffusion. Mention any two applications of this. vessel of volume 100 mL contains 10% of oxygen and 90% of an unknown gas. The gases diffuse in through a small hole of the vessel. If pure oxygen diffuses in 75 sec. under same condition, fi molecular weight of the gas.

Graham's law of gaseous diffusion: Please refer to 2070 Supp. Q.No. 32

Application of Graham's law of diffusion: Please refer to 2074 Set B Q.No. 30

Numerical:

Given,

Volume of mixture $(V_1) = 100$ mL

Time taken for mixture $(t_1) = 86$ sec

Time taken for diffusion of pure O_2 $(t_2) = 75$ sec

Volume of pure O_2 $(V_2) = 100$ mL (gas is kept at the same vessel)

Density of O_2 $(dO_2) = 16$

Density of mixture $(d_{mix}) = ?$

We know that, at the same volume

$$\frac{t_2}{t_1} = \sqrt{\frac{d_2}{d_1}} = \sqrt{\frac{dO_2}{dmix}}$$

or, $$\frac{75}{86} = \sqrt{\frac{16}{dmix}}$$

Squaring both side

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$$\frac{75^2}{86^2} = \frac{16}{d\ mix}$$

or, $d_{mix} = \frac{16 \times 86 \times 86}{75 \times 75} = 21.03$

We know that,

$d = \frac{M}{V}$

$$\text{Total density} = \frac{\text{Total mass}}{\text{Total volume}} = \frac{\text{Mass of oxygen } (d \times V) + \text{Mass of unknown gas } (d \times V)}{\text{Total volume}}$$

$$21.03 = \frac{(10 \times 16) + (90 \times d)}{100}$$

So, d (density of unknown gas) = 21.58

We know that, M = 2 x d = 2 x 21.58 = 43.17 is the molecular mass of unknown gas.

Hence, the molecular mass of unknown gas is 43.17 amu.

29. 2075 GIE Q.No. 32 **State Boyle's Law and derive $P_1V_1 = P_2V_2$. How would you justify Boyle's Law by graphical explanations? A fire extinguisher of capacity 5 liters contains 2Kg of CO_2 gas. What volume of the gas will be delivered to extinguish fire at STP?** **[1+1+4+4]**

Boyle's law: Please refer to 2071 Supp Q. No. 30

Numerical:

Given,

Capacity of fire extinguisher = 5 L

Mass of CO_2 gas = 2 Kg = 2000 g

Molecular mass of CO_2 gas = 44

Temperature (T) = 273K

Pressure (P) = 1 atm

Universal gas constant (R) = 0.0821 L atm $K^{-1}mol^{-1}$

Volume of gas (V) = ?

We know that,

PV = nRT

or, $PV = \frac{m}{M}RT$

or, $V = \frac{m}{MP}RT = \frac{2000 \times 0.0821 \times 273}{44 \times 1} = 1018.78$ Litre

Hence, the volume of gas delivered to extinguish fire at STP is (1018.78 – 5) = 1013.78 Litre.

30. 2075 Set A Q.No. 30 **What are the basic postulates of kinetic theory of gases? State the proper conditions for the deviation of gases from their ideal behaviour. An evacuated glass vessel weighs 50 gm when empty, 148 g when filled with a liquid of density 0.98 g/mL and 50.5 g when filled with an ideal gas at 760 mmHg at 27°C. Determine the molecular mass of the gas. How many number of molecules are present in 12.3 g in the gas?** **[5+1+3+1]**

Postulates of Kinetic theory of gas: Please refer to 2071 (Set C) Q.No. 30

The real gas nearly obeys the ideal gas equation at high temperature and low pressure. On decreasing the temperature and increasing pressure, there is deviation of real gas from ideal gas behavior.

Numerical:

Given, Weight of empty vessel = 50 g

Weight of vessel and liquid = 148 g

So, weight of liquid = (148 – 50) = 98 g

Density of liquid = 0.98 g/mL

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So, volume of liquid = $\frac{\text{Mass}}{\text{Density}} = \frac{98}{0.98} = 100$ mL

Again,
Weight of empty vessel = 50g
Weight of vessel with ideal gas = 50.5 g
Weight of ideal gas (w) = (50.5 – 50) = 0.5 g
Volume of ideal gas (V) = 100 mL = 0.1 litre
[Because gas is kept in the same vessel which is completely evacuated]
Temperature (T) = 27°C = (27 + 273) = 300K
Pressure (P) = 760 mm Hg = 1 atm.
R = 0.0821 L atm. $K^{-1}Mol^{-1}$
Molecular mass of ideal gas (M) = ?
We know that,

$$PV = \frac{w}{M} RT$$

$$M = \frac{wRT}{PV} = \frac{0.5 \times 0.0821 \times 300}{1 \times 0.1} = 123.15 \text{ amu.}$$

Hence, the molecular mass of gas is 123.15 amu.
We know that,
1 mole of gas = 123.15 g
1mole of gas = 6.022×10^{23} molecules
123.15 g gas = 6.022×10^{23} molecules

$$12.3 \text{ g gas} = \frac{6.022 \times 10^{23} \times 12.3}{123.15} = 6.014 \times 10^{22} \text{ molecules.}$$

Hence, the number of molecules of gas present is 6.014×10^{22} molecules.

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31. 2075 Set B Q.No. 32 2072 Set D Q.No. 32 State and explain Dalton's law of partial pressure. What is i application? A spherical balloon of 21 cm diameter is to be filled with hydrogen gas at NTP from a cylind containing hydrogen gas at 20 atms, and 27°C. If the cylinder can hold 2.66 litres of water at NTP, calcula the number of balloon that can be filled up. [5+1

Dalton's law of partial pressure: Please refer to 2067 Q.No. 30

Application: Dalton's law of partial pressure is broadly used to calculate the pressure of pu gases when they are collected over the water. When the gas is collected over the water becomes moist due to presence of small quantity of water vapour caused by evaporation.
Pressure of dry gas = Pressure of moist gas – pressure of water vapour (aqueous tension)
$P_{dry} = P_{moist} - f$ (aqueous tension)
So, $P_{moist} = P_{dry} - f$
The partial pressure exerted by water vapour in the moist gas is called aqueous tension. It denoted by *f*.
The combined gas equation becomes

$$\frac{(P-f)V_1}{T_1} = \frac{P_2V_2}{T_2}$$

Where,

P = Pressure exerted by moist gas
f = Aqueous tension
V_1 = Volume of gas
T_1 = Room temperature
V_2 = Volume of the gas at temperature T_2
P_2 = Pressure of dry gas at volume V_2
T_2 = Temperature of gas at V_2

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Numerical:

Given,

Diameter of sphere (d) = 21 cm

Radius of sphere (r) $= \frac{21}{2} = 10.5$ cm

Volume of spherical balloon (V_1) $= \frac{4}{3}\pi r^3 = \frac{4}{3} \times 3.14 \times (10.5)^3 = 4846.59$ cm^3

Pressure of H_2 gas (P_1) = 1 atm

Temperature (T_1) = 273 K

For RTP

V_2 = ?

P_2 = 20 atm

T_2 = 27°C = (27 + 273) = 300 K

We know that

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

or, $$V_2 = \frac{P_1V_1T_2}{P_2T_1} = \frac{1 \times 4846.59 \times 300}{20 \times 273} = 266 \text{ cc}$$

Here, the volume of water vapour that can hold in cylinder = 2.66 litre = 2660 cc

The number of balloon that can be filled by hydrogen gas $= \frac{2660}{266} = 10$

Hence, number of balloon = 10

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32. 2074 Supp Q.No. 32 **State and explain Graham's law of diffusion. 0.23 g of a volatile liquid occupies 126.4 cc at 27°C and 760 mm pressure. Calculate the molecular weight of the liquid. How many molecules of the liquid are present in 0.23g?** [6+3+1]

State and explain Graham's law of diffusion: Please refer to 2070 Supp. Q.No. 32

Numerical:

Given mass of volatile liquid (m) = 0.23 g

Molecular weight of volatile liquid (M) = ?

Volume of volatile liquid (V) = 126.4 cc $= \frac{126.4}{1000} = 0.1264$ L

Pressure of volatile liquid (P) = 760 mm Hg = 1 atm

Temperature of volatile liquid (T) = 27°C = (27 + 273) = 300 K

Universal gas constant (R) = 0.0821 L atm $K^{-1}mol^{-1}$

We know that,

PV = nRT

Or, $$PV = \frac{m}{M}RT$$

Or, $$M = \frac{mRT}{PV} = \frac{0.23 \times 0.0821 \times 300}{1 \times 0.1264} = 44.81 \text{ amu}$$

Hence, the molecular weight of volatile liquid is 44.81 amu.

We know that,

1 mole of volatile liquid = 44.81 g

1 mole of volatile liquid = 6.022×10^{23} molecules

44.81 g of volatile liquid = 6.022×10^{23} molecules

0.23 g of volatile liquid $= \frac{6.022 \times 10^{23} \times 0.23}{44.81}$ molecules

$= 3.09 \times 10^{21}$ molecules

Hence, the number of volatile molecules is 3.09×10^{21}.

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33. 2074 Set A Q.No. 32 State Boyle's Law and Charle's Law. Derive the relation PV = nRT. An evacuated g vessel weighs 50 g when empty, 148 g when filled with a liquid of density 0.98 g/mL and 50.5 g, when f with an ideal gas at 760 mm Hg at 27°C. Determine the molecular mass of the gas. How many numbe molecules are present in 12.3 g in the gas? [2+4+

Boyle's Law: Please refer to 2071 Supp Q. No. 30
Charle's Law: Please refer to 2071 Supp Q. No. 30
Derivation PV = nRT : Please refer to Please refer to 2071 Supp Q. No. 30
Numerical: Please refer to 2075 Set A Q.No. 30

34. 2074 Set B Q.No. 30 State and explain Graham's law of diffusion of gas. Give its an application. 0.23 g volatile liquid occupies 126.4 cc at 27°C and 760 mm Hg pressure. Calculate the molecular weight of liquid. How many molecules of the liquid are present in 0.23 g? [5+

State and Explain Graham's law of diffusion: Please refer to 2070 Supp. Q.No. 32
Application of Graham's law of diffusion:
Following are the main application
i. It is used to determine the rate of diffusion of gas.
ii. It is used to determine the density of gas.
iii. It is used to determine the molecular mass of gas.
iv. It is used to separate the isotopes of gases whether lither isotopes diffuse faster.
v. It is used to separate the mixture of gases.
Numerical: Please refer to 2074 Supp Q.No. 32

35. 2073 Supp Q.No. 30 What are the basic assumptions of Kinetic theory of gas ? Why do gases deviate fro ideal behaviour at low temperature and high pressure? A Saturated hydrocarbon (C_nH_{2n+2}) diffuses thro a porous membrane twice as fast as SO_2. Determine the molecular formula of the hydrocarbon. [5+

Basic assumptions of Kinetic theory of gas: Please refer to 2071 (Set C) Q.No. 30
Deviation of gas: Please refer to 2071 Set C Q.No. 30
Numerical:
The rate of diffusion of SO_2 gas (r_1) = 1
The rate of diffusion of hydrocarbon (r_2) = 2
Molecular mass of SO_2 (M_1) = (32+32) = 64
Molecular mass of hydrocarbon (M_2) = ?
We know that,

$$\frac{r_1}{r_2} = \sqrt{\frac{M_2}{M_1}}$$

$$\text{or, } \frac{1}{2} = \sqrt{\frac{M_2}{64}}$$

$$\text{or, } (0.5)^2 = \frac{M_2}{64}$$

$$\text{or, } 0.25 = \frac{M_2}{64}$$

$$\text{or, } M_2 = 16$$

Hence, the molecular mass of hydrocarbon = 16
Now,
$C_nH_{2n+2} = 16$
or, $12 \times n + 1 + (2n+2) = 16$
or, $(12n + 2n + 2) = 16$
or, $14n = (16 - 2)$
or, $14n = 14$

$$\text{or, } n = \frac{14}{14} = 1$$

The value of n in hydrocarbon is 1. Hence, the molecular formula of hydrocarb
$C_1H_{2\times1+2} = CH_4$ i.e. Methane.

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2073 Set C Q. No. 30 **State Boyle's Law. Plot pressure – volume relationship to explain Boyle's law. Mention its important application.**
A straight glass tube of length 25 cm has two inlets (A) and (B). NH_3 gas through the inlet (A) and HCl gas through the inlet (B) are allowed to enter the tube at the same time. White fumes of NH_4Cl appear at a point (M) inside the tube. Find the distance M from A. **[1+5+4]**

Statement of Boyle's Law: Please refer to 2071 Supp Q. No. 30

Graphs of Boyle's law: Please refer to 2071 Supp Q. No. 30

Application of Boyle's law: Boyle's law proves a important fact that gases are compressible in nature. If pressure is increased, the density of gas is increased. Hence, it is concluded that at constant temperature, the density of gas is directly proportional to pressure. At high altitude, as the atmospheric pressure is low, the air is less dense. As a result, less oxygen is available for breathing. Therefore, mountain climber carry oxygen cylinder for breathing.

Numerical:

Let the x cm is distance from NH_3 side in which NH_4Cl forms.



For HCl

$M_1 = 36.5$

Distance $(d_1) = x$ cm

$$r_1 = \frac{\text{distance travelled}}{\text{time taken}} = \frac{x}{t}$$

For NH_3

$M_2 = 17$

Distance $(d_2) = (25 - x)$ cm

$$r_2 = \frac{\text{distance travelled}}{\text{time taken}} = \frac{25 - x}{t}$$

According to Graham's law of diffusion

$$\frac{r_1}{r_2} = \sqrt{\frac{M_2}{M_1}}$$

$$\frac{x}{25 - x} = \sqrt{\frac{17}{36.5}} = \sqrt{0.465} = 0.682$$

$\therefore x = 17.05 - 0.682x$

$\therefore x + 0.682x = 17.05$

$\therefore x(1 + 0.682) = 17.05$

$$\therefore x = \frac{17.05}{1.682} = 10.13$$

Hence, the distance from side A i.e. NH_3 is $(25 - x) = (25 - 10.13) = 14.87$ cm.

2073 Set D Q. No. 30 **State Charle's Law. How did this law lead to the development of the absolute temperature scale? Plot temperature-volume relationship indicating absolute zero.**
A saturated hydrocarbon (C_nH_{2n+2}) diffuse through a porous membrane twice as fast as sulphur dioxide. Determine the molecular formula of the hydrocarbon. **[1+4+1+4]**

First part: Please refer to 2071 Supp Q. No. 30

Numerical: Please refer to 2073 Supp Q.No. 30

2072 Supp Q. No. 32

i. **State and explain Graham's law of Gaseous diffusion. What is application?** **[2+3]**
ii. **The relative densities of carbon dioxide and ozone are 22 and 24 respectively. If 12 mL of carbon dioxide diffuse in 100 seconds, what volume of ozone will diffuse in the same time under similar condition?** **[5]**

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i. **Graham's law of gaseous diffusion:** Please refer to 2070 Supp. Q.No. 32
Application of Graham's law of diffusion: Please refer to 2074 Set B Q.No. 30

ii. Given, relative density of CO_2 (d_1) = 22
Relative density of O_3 (d_2) = 24
Volume of gas diffused by CO_2 (V_1) = 12 mL
Time taken for diffusion of CO_2 = 100 sec.
Volume of gas diffused by O_3 (V_2) = ?
Time taken for diffusion of O_3 = 100 sec. (time is same)
We know that,

$$\frac{V_1}{V_2} = \sqrt{\frac{d_2}{d_1}}$$

Or, $\frac{12}{V_2} = \sqrt{\frac{24}{22}}$

Or, $\frac{144}{V_2^2} = \frac{24}{22}$

Or, $V_2^2 = \frac{144 \times 22}{24}$

Or, $V_2^2 = 132$

Or, $V_2 = 11.48$ mL

Hence, the volume of ozone gas diffused in the same time is 11.48 mL.

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39. 2072 Set C Q.No. 32 2072 Set E Q.No. 32 **State Graham's law of diffusion of gas. Mention its applications. A spherical balloon of 21 cm diameter is to be filled with hydrogen gas at NTP from a cylinder containing at 20 atm. and 27°C. If the cylinder can hold 2.66 litres of water vapour at NTP, calculate the number balloon that can be filled up.**

Graham's law of gaseous diffusion: Please refer to 2070 Supp. Q.No. 32
Application of Graham's law of diffusion: Please refer to 2074 Set B Q.No. 30
Numerical: Please refer to 2075 Set B Q.No. 32

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40. 2069 (Set A) Q. No. 32 **State Boyle's law and Charle's law. Derive the relation PV = n RT. Two moles of ammonia are enclosed in a five liters flask at 27°C. Calculate the pressure exerted by the gas assuming the gas behaves like an ideal gas.**

Boyle's Law: Please refer to 2071 Supp Q. No. 30
Charle's law: Please refer to 2071 Supp Q. No. 30
Derivation of PV = nRT: Please refer to 2071 Supp Q. No. 30
Numerical
Given,
Number of mole (n) = 2
Temperature of ammonia gas (T) = 27°C = (27 + 273) = 300 K
Pressure of gas (P) = ?
Volume of gas (V) = 5 liter
R = 0.0821 L atm K^{-1} mol^{-1}
We know that,
PV = nRT

$$P = \frac{nRT}{V} = \frac{2 \times 0.0821 \times 300}{5} = 9.852 \text{ atm}$$

Hence, the pressure exerted by the gas = 9.852 atm.

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41. 2069 (Set B) Q. No. 31 **State Boyle's law and draw sketch graphs of:**

i. **P against V** ii. **P against $\frac{1}{V}$**

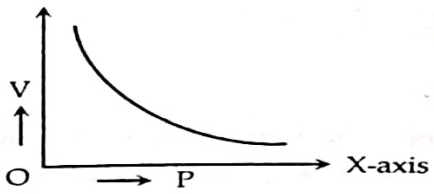
iii. PV against P. iv. PV against V.

For a perfect gas at constant temperature. The mass of 525 cc of a gaseous compound at 28°C and 730 mm Hg pressure was found to be 0.9 g. What will be the volume of 2 g of the gas at 30°C and 760 mm Hg pressure? [Given; R = 0.0821 litre atm $K^{-1}mol^{-1}$] [2+4+4]

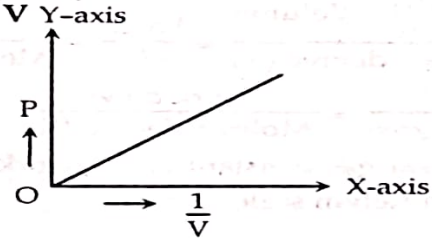
State Boyle's law: Please refer to 2071 Supp Q. No. 30

Graphs of:

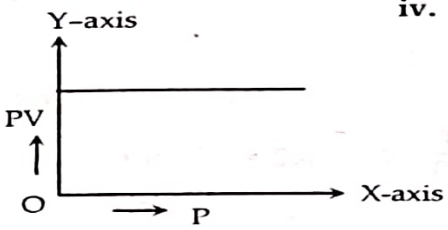
i. P vs V



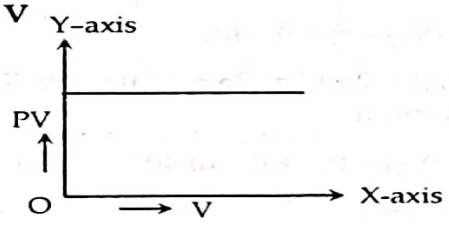
ii. P vs $\frac{1}{V}$



iii. PV vs P



iv. PV vs V



Numerical

For first condition

Mass of gas (m) = 0.9 g

Volume of gas (V) = 525 cc = 0.525 liter

temperature (T) = 28°C = (28 + 273) = 301 K

Pressure of gas (P) = 730 mm Hg = 0.96 atm

R = 0.0821 L atm $K^{-1}mol^{-1}$

Molecular mass(M) = ?

We know that,

$PV = nRT$

$PV = \frac{m}{M}RT$

$M = \frac{mRT}{PV} = \frac{0.9 \times 0.0821 \times 301}{0.96 \times 0.525} = 44.12$ g

For second condition

Mass of gas (m) = 2 g

Temperature (T) = 30°C = (30 + 273) = 303 K

Pressure of gas (P) = 760 mm Hg = 1 atm

Molecular mass (M) = 44.12 g

R = 0.0821 L atm K^{-1} mol^{-1}

Volume of gas (V) = ?

We know that,

$PV = \frac{m}{M}RT$

$V = \frac{mRT}{MP} = \frac{2 \times 0.0821 \times 303}{1 \times 44.12} = 1.127$ liter

Hence, the volume of gas is 1.127 liter.

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42. 2068 Q.No. 30 **Derive the relation PV = nRT. Under what condition does a gas follow the above relation? would you define universal gas constant 'R' ? How much increase in temperature is necessary to incr volume of half litre of the gas by 40 % at 25°C, keeping the pressure constant?** [4+1+1+

Derivation of PV = nRT: Please refer to 2071 Supp Q. No. 30

Universal gas constant: From ideal gas equation

$PV = nRT$

$$R = \frac{PV}{nT} = \frac{\left(\frac{\text{Force}}{\text{Area}}\right) \times \text{Volume}}{\text{Mole} \times \text{degree (K)}} = \frac{\text{Force}}{l^2} \times \frac{l^3}{\text{Moles} \times \text{degree (K)}}$$

$$= \frac{\text{Force} \times l}{\text{Moles} \times \text{degree}} = \frac{\text{Work done}}{\text{Moles} \times \text{degree (K)}}$$

Thus, the universal gas constant is the work done when the temperature of 1 mole of ga increased by 1° in Kelvin scale.

Numerical,

At one condition

Volume of gas $(V_1) = \frac{1}{2} = 0.5$ liter

Temperature $(T_1) = 25°C = (25 + 273) = 298$ K

At another condition

Volume of gas $(V_2) = 0.5 + 0.5$ of $40\% = 0.5 + 0.5 \times \frac{40}{100} = 0.5 + 0.2 = 0.7$ liter

Temperature $(T_2) = ?$

We know that,

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

$$T_2 = \frac{V_2 \times T_1}{V_1} = \frac{0.7 \times 298}{0.5} = 417.2K = (417.2 - 273) = 144.2°C$$

Hence, the increased temperature is $(144.2 - 25) = 119.2°C$

43. 2066 Q.No. 30 **State and explain the Graham's Law of diffusion. What is the main application of Grah Law? A Flask of 0.3 litre capacity was weighed after it had been evacuated. It was then filled with a g unknown molecular mass at 1.0 atm pressure and temperature of 300K. The increase in mass of the was 0.977g. Calculate the molecular mass of the gas.** [4

Graham's law of diffusion: Please refer to 2070 Supp. Q.No. 32

Application of Graham's law of diffusion: Please refer to 2074 Set B Q.No. 30

Numerical,

Given,

Volume (V) = 0.3 liter

Pressure (P) = 1.0 atm

temperature (T) = 300 K

Weight of gas (w) = 0.977 g

Molecular mass (M) = ?

We know that from Ideal gas equation,

$PV = nRT$ where, n = no. mole of gas $= \frac{w}{M}$

$$PV = \frac{w}{M} RT$$

$$M = \frac{wRT}{PV} = \frac{0.977 \times 0.0821 \times 300}{1 \times 0.3} = 80.2 \text{ amu.}$$

Hence, molecular mass of gas is 80.2 amu

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2065 Q. No. 30 What are the basic postulates of Kinetic theory of gas? Why do gases not show ideal behaviour at low temperature and high pressure? An evacuated glass vessel weighs 50 g when empty, 148 g when filled with a liquid of density of 0.98 g / cc, and 50.5 g when filled with an ideal gas at 760 mm Hg and at 300K. Determine the molecular mass of the gas. [4+2+4]

Postulates of Kinetic theory of gas: Please refer to 2071 (Set C) Q.No. 30

Numerical:

Given,

Weight of empty vessel = 50 g

Weight of vessel and liquid = 148 g

So, weight of liquid = (148 – 50) = 98 g

Density of liquid = 0.98 g/cc

So, volume of liquid $= \frac{\text{Mass}}{\text{Density}} = \frac{98}{0.98} = 100$ cc

gain,

Weight of empty vessel = 50 g

Weight of vessel with Ideal gas = 50.5 g

Weight of Ideal gas (w) = (50.5 – 50) = 0.5 g

Volume of Ideal gas (V) = 100 cc = 0.1 L

[Because gas is kept in the same vessel which is completely evacuated]

Temperature (T) = 300 K

Pressure (P) = 760 mm Hg = 1 atm

Molecular mass of Ideal gas (M) = ?

/e know that,

$$PV = \frac{w}{M}RT$$

$$M = \frac{wRT}{PV} = \frac{0.5 \times 0.0821 \times 300}{1 \times 0.1} = 123.15 \text{ amu.}$$

Hence, Molecular mass of gas is 123.15 amu.

2063 Q.No. 23 A mixture of ozone and oxygen containing 20 % by volume of ozone diffused through a porous plug in 172 seconds, while the same volume of pure oxygen took 164 seconds to diffuse through the same plug. Calculate the relative density of ozone.

olution

iven,

Suppose, the total volume of mixture i.e. ozone and oxygen (V_{mix}) = 100 mL

According to question,

Volume of ozone in mixture (VO_3) = 20 mL

Volume of oxygen in mixture (VO_2) = (100 – 20) = 80 mL

Diffusion time of mixture (t_{mix}) = 172 sec

Diffusion time of pure oxygen (tO_2) = 164 sec

Molecular mass of pure oxygen = 32

So, the density of pure oxygen (dO_2) $= \frac{32}{2} = 16$

Density of mixture (d_{mix}) =?

We know that,

$$\frac{r_{mix}}{rO_2} = \sqrt{\frac{dO_2}{d_{mix}}}$$

r, $$\frac{\frac{V}{t_{mix}}}{\frac{V}{tO_2}} = \sqrt{\frac{dO_2}{d_{mix}}}$$

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$$\text{or, } \frac{164}{172} = \sqrt{\frac{16}{d_{mix}}}$$

$$\text{or, } \left(\frac{164}{172}\right)^2 = \frac{16}{d_{mix}}$$

$$\text{or, } d_{mix} = \frac{16 \times 172 \times 172}{164 \times 164}$$

$$\text{or, } d_{mix} = 17.6$$

Again,

Total mass of mixture = mass of O_2 + mass of O_3

$V_{mix} \times d_{mix} = VO_2 \times dO_2 + VO_3 \times dO_3$

$$\text{or, } 100 \times 17.6 = 80 \times 16 + 20 \times d_{O3}$$

$$\text{or, } dO_3 = \frac{(100 \times 17.6) - (80 \times 16)}{20}$$

$$\text{or, } dO_3 = \frac{480}{20}$$

$$\text{or, } dO_3 = 24$$

Hence, the relative density of ozone is 24.

---

46. 2062 Q.No. 1 Calculate the mass of oxygen gas whose volume is 320 mL at 17°C and 2 atm pressure.

Solution

Mass of oxygen (m) = ?

Molecular mass of oxygen (M) = 32

Volume of oxygen (V) = 320 mL = 0.320 liter

Pressure (P) = 2 atm

Temperature (T) = 17°C = (17 + 273) = 290 K

R = 0.0821 L atm K^{-1} mol^{-1}

We know from Ideal gas equation

$$PV = nRT = \frac{m}{M}RT$$

$$\text{or, } m = \frac{PVM}{RT}$$

$$\text{or, } m = \frac{2 \times 0.320 \times 32}{0.0821 \times 290}$$

$$\text{or, } m = 0.86 \text{ g}$$

Hence, the mass of oxygen is 0.86 g.

---

47. 2061 Q.No. 24 State Graham's law of diffusion. How long will it take 500 mL of hydrogen gas t through a partition if 250 mL of oxygen diffuse in 50 minutes under similar conditions?

Graham's law of diffusion: Please refer to 2070 Supp. Q.No. 32

Numerical

For hydrogen gas

Volume (V_1) = 500 mL

Time (t_1) = ?

Molecular mass (M_1) = 2 g

Rate of diffusion of hydrogen: $r_1 = \frac{V_1}{t_1} = \frac{500}{t_1}$

For oxygen gas

Volume (V_2) = 250 mL

Time (t_2) = 50 minute

Molecular mass (M_2) = 32 g

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Rate of diffusion of hydrogen: $r_2 = \frac{V_2}{t_2} = \frac{250}{50} = 5$

We know that,

$$\frac{r_1}{r_2} = \sqrt{\frac{M_2}{M_1}}$$

$$\frac{\frac{500}{t_1}}{5} = \sqrt{\frac{32}{2}}$$

$$\frac{500}{t_1 \times 5} = \sqrt{16} = 4$$

$$t_1 = \frac{100}{4} = 25 \text{ minute}$$

ence, the time will take by hydrogen gas is 25 minute.

2062 Q.No. 30 **State Boyle's Law and Charle's Law. Derive PV = nRT. 0.50 g of a volatile liquid was introduced into a globe of 1000 mL capacity. The globe was heated to 91°C, so that all the liquid vapourized exerted a pressure of 190 mm Hg.** **[2+4+4]**

Boyle's Law: Please refer to 2071 Supp Q. No. 30

Charle's Law: Please refer to 2071 Supp Q. No. 30

Derivation of PV = nRT: Please refer to 2071 Supp Q. No. 30

Numerical:

Given mass of volatile liquid (m) = 0.50 g

Volume (V) = 1000 mL = 1 liter

Temperature (T) = 91°C = (91 + 273) = 364 K

Pressure (P) = 190 mm Hg = 0.25 atm

R = 0.0821 L atm K^{-1} mol^{-1}

Molecular mass (M) = ?

We know from Ideal gas

PV = nRT

$$PV = \frac{m}{M} RT$$

$$M = \frac{mRT}{PV} = \frac{0.5 \times 0.0821 \times 364}{0.25 \times 1}$$

M = 59.76

Hence, the molecular mass of volatile liquid is 59.76 amu.

2060 Q.No. 4 **The rate of diffusion of a saturated hydrocarbon ($C_n H_{2n+2}$) gas is 1.206 times that of SO_2 gas under identical conditions. Find the molecular mass and the value of 'n' for the gas. (Mol. mass of SO_2 = 64).[2]**

ution

The rate of diffusion of SO_2 gas (r_1) = 1

The rate of diffusion of hydrocarbon (r_2) = 1.206

Molecular mass of SO_2 (M_1) = (32 + 32) = 64

Molecular mass of hydrocarbon (M_2) = ?

We know that,

$$\frac{r_1}{r_2} = \sqrt{\frac{M_2}{M_1}}$$

$$\frac{1}{1.206} = \sqrt{\frac{M_2}{64}}$$

$$(0.829187)^2 = \frac{M_2}{64}$$

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or, $M_2 = (0.68 \times 64) = 44$

Hence, the molecular mass of hydrocarbon = 44

Now,

$C_nH_{2n+2} = 44$

or, $12 \times n + 1 \times (2n+2) = 44$

or, $(12n + 2n + 2) = 44$

or, $14n = (44 - 2)$

or, $14n = 42$

or, $n = \frac{42}{14}$

or, $n = 3$

Hence, the value of n in hydrocarbon is 3 and the molecular formula is $C_3H_{2 \times 3 + 2} = C$ propane

---

50. 2059 Q.No. 24 State Graham's law of diffusion. A vessel of volume 100 mL contains 10% O_2 a unknown gas. The gases diffuse in 86 sec through a small hole of the vessel. If pure oxygen under t condition diffuses in 75 sec, find the molecular mass of the unknown gas.

Graham's law of gaseous diffusion: Please refer to 2070 Supp. Q.No. 32

Numerical: Please refer to 2076 Set C Q.No. 31

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51. 2058 Q.No. 6 One litre of a gas at 0°C is heated to 100°C keeping pressure constant. What will be t volume at 100°C?

Solution

At one condition

Volume of gas (V_1) = 1 liter

Temperature (T_1) = 0°C = 273 K

At another condition

Volume of gas (V_2) = ?

Temperature (T_2) = 100°C = (100 + 273) = 373 K

We know from Charle's law

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

or, $V_2 = \frac{V_1 \times T_2}{T_1} = \frac{1 \times 373}{273}$

or, $V_2 = 1.366$ liter

Hence, the new volume will be 1.366 liter.

---

52. 2058 Q.No. 30 Outline the basic assumptions of Kinetic model of gas. What are relative diffusion methane (CH_4) and sulphur dioxide (SO_2)? If these two gases are simultaneously introduced into o ends of 100 cm tube and allowed to diffuse toward each other, at what distance from the SO_2 end molecules of two gases meet?

Basic assumption of Kinetic model of gas: Please refer to 2071 Set C Q.No. 30

Relative rate of diffusion of CH_4 and SO_2:

Molecular mass of CH_4 (M_1) = 16

Molecular mass of SO_2 (M_2) = 64

According to Graham's law of diffusion

$$\frac{r_1}{r_2} = \sqrt{\frac{M_2}{M_1}}$$

$$\frac{rCH_4}{rSO_2} = \sqrt{\frac{64}{16}}$$

$$\frac{rCH_4}{rSO_2} = \frac{2}{1} = 2:1$$

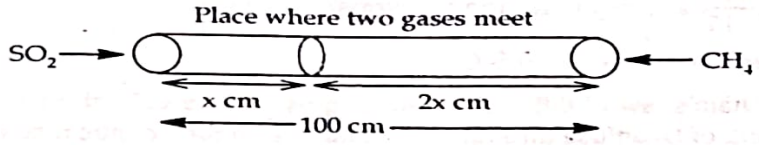
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Hence, the rate of diffusion of CH_4: rate of diffusion of SO_2 = 2 : 1

Solution

Let, the distance covered by SO_2 gas from SO_2 end = x cm

And distance covered by CH_4 from CH_4 end = 2x cm



Now, x + 2x = 100

or, 3x = 100

or, $x = \frac{100}{3}$

or, x = 33.33

Hence, at 33.33 cm from the SO_2 end two gases will meet.

---

53. 2057 Q.No. 3 **A gas X diffuses five times as rapidly as another gas Y. Calculate the ratio of molecular mass of X and Y.** **[2]**

Solution

For X gas

Diffusion rate (r_1) = 5

Molecular mass = M_1

For Y gas

Diffusion rate (r_2) = 1

Molecular mass = M_2

We know that,

$$\frac{r_1}{r_2} = \sqrt{\frac{M_2}{M_1}}$$

or, $$\frac{5}{1} = \sqrt{\frac{M_2}{M_1}}$$

or, $$\left(\frac{5}{1}\right)^2 = \frac{M_2}{M_1}$$

or, $$\frac{25}{1} = \frac{M_2}{M_1}$$

or, $$\frac{M_1}{M_2} = \frac{1}{25}$$

or, $M_1 : M_2 = 1 : 25$

Hence, the ratio of molecular mass of X : Y i.e. $M_1 : M_2 = 1 : 25$

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54. 2057 Q.No. 30 **State Boyle's law and Charle's law. Derive the relation PV = nRT. A gas cylinder cooking gas can withstand up to pressure 14.9 atm. The pressure gauge of cylinder indicates 12 atm at 27°C. Due to sudden fire in the building its temperature starts rising. At what temperature will the cylinder explode?** **[10]**

Boyle's Law: Please refer to 2071 Supp Q. No. 30

Charle's Law: Please refer to 2071 Supp Q. No. 30

Derivation of PV = nRT: Please refer to 2071 Supp Q. No. 30

Numerical

Given,

P_1 = 12 atm

T_1 = 27°C = (27 + 273) = 300 K

$P_2 = 14.9$ atm

$T_2 = ?$

At constant volume, $\frac{P_1}{T_1} = \frac{P_2}{T_2}$

or, $T_2 = P_2 \times \frac{T_1}{P_1} = 14.9 \times \frac{300}{12} = 372.5\ K = (327.5 - 273)°C = 99.5°C$

Hence, the cylinder will explode at 99.5°C.

---

55. 2056 Q.No. 25 **State Graham's law of diffusion. How long will it take 600 mL of H_2 gas to diffuse thro porous partition, if 300 mL of O_2 diffuse through it in 10 minutes under identical conditions?**

Solution

Graham's law of diffusion: Please refer to 2070 Supp. Q.No. 32

Numerical:

For H_2 gas

Volume of gas (V_1) = 600 mL

Time taken for diffusion (t_1) = ?

Molecular mass (M_1) = 2

Rate of diffusion (r_1) $= \frac{V_1}{t_1} = \frac{600}{t_1}$

For O_2 gas

Volume (V_2) = 300 mL

Time (t_2) = 10 minute

Molecular mass (M_2) = 32

Rate of diffusion (r_2) $= \frac{V_2}{t_2} = \frac{300}{10} = 30$

We know that,

$$\frac{r_1}{r_2} = \sqrt{\frac{M_2}{M_1}}$$

or, $\frac{\frac{600}{t_1}}{30} = \sqrt{\frac{32}{2}} = 4$

or, $\frac{600}{t_1 \times 30} = 4$

or, $t_1 = \frac{600}{30 \times 4} = 5$ minute

Hence, time taken for H_2 gas is 5 minute.

---

56. 2055 Q.No. 9 **Two grams of hydrogen diffuses from containers in 10 minutes. How many grams of ox would diffuse through the same container in the same time under similar conditions?**

Solution

For hydrogen

Mass of hydrogen (m) = 2 g

Molecular mass (M_1) = 2

Time for diffusion (t_1) = 10 minute

For oxygen

Mass of oxygen (m) = ?

Molecular mass (M_2) = 32

Time for diffusion (t_2) = 10 minute

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We know that,

$\frac{V_1}{V_2} = \sqrt{\frac{M_2}{M_1}}$ [For the same time]

or, $\frac{V_1}{V_2} = \sqrt{\frac{32}{2}}$

or, $\frac{V_1}{V_2} = \frac{4}{1}$

or, $V_1 = 4 \times V_2$

We know that,

$d = \frac{m}{v}$

$V_1 = \frac{m_1}{d_1} = \frac{2}{1}$ [For hydrogen $d_1 = 1$]

$V_2 = \frac{m_2}{d_2} = \frac{m_2}{16}$ [For oxygen $d_2 = 16$]

Now, $\frac{2}{1} = 4\frac{m_2}{16}$

or, $4m_2 = 32$

or, $m_2 = \frac{32}{4} = 8$

Hence, the mass of oxygen for the diffusion at the same time is 8 g.

7. 2055 Q.No. 10 **One mole of a gas occupies a volume of 1 litre at 27°C. What will be the pressure of the gas?[2]**

Solution

Given,

No. of mole of gas = 1 mol

Volume of gas (V) = 1 liter

Temperature of gas (T) = 27°C = (27 + 273) = 300 K

Pressure of gas (P) = ?

R = 0.0821 L atm $K^{-1}mol^{-1}$

We know that,

PV = nRT

or, $P = \frac{nRT}{V} = \frac{1 \times 0.0821 \times 300}{1} = 24.63$ atm

Hence, pressure of gas is 24.63 atm.

8. 2054 Q.No. 31(b) **A balloon can hold 1000 cc of air before bursting. The balloon can hold 975 cc of air at 5°C. Will it burst when it is taken into a home at 25°C? Assume that the pressure of the gas in the balloon remains constant. [2]**

Solution

At one condition

Volume of gas (V_1) = 975 cc

Temperature of gas (T_1) = 5°C = (5 + 273) = 278 K

At another condition

Volume of gas (V_2) = ?

Temperature of gas (T_2) = 25°C = (25 + 273) = 298 K

Pressure of gas remains constant i.e. $P_1 = P_2$

We know that,

$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$ [$P_1 = P_2$]

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

or, $V_2 = \frac{V_1 T_2}{T_1}$

or, $V_2 = \frac{975 \times 298}{278}$

or, $V_2 = 1045.14$ cc

The capacity of balloon before bursting is 1000 cc but the volume of gas will have v
1045.14 cc at 25°C. So, the balloon will burst.

59. 2053 Q.No. 8 The value of carbon monoxide gas collected over water at 25°C is 680 cc with a total p of 752 mm Hg. The vapour pressure of water at 25°C is 23.8 mm Hg. Determine the partial pressure o container.

Solution

The pressure of moist gas = 752 mm Hg

Aqueous tension i.e. vapour pressure of water = 23.8 mm Hg

So, the pressure of dry gas = (752 – 23.8) = 728.20 mmHg

Thus, the partial pressure of CO gas = 728.20 mm Hg.

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3.2 Liquid State

VERY SHORT ANSWER QUESTIONS

1. 2076 Set B Q.No. 3 **Differentiate between evaporation and boiling.** [2]

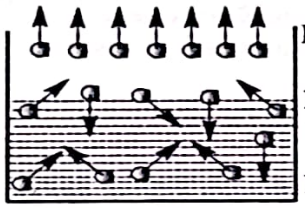
Boiling point of liquid is the temperature at which the vapour pressure of liquid is equal to the atmospheric pressure but evaporation is the process of escaping the surface molecule of liquid in the form of vapour at any temperature

2. 2076 Set C Q.No. 3 **At what condition does a liquid boil? Point out the effect of increasing temperature on boiling point of liquid.** [1+1]

If the vapour pressure of liquid is equal to atmospheric pressure, the liquid starts to boil. There is no effect of increasing temperature on the boiling point of liquid. We know that all the liquid has fixed boiling point.

3. 2075 Set A Q.No. 3 **'Cooling is caused by evaporation'. Give reason.** [2]

Evaporation occurs when the hottest, fastest molecules cross the phase barrier to become a gas. This causes the molecules that remain to be cooler on average. During evaporation of a liquid the molecules of liquid having high kinetic energy move out off the surface of the liquid leaving behind the molecules with low kinetic energy. In this way the temperature of the liquid decrease and is become less as compare to our environment, so compensate this loss heat from environment is absorbed by liquid and temperature of surrounding decrease that is why cooling cause.



4. 2075 Set B Q.No. 3 **Mention two suitable examples to show evaporation causes cooling.** [2]

When a liquid evaporates the more energetic molecules leave as a result, the average kinetic energy of the remaining liquid decrease and the temperature falls. This is called cooling caused by evaporation. Example:

i. When we put some acetone on our palm its feels cold just because of evaporation.
ii. When tea is poured into a saucer when it is very hot. It is exposed to a large area which causes evaporation and the tea becomes cool.

5. 2074 Supp Q.No. 3 **Define surface tension and write its unit.** [2]

The force per unit length acting perpendicular to the line drawn at the surface of the liquid is known as surface tension. Its unit is dynes cm^{-1} (in CGS).

6. 2074 Set A Q.No. 3 **Give proper reason for the following:** [1+1]
   i. Evaporation takes place from the surface of liquid.
   ii. Liquid drops are spherical shape.

i. At any temperature the surface molecule spontaneous escape in the form of vapour. This is called evaporation. The kinetic energy of surface molecules has higher than that of bulk molecule and due to this the evaporation takes place in the surface molecule.
ii. Due to the surface tension, falling liquid drops are spherical. The surface molecules of liquid experience an inward force of attraction that reduces the surface area of liquid. So, the falling liquid drops have spherical shape.

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7. 2074 Set B Q.No. 3 **Does atmospheric pressure affect boiling point of liquid? Explain.**

The boiling point of liquid depend up on the vapour pressure of liquid and vapour pressure liquid depends up on the temperature of liquid. So, boiling point of liquid rise of increas pressure.

8. 2073 Supp Q.No. 3 **Distinguish between continuous and discontinuous solubility curves.**

Following are the difference:

Continuous solubility curve	Discontinuous solubility curve
The solubility curve which shows regular increase or decrease in the solubility with temperature change is called continuous solubility curve.	The solubility curve which shows irregul increase or decrease in the solubility wi temperature change is called continuo solubility curve.
Anhydrous salt like NaCl, KNO_3, KBr, $NaNO_3$ etc. shows this type of curve.	Hydrous salt like $CuSO_4.5H_2O$, $CaCl_2.6H_2$ $Na_2CO_3.10H_2O$ etc. shows this type of curv

9. 2073 Set C Q. No. 3 **Does temperature of boiling liquid increase, decrease or remain constant even tho the heat is continued? Give reason.**

The temperature of boiling point remains constant when heat is continued because boiling po of liquid is the temperature at which the vapour pressure of lipuid is equal to the atmosphe pressure. If the external pressure is changed then the boiling point of liquid is also changed.

10. 2073 Set D Q. No. 3 **Define discontinuous solubility curve. What types of salt are responsible for s curves?**

Discontinuous solubility curve: The solubility curve which shows irregular variation solubility with temperature is known as discontinuous solubility curve. The hydrated salts responsible for discontinuous solubility curve. Example: $CuSO_4.5H_2O$, $CaCl_2.6H_2$ $Na_2SO_4.10H_2O$ etc.

11. 2072 Supp Q. No. 4 **How does surface tension work to form spherical shape of liquid drop?**

Liquid drop have equal surface tension on all side of drop. Due to this surface molecules of liquid drop experience an inward force of attraction which reduces the surface area of liquid. So, the liquid drops have spherical shape.



12. 2072 Set C Q.No.3i **Explain, why Boiling point of water is lower at higher altitude.**

We know that the boiling point of liquid is that temperature at which the vapour pressure liquid is equal to the atmospheric pressure. The boiling point of liquid can be changed changing external pressure. The liquid boils at lower temperature at higher altitude as atmospheric pressure decreases at higher attitude. Hence, boiling point of water is lower higher altitude.

13. 2072 Set C Q.No. 3 **Define the terms:**

i. Aqueous tension **ii. Surface tension**

i. The partial pressure of water vapour is called aqueous tension. It is denoted by symbol 'f'.

ii. The force per unit length acting perpendicular to the line drawn at the surface of the liquid known as surface tension. Its unit is dynes cm^{-1} (in CGS).

14. 2072 Set E Q.No. 3 **The boiling point of a liquid rises with increasing atmospheric pressure. Give reason.**

Please refer to 2074 Set B Q.No. 3

15. 2071 Supp Q. No. 3 **Give reasons why:**

a. Water drops has a spherical shape?

b. Alcohol can flow easily but honey can't?

a. Due to the surface tension, falling liquid drops are spherical. The surface molecules of liq experience an inward force of attraction that reduces the surface area of liquid. So, the fall liquid drops have spherical shape.

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b. The viscosity of honey is higher than that of alcohol. So, the alcohol can flow easily than honey. We know that higher the viscosity of liquid lower the flowing property of liquid.

16. 2071 (Set D) Q.No. 4 **Boiling point of liquid P and Q are 70°C and 90°C respectively. Which of the two has higher vapour pressure at 70°C? Give reason.** [2]

Ans Two liquid P and Q have boiling point 70°C and 90°C. We know that lower the boiling point of liquid higher the vapour pressure of liquid. So, liquid P has higher vapour pressure at 70°C than the liquid Q having boiling point 90°C. At 70°C liquid Q does not form more vapour and having less vapour pressure because the boiling point of Q liquid has 90°C.

17. 2070 Supp. Q.No. 4 **Differentiate boiling from evaporation.** [1+1]

Ans Boiling point of liquid is the temperature at which the vapour pressure of liquid is equal to the atmospheric pressure but evaporation is the process of escaping surface molecules of liquid in the form of vapour at any temperature.

18. 2070 Set C Q.No. 3 2068 Q.No. 3 **Define surface tension. Write its unit.** [1+1]

Ans Please refer to 2074 Supp Q No. 3

19. 2070 Set D Q.No. 3 **Write any two physical properties of liquid caused by surface tension.** [1+1]

Ans Two physical properties of liquid caused by surface tension are:

a. Cleansing action of soaps and detergents.
b. Efficiency of tooth paste.

20. 2069 (Set B) Q. No. 3 **State the physical principle behind the following phenomenon:** [1+1]

i. Rain drops are spherical.
ii. A drop of ether on your skin disappears fast and the skin feels cool.

Ans

. Due to the surface tension, rain drops are spherical. The surface molecules of liquid experience an inward force of attraction that reduces the surface area of liquid. So, the rain drops have spherical shape.

i. Ether is volatile liquid and evaporates very fast at normal temperature so, disappears fast when it is kept is skin and skin feels cool due to decrease in temperature

21. 2067 Q.No. 6 **Give reason:** [1 + 1]

i. It is more efficient to wash clothes in hot water than cold water.
ii. Evaporation takes place from the surface of the liquid.

Ans

. Hot water lower the surface tension of water and dirt, so it is easier to wash clothes in hot water than cold water.

i. At any temperature the surface molecule spontaneous escape in the form of vapour. This is called evaporation. The kinetic energy of surface molecules have higher than that of bulk molecule and due to this the evaporation takes place in the surface molecule.

22. 2066 Q.No. 5 **How is boiling of Liquid different from Evaporation?** [2]

Ans Please refer to 2070 Supp. Q No. 4

23. 2065 Q. No. 4 **What is surface tension? Mention any one physical properties of liquid due to surface tension.** [2]

Ans The force per unit length acting perpendicular to the line drawn at the surface of the liquid is known as surface tension. Its unit is dynes cm^{-1} (in CGS).

Physical properties of liquid due to surface tension is Liquid drops have spherical shape.

24. 2064 Q.No. 4 **Why does boiling point of liquid rise on increasing pressure?** [2]

Ans Please refer to 2074 Set B Q No. 3

25. 2063 Q.No. 4 **What happens to the vapour pressure of a solvent, when non volatile solute particles are dissolved in it?** [2]

Ans The vapour pressure of solvent is decreased by addition of non-volatile solute particle. This is due to the lowering the vapour pressure of liquid.

26. 2063 Q.No. 9 **Define the term coefficient of viscosity.**

Coefficient of viscosity (η) is defined as the force in dyne per square cm required to maintain difference of velocity of 1cm/sec. between of 1cm apart.

27. 2062 Q.No. 3 **Give reason:**

a. Falling liquid drops are spherical

b. Evaporation takes place from the surface of liquid

a. Due to the surface tension, falling liquid drops are spherical. The surface molecules of liq experience an inward force of attraction that reduces the surface area of liquid. So, the fal liquid drops have spherical shape.

b. At any temperature the surface molecule spontaneous escape in the form of vapour. Th called evaporation. The kinetic energy of surface molecules has higher than that of h molecule and due to this the evaporation takes place in the surface molecule.

28. 2061 Q.No. 3 **What do you mean by boiling point and evaporation?**

Boiling point: The temperature at which the vapour pressure of liquid is equal to atmospheric pressure is called boiling point.

Example: b.p. of alcohol is 78°C

Evaporation: The process of escaping the surface molecule of liquid in the form of vapor at temperature is called evaporation. It depends upon the temperature of liquid.

29. 2061 Q.No. 5 2058 Q.No. 10 **What is meant by viscosity?**

The frictional force or the viscous force acting between two parallel layers of the liquid of cross sectional area, is known as viscosity. Unit of viscosity is poise (p)

$1p = 1 dyne\ cm^{-2} sec.$

Viscosity depends upon the nature of liquid and Temperature.

30. 2059 Q.No. 2 **Define surface tension.**

The force per unit length acting perpendicular to the line drawn at the surface of the liqu known as surface tension. Its unit is dynes cm^{-1} (in CGS).

31. 2056 Q.No. 5 **How is surface tension of a liquid originated?**

Molecules in the bulk of the liquid are attracted equally in all sides so that the attractive pul these molecules is zero. However, the surface molecules are subjected only to the attrac force of the bulk molecules lying below these surface molecules. This inward force of attrac is responsible for the origin of the surface tension.

32. 2055 Q.No. 11 **What do you understand by the term 'Surface tension'?**

Surface tension: The force per unit length acting perpendicular to the line drawn on the sur of liquid is called surface tension.

33. 2054 Q.No. 1 **In terms of vapour pressure, what do you mean by a boiling point of a liquid?**

The temperature at which vapour pressure of a liquid becomes equal to the atmosph pressure is known as boiling point.

34. 2054 Q.No. 4 **The meniscus for mercury in a glass tube is concave down ward. Explain.**

In any liquid there are two types of force are operating in capillary action.

Cohesive force: The attractive force exert between liquid molecules are called cohesive force

Adhesive force: The attractive force exerts between liquid and solid surface is called adhe force.

When cohesive force is greater than adhesive force, liquid is convex upward or con downward.

In the case of mercury liquid, the cohesive force is greater than adhesive force. When a tube is dipped inside the mercury liquid, the mercury rises inside. In this case the cohesive is greater than adhesive force. So, there is concave downward in the mercury liquid.

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2054 Q.No. 13 What do you understand by viscosity? [2]

Please refer to 2061 Q.No. 5

2054 Q.No. 18 What is the effect of temperature on: [2]

a. Surface tension b. Viscosity c. Vapour pressure of liquid

Surface tension decrease by increasing the temperature of liquid.
Viscosity of liquid decrease by increasing the temperature of liquid.
Vapour pressure of liquid increase by increasing the temperature of liquid.

2053 Q.No. 4 Group A Why is Glycerine more viscous than water? [1.5]

Glycerine is more viscous than water because its viscosity is higher than water.
Glycerine molecules have three -OH group but water molecule has only one -OH group. More the -OH group greater the formation of hydrogen bond with molecule, due to this reason glycerine form more hydrogen bond than water and having more molecular association.

2053 Q.No. 5 Group A Why is a mercury droplet spherical? [1.5]

Mercury metal is found in liquid state. In mercury, cohesive force is greater than adhesive force, due to this the surface of liquid tends to contract to the smallest possible area for a given volume of liquid which is called surface tension. Hence, due to the very high surface tension mercury droplets are spherical.

2052 Q.No. 1 Group A Name the physical property behind rise of liquids in capillary tube. [1.5]

Due to the surface tension liquid rise in capillary tube. The adhesive force i.e. the force between liquid and solid surface.

2052 Q.No. 8 Group A Define aqueous tension. Why is it subtracted from the total pressure to determine the pressure of a dry gas? [1.5]

Aqueous tension: The partial pressure of water vapour is known as aqueous tension. It is denoted by 'f'.

When any gas is collected by the downward displacement of water, some water molecules are mixed with gas. This gas is called moist gas. In the moist gas, water vapours also exert pressure. The total pressure of gas is equal to the partial pressure of dry gas and partial pressure of water vapour.

$P_{mix} = P_{dry} + P_{water\ vpour}$

$P_{dry} = P_{mix} - P_{water}$

$P_{dry} = P_{mix} - f$

2052 Q.No. 18 Group A What is evaporation? How does it differ from boiling point? [1.5]

Evaporation is a type of vaporization that occurs on the surface of a liquid as it changes into the gas phase.

Evaporation is surface phenomenon but boiling point is bulk phenomenon. Evaporation occurs below the boiling point but boiling point occurs at any temperature.

2052 Q.No. 22 Group A Define coefficient of viscosity, How coefficient of viscosity is related with viscous force? [1.5]

Coefficient of viscosity: The force in Newton per square metre required to maintain a difference of velocity of one metre per second, between two parallel layers of the liquid at a distance of one meter from each other is called Coefficient of viscosity.

Coefficient of viscosity is related with viscous force(f) as:

$$f = \eta A \frac{dv}{dt}$$

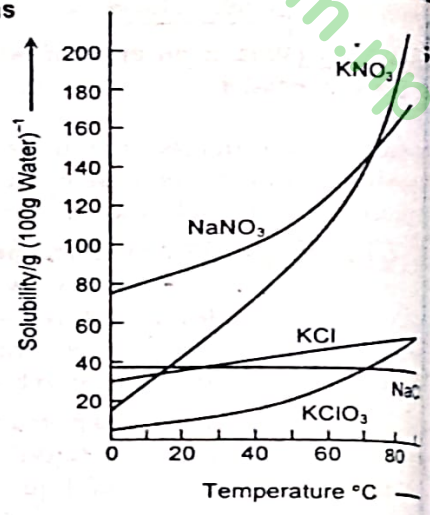
Where, f = viscous force
η = coefficient of viscosity
A = Area of liquid layer
$\frac{dv}{dt}$ = velocity gradient

LONG ANSWER QUESTIONS

43. 2056 Q.No. 32 (c) Write notes on solubility curve and its applications

Solubility Curve: The curve obtained by plotting the solubility of a substance at different temperature is known as solubility curve. It gives the variation of solubility with temperature The solubility curves are of two types.

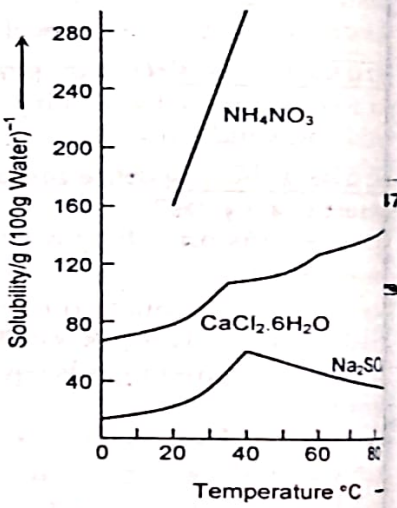
Continuous Solubility Curve: The solubility curve which shows regular increase or decrease in the solubility with temperature Change is called continuous solubility curve. This type of curve is given by anhydrous salt, acid and base like NaCl, KNO_3, KBr, $NaNO_3$ etc.



Discontinuous Solubility Curve: The solubility curve which shows irregular variation in solubility with temperature is known as discontinuous curve. This type of curve is given by hydrated salt like $CuSO_4.5H_2O$, $CaCl_2.6H_2O$, $Na_2SO_4.10H_2O$, $Na_2CO_3.10H_2O$ etc.

Information obtained from Solubility Curve

i. It is used to find the solubility of a substance at a desired temperature
ii. It is used to study the variation of solubility with temperature
iii. It is used to compare the solubility of number of substance at different temperature
iv. It informs about the nature of substance whether it is hydrous or anhydrous.
iv. It also indicates which substance in binary mixture will crystallize first during fractional crystallization.



44. 2052 Q.No. 4 Group C What are solubility curves? What information is obtained from solubility curve?

Please refer to 2056 Q.No. 32 (c)

NUMERICAL PROBLEMS

45. 2075 GIE Q.No. 3 60 gram of saturated solution of a salt has the solubility 60 at 60°C. Calculate the we solute present in it.

Solution

At 60°C

Solubility = 60

i.e. 60 g of solute can be dissolved in 100 g of solvent to make saturated solution. So, the of saturated solution = 60 + 100 = 160 g

Given Weight of saturated solution = 60g

Here,

160 g of saturated solution contains 60 g of solute.

60 g of saturated solution contains $\frac{60 \times 60}{160}$ = 22.5 g of solulte.

Hence, the weight of solute present is 22.5 g.

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s. **2071 (Set C) Q.No. 3** **A salt has solubility 80 and 160 respectively at 20°C and 60°C. Calculate the mass of the crystal formed on cooling 50 g saturated solution from 60° to 20°C.** **[2]**

olution

At 60°C

Solubility = 160

i.e. 160 g of solute can be dissolved in 100 g of solvent to make saturated solution

So, the weight of saturated solution = (160 + 100) = 260 g

Given weight of saturated solution = 50 g

Here,

260 g of saturated solution contains 160 g of solute

1 g of saturated solution contains $\frac{160}{260}$ g of solute

50 g of saturated solution contains $\frac{160}{260} \times 50$ g of solute = 30.76 g

Thus, the weight of solute at 60°C in 50 g solution = 30.76 g

So, the weight of solvent at 60°C in 50 g of solution = (50 – 30.76) = 19.23 g

At 20°C

Solubility = 80

Wt. of saturated solution = (80 + 100) = 180 g

100 g of solvent contains 80 g of solute

19.23 g of solvent contains $\frac{80}{100} \times 19.23 = 15.38$ g

Thus, the weight of crystal formed on cooling temperature from 60oC to 20°C is (30.76 – 15.38) = 15.38 g

7. **2060 Q.No. 24** **Define solubility of a salt. The solubility of salt in water at 75°C is 155. When 80 g of its saturated solution at 75°C was cooled to 15°C, 40 g of the salt was precipitate. Find the solubility of the salt at 15°C.** **[1+4]**

Solubility of salt: The maximum amount of solute that can be dissolved in 100 g of solvent to make a saturated solution at a given temperature is called solubility of salt.

$$\text{Solubility} = \frac{\text{Weight of solute in g}}{\text{Weight of solvent in g}} \times 100$$

Numerical:

At 75°C

Solubility = 165

Weight of solution = 80g

Suppose weight of solute = x g

Weight of solvent = (80 – x) g

We know that,

$$\text{Solubility} = \frac{\text{Weight of solute}}{\text{Weight of sovlent}} \times 100$$

r, $155 = \frac{x}{(80 - x)} \times 100$

r, $12400 - 155x = 100x$

r, $x = 48.62$ g

Weight of salt (x) = 48.62 g

Weight of solvent = (80 – 48.62) = 31.38 g

At 15°C

40 g salt was precipitated

So, weight of salt present = (48.62 – 40) = 8.62 g

$$\text{Solubility} = \frac{\text{Weight of solute}}{\text{Weight of solvent}} \times 100$$

r, $\text{Solubility} = \frac{8.62}{31.38} \times 100 = 27.46$ at 15°C

Hence, solubility of salt at 15°C is 27.46.

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48. 2054 Q.No. 30 **What do you mean by solubility? Represent different types of solubility curves and gi applications. Calculate the weight of crystal formed on cooling 80g of saturated solution from 60°C to Solubility of salt at 60°C and 30°C are 132 and 95 respectively.**

Solubility: The maximum amount of solute that can be dissolved in 100 g of solvent to ma saturated solution at a given temperature is called solubility of salt.

$$\text{Solubility} = \frac{\text{Weight of solute in g}}{\text{Weight of solvent in g}} \times 100$$

Application of solubility curve: Please refer to 2056 Q.No. 32c

Numerical:

At 60°C

Solubility = 132

i.e. 132 g of solute can be dissolved in 100 g of solvent to make saturated solution

So, the weight of saturated solution = (132 + 100) = 232 g

Given weight of saturated solution = 80 g

Given,

232 g of saturated solution contains 132 g of solute

1 g of saturated solution contains $\frac{132}{232}$ gm of solute

80 g of saturated solution contains $\frac{132}{232} \times 80$ g of solute = 45.51 g

Thus, the weight of solute at 60°C in 80 g solution = 45.51 g

So, the weight of solvent at 60°C in 80 g of solution = (80 – 45.51) = 34.48 g

At 30°C

Solubility = 95

Weight of saturated solution = (95 + 100) = 195 g

100 g of solvent contains 95 g of solute

34.48 g of solvent contains $\frac{95}{100} \times 34.48 = 32.75$ g

Thus, the weight of crystal formed on cooling temperature from 60°C to 30°C is (45.51 – 32.75) = 12.76 g

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49. 2052 Q.No. 4 (b) **The solubility of salt at 0°C is 12. How much salt will 50 g of its saturated solution conta that temperature?**

Solution

Given,

Solubility of salt = 12

Weight of saturated solution = 50 g

Weight of salt i.e. solute = ?

Suppose weight of solute = x g

Weight of solvent = (50 – x) g

We know that,

$$\text{Solubility} = \frac{\text{Weight of solute}}{\text{Weight of solvent}} \times 100$$

or, $12 = \frac{x \text{ g}}{(50 - x) \text{ g}} \times 100$

or, $600 - 12x = 100x$

or, $600 = 100x + 12x$

or, $600 = 112x$

or, $x = \frac{600}{112} = 5.35$ g

Thus, the weight of solute is 5.35 g.

3.3 Solid State

VERY SHORT QUESTIONS ANSWER

2076 Set B Q.No. 4ii Give reasons: Deliquescent substances turn into liquid when exposed to atmospheric air. [1]

Deliquescent substances are the substances which can absorb such a huge amount of moisture from the air when exposed to atmospheric air and they dissolve in it to become a liquid. Deliquescence occurs when the vapour pressure of the solution that is formed is less than the partial pressure of water vapour in the air.

2076 Set C Q.No. 4a Give reasons: Efflorescent substances lose water of crystallization after being exposed to air. [1]

Efflorescent substances lose water of crystallization after being exposed to air, when the aqueous vapour pressure of hydrated salt is greater than that of the partial pressure of the water vapour in the air. Example: vapour pressure of washing soda ($Na_2CO_3.10H_2O$) is normally exceed than that of water vapour in the atmosphere.

2075 GIE Q.No. 4 Distinguish between isotropic and anisotropic substance with an example of each. [1+1]

Distinction between isotropic and anisotropic substance:

Isotropic substance	Anisotropic substance
1. It is the substance having similar physical properties in all direction.	1. It is the substance having different physical properties in different direction.
2. Example: glass, rubber	2. Example: diamond

2075 Set A Q.No. 4 Differentiate between efflorescent and deliquescent substances with an example of each. [2]

Following are the differentiate between efflorescent and deliquescent substance:

Efflorescent Substance	Deliquescent Substance
The substance which looses the water of crystallization when exposed in open air for a long time at normal temperature is called efflorescent substance.	The substance which absorbs excess moisture from atmosphere and changed into liquid is known as deliquescent substance.
Example: $FeSO_4.7H_2O$, $Na_2CO3.10H_2O$	Example: anh.$CaCl_2$, anh.$FeCl_3$, anh.$MgCl_2$

2075 Set B Q.No. 4 Distinguish between efflorescent and deliquescent substances with one example of each. [1+1]

Following are the difference between efflorescent and deliquescent substance:

Efflorescent Substance	Deliquescent Substance
The substance which looses the water of crystallization when exposed in open air for a long time at normal temperature is called efflorescent substance.	The substance which absorbs excess moisture from atmosphere and changed into liquid is known as deliquescent substance.
Example: $FeSO_4.7H_2O$, $Na_2CO3.10H_2O$	Example: anh.$CaCl_2$, anh.$FeCl_3$, anh.$MgCl_2$

2074 Supp Q.No. 4 2071 (Set D) Q.No. 3 2069 (Set A) Q. No. 3 2066 Q.No. 10 Differentiate between Crystalline solid and Amorphous solid with an example of each.

The difference between crystalline and amorphous solid are discussed below: [2]

Crystalline solid	Amorphous solid
1. They possess characteristics geometrical shapes.	1. They do not possess characteristics geometrical shape.
2. The constituent particles (atoms, ions or molecules) are arranged in orderly arrangement in a three dimensional pattern.	2. The constituent particle are not orderly arranged in the three dimensional pattern.

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3. They have sharp melting point.	3. They do not have sharp m.p.
4. The crystalline solid possess anisotropic nature i.e. the substance whose physical properties like electrical conductivity, refractive index, thermal conductivity, thermal expansion etc. not in all direction are called anisotropic substance and the phenomenon is known as anisotropy.	4. They possess isotropic in nature.

7. **2074 Set A Q.No. 4 Differentiate between hygroscopic and deliquescent substance giving an example each.**

Following are the difference between hygroscopic and deliquescent substance;

Hygroscopic substance	Deliquescent substance
The substance which absorbs moisture from atmosphere to form hydrated substance is called hygroscopic substance.	The substance which absorbs excess moisture from atmosphere and change into liquid is known as deliquescent substance.
Example: NaOH,KOH,Na_2CO_3 etc.	Example: anhydrous $CaCl_2$, anh. $MgCl_2$, $FeCl_3$ etc.

8. **2074 Set B Q.No. 4 What is meant by water of crystallization? Write an example of it.** [1+

Water of crystallization

The number of water molecule which is associated with one molecule of the solid is called water of crystallization. Example

$Na_2CO_3.10H_2O$ water of crystallization is 10

$MgSO_4.7H_2O$ water of crystallization is 7

9. **2073 Supp Q.No. 4 Mention any two important characteristics of each of the followings.** [1+

i. **Deliquescent substance.**
ii. **Crystalline Solid**

Two important characteristics of

i. **Deliquescent substance:**
   a. It absorbs excess of water vapour from atmospheric air.
   b. It changes into liquid state by absorbing excess water vapour.
ii. **Crystalline solid:**
   a. The constituent particles like atoms, ions or molecules are arranged in a particular order.
   b. It has sharp melting point.

10. **2073 Set C Q. No. 4 Give an example and one important characteristics of each of** [1+

i. **Crystalline solid**
ii. **Efflorescent substance**

i. **Crystalline solid**: It has sharp melting point. Example: Blue vitriol ($CuSO_4.5H_2O$)
ii. **Efflorescent substance**: It loses its water of crystallization when exposed in open air. Example: Washing soda ($Na_2CO_3.10H_2O$)

11. **2073 Set D Q. No. 4 Mention any two important characters of each of the following:** [1+

i. **Efflorescent substance**
ii. **Amorphous solid**

Tow important characters of:

i. **Efflorescent substance:**
   a. It loses its water of crystallization when exposed in open air.
   b. It loses its molecular weight by losing water molecule.
ii. **Amorphous solid:**
   a. It does not have sharp melting point.
   b. It has isotropic property.

12. 2072 Supp Q. No. 2 | 2072 Set D Q.No. 4 | 2070 Set D Q.No. 4 **Differentiate between isotropic and anisotropic substance giving an example of each.** [2]

Please refer to 2075 GIE Q.No. 4

13. 2072 Set C Q.No.4 **What is meant by the terms:** [1+1]
i. Isotropy ii. Hygroscopy

i. **Isotropy:** The physical properties of amorphous sold like electrical conductivity, refractive index, thermal conductivity, thermal expansion, etc. are identical in all directions like gases or liquids. This property is called isotropic and the phenomenon is called isotropy.

ii. **Hygroscopy:** The solid which absorbs certain molecule of water are called hygroscopic solid.

14. 2072 Set E Q.No. 4 **What is meant by water of crystallization? Give any two correct examples of it.** [1+1]

Please refer to 2074 Set B Q.No. 4

15. 2070 Supp. Q.No. 3 | 2070 Set C Q.No. 4 **Give an example of each of the following.** [4×0.5=2]
i. Efflorescent substance ii. Isotropic substance
iii. Anisotropic substance iv. Hygroscopic substance

Example:

a. **Efflorescent substance:** $Na_2CO_3.10H_2O$ (Washing soda)
b. **Isotropic substance:** $CaCO_3$ powder
c. **Anisotropic subatance:** Diamond
d. **Hygroscopic substance:** CaO (calcium oxide)

16. 2069 (Set B) Q. No. 4 **Write an example of each of the followings:** [0.5×4=2]
i. Crystalline solid ii. Hygroscopic substance
iii. Water of crystallization iv. Isotropic substance.

i. **Crystalline solid:** $CuSO_4.5H_2O$ blue vitriol
ii. **Hygroscopic solid:** CaO i.e. calcium oxide
iii. In $CuSO_4.5H_2O$, water of crystallization is 5
iv. **Isotropic substance:** $CaCO_3$ powder

17. 2068 Q.No. 4 **Distinguish between Crystal Lattice and unit cell.** [2]

The difference between crystal lattice and unit cell are discussed below:

Crystal lattice	Unit cell
1. The regular arrangement of ions, atoms or molecules i.e. the constituting particle in the three dimensional space within the crystal is known as crystal lattice.	1. The smallest portion of crystal lattice which are repeated again and again in different direction to produce complete crystal lattice is known as unit cell.

18. 2065 Q. No. 10 **Explain why sodium chloride does not conduct electricity in solid state but a good conductor when molten.** [2]

Solid sodium chloride does not ionize its respective ions i.e. Na^+ and Cl^-. But in the case of molten sodium chloride, it is ionized to Na^+ and Cl^- and migrate towards its respective electrode which helps to conduct the electricity. Hence, solid sodium chloride does not conduct electricity but molten sodium chloride conduct electricity.

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Unit 4

Atomic Structure

VERY SHORT ANSWER QUESTIONS [2 MARKS]

1. 2076 Set B Q.No. 5 2076 Set C Q.No. 5 **What is the conclusion made by de-Broglie? Write its mathema relationship.**

The de-Broglie equation relates a moving particle's wavelength with its momentum. The Broglie wavelength is the wavelength, λ, associated with a moving particle and is rel to its momentum, p, through the Planck constant, h: In other words, you can say that matter behaves like waves.

$$\lambda = \frac{h}{p}$$

2. 2076 Set B Q.No. 6 2076 Set C Q.No. 6 **Identify the four quantum numbers of 19th electron of an elem having atomic number 24.**

The element chromium has atomic number 24 and electronic configuration

$Cr_{24} = 1s^2 2s^2 2p^6 3s^2 sp^6 4s^1 3d^5$

The 19th electron goes to 4s orbital and having the values of four quantum numbers are

Principal quantum number (n) = 4

Azimuthal quantum number (l) = 0

Magnetic quantum number (m) = 0

Spin quantum number (s) = $+\frac{1}{2}$

3. 2075 GIE Q.No. 5 **Write down the electronic configuration of i) copper ii) potassium.**

The electronic configuration of

i. $Cu_{29} = 1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^{10}$

ii. $K_{19} = 1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$

4. 2075 GIE Q.No. 6 **Which principle goes against the concept of Bohr's fixed orbits? State the principle.**

Heisenberg uncertainty principle goes against the concept of Bohr's atomic model. It states t It is impossible to determine the exact position as well as momentum of a microscopic mov particle."

5. 2075 Set A Q.No. 5 **Name the quantum number that specifies the shape of an orbital. What are the values and m for $4s^1$ electrone?**

Azimuthal quantum number specifies the shape of an orbital. The values of l and m for $4s^1$ ar

Principle quantum number (n) = 4

Azimuthal quantum number (l) = 0 to (n – l) = 0 to (4 – 1) = 0 to 3 = 0,1,2,3

For s-orbital the value of l = 0

Magnetic quantum number (m) = $+l$ to $-l$ = 0

For s-orbital the value of m = 0

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6. **2075 Set A Q.No. 6 Calculate the atomic number and number of p-electrons of an atom whose valence shell electronic configuration is $4s^2$? [2]**

The element whose valence shell electronic configuration $4s^2$ may be Calcium (Ca). The atomic number of calcium is 20. The electronic configuration of calcium is

$Ca_{20} = 1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$

The total number of p-electrons are 12.

7. **2075 Set B Q.No. 5 What are the values of quantum numbers n, l and m of the electrons for 3p and 2s? [1+1]**

For 3p

Principle quantum number (n) = 3

Azimuthal quantum number (l) = 0 to (n – 1) = 0 to (3 – 1) = 0 to 2 = 0,1,2

For p-orbital the value of l = 1

Magnetic quantum number (m) = $+l$ to $-l$ = +1 to – 1 = +1,0, – 1

For 2s

Principle quantum number (n) = 2

Azimuthal quantum number (l) = 0 to (n – 1) = 0 to (2 – 1) = 0 to 1 = 0,1

For s-orbital the value of l = 0

Magnetic quantum number (m) = 0

8. **2075 Set B Q.No. 6 Write the electronic configuration of (i) Mg^{++} (ii) Cl^-. [1+1]**

Electronic configuration of:

i. $Mg^{++} = 1s^2 2s^2 2p^6$

ii. $Cl^- = 1s^2 2s^2 2p^6 3s^2 3p^6$

9. **2074 Supp Q.No. 5 Name the quantum number that specifies the energy of an electron in an atom. What designation is given to an orbital having n = 3 and l = 2. [1+1]**

The principal quantum number (n) specifies the energy of an electron in an atom. The orbital having n = 3 represents the 3rd shell i.e. M shell of an atom and l = 2 represents 3rd shell i.e. M shell of an atom which having three sub-shell i.e. s-sub shell, p-sub shell and d-sub shell.

10. **2074 Supp Q.No. 6 2074 Set A Q.No. 6 2074 Set B Q.No. 6 Calculate the atomic number and number of p-electrons of an atom whose valence-shell electronic configuration is $4s^2$. [1+1]**

The element whose valence shell electronic configuration is $4s^2$

$Ca_{20} = 1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$

The atomic number element is 20 and the number of p-electrons is 12.

11. **2074 Set A Q.No. 5 What information is provided by the magnetic quantum number? Give the value of l and m for $3p_x$ orbital. [1+1]**

Magnetic quantum number represents the orientation of orbital in three dimensional spaces i.e. the number of orbital that are present for a particular value of principle quantum number.

For $3p_x$ orbital

The value of azimuthal quantum number (l) = 0 to (n – 1)
= 0 to (3 – 1)
= 0 to 2
= 0,1,2

For p-orbital the value of l is 1

The value of magnetic quantum number (m) = $+l$ to $-l$
= +1 to – 1
= +1, 0, – 1

For p_x-orbital the value of m is +1

12. **2074 Set B Q.No. 5 Name the quantum number that specifies the orientation of an orbital. What are the values of n and l for 3d orbital? [1+1]**

Magnetic quantum number specifies the orientation of an orbital.

For 3d orbital

The value of Principle quantum number (n) = 3
The value of Azimuthal quantum number (l) = 0 to (n – 1)
= 0 to (3 – 1)
= 0 to 2
= 0, 1, 2

For d-orbital, the value of l is 2

13. 2073 Supp Q.No. 5 Assign the values of the quantum number n, l and m for the outermost electro potassium atom.

Electronic configuration of K_{19} is $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$
The outermost electron present in 4s orbital. The value of quantum numbers are:
Principal quantum number (n) = 4
Azimuthal quantum number (l) = 0
Magnetic quantum number (m) = 0

14. 2073 Supp Q.No. 6 Write down the electronic configuration of (i) Cu^{2+} (ii) Ar.

Electronic configuration of:
i. $Cu^{2+} = 1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^7$
ii. $Ar = 1s^2 2s^2 2p^6 3s^2 3p^6$

15. 2073 Set C Q. No. 5 Assign the value of quantum number n and l for the orbital designation (i) (ii) 3px.

i. 2s
The value of
Principle quantum number (n) = 2
Azimuthal quantum number (l) = 0 to (n – 1) = 0 to (2 – 1) = 0 to 1 = 0, 1
For s-orbital value of l = 0

ii. 3 px
The value of
Principle quantum number (n) = 3
Azimuthal quantum number (l) = 0 to (n – 1) = 0 to (3 – 1) = 0 to 2 = 0, 1, 2
For p-orbital value of l = 1

16. 2073 Set C Q. No. 6 Write down the electronic configuration of (i) Cu (ii) Cl^-

Electronic configuration of
i. $Cu_{29} = 1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^{10}$
ii. $Cl^- = 1s^2 2s^2 2p^6 3s^2 3p^6$

17. 2073 Set D Q. No. 5 Assign the value of the quantum number n, l and m for the outermost electron in so atom.

The outer most electronic configuration of sodium is $3s^1$
The value of:
Principal quantum number (n): 3
Azimuthal quantum number (l): 0 to (n – 1) = 0 to (3 – 1) = 0 to 2 = 0,1,2
For s-orbital, l = 0
Magnetic quantum number (m) = +l to –l = +2,+1,0,-1,-2
For s-orbital, m = 0

18. 2073 Set D Q. No. 6 Write down the electronic configuration of
i. Al^{3+} ii. S

Electronic configuration of:
i. $_{13}Al^{+3} = 1s^2 2s^2 2p^6$
ii. $_{16}S = 1s^2 2s^2 2p^6 3s^2 3p^4$

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19. **2072 Supp Q. No. 5 What is meant by quantization of angular momentum?** [1+1]

In an orbit, the angular momentum is always quantized. Quantization means that a quantity can vary only discontinuously to get a specific value i.e. the orbits are possible only after a certain separation and they are not possible continuously.

$mvr = \frac{nh}{4\pi}$

20. **2072 Supp Q. No. 6 The valence shell electronic configuration of two atoms A and B are $4s^1$ and $3s^23p^5$ respectively.**
   a. Write their atomic number
   b. Name their group position in the modern periodic table. [1+1]

The valence shell electronic configuration of atom (A) is $4s^1$, the atom (A) must be potassium which has electronic configuration $1s^22s^22p^63s^23p^64s^1$

The valence shell electronic configuration of atom (B) is $3s^23p^5$, the atom (B) must be chlorine which has electronic configuration $1s^22s^22p^63s^23p^5$

a. The atomic number of A atom i.e. potassium is 19 and the atomic number of B atom i.e. chlorine is 17.

b. In modern periodic table, potassium is placed in group IA and chlorine is placed in group VIIA.

21. **2072 Set C Q.No.5 Write down electronic configuration of:** [1+1]
   i. K^+ ii. Cr

i. K^+
$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$

ii. Cr
$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1\ 3d^5$

22. **2072 Set C Q.No. 6 Which quantum number specifies the shape of orbital? State the quantum number.** [1+1]

Azimuthal quantum number (l) specifies the shape of orbital.

Quantum number: The atomic parameter which is used to describe the position and energy of an electron in an atom is called quantum number.

23. **2072 Set D Q.No. 5 Calculate the atomic number of the following elements whose outermost electrons are represented by:** [1+1]
   i. $3s^2\ 3p^2$ ii. $3d^6$

i. The element whose outermost electrons are represented by $3s^2\ 3p^2$. The element must be silicon.
Si = $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^2$
Atomic number of silicon is 14.

ii. The element whose outermost electrons are represented by $3d^6$. The element must be iron.
Fe = $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^2\ 3d^6\ 4s^2$
Atomic number of silicon is 26.

24. **2072 Set D Q.No. 6 What is meant by degenerate orbitals? Give suitable example of it.** [1+1]

Degenerate orbital: In the case of filling of electrons into the orbital having equal energies, called degenerate orbital. It states that, "Electrons will distribute themselves in degenerate orbitals so as to give maximum multiply as much as possible." Example:

Nitrogen (N) = Atomic number = 7

Electron will distribute in orbital like

↿⇂	↿⇂	1	1	1
1s	2s	2px	2py	2pz

25. **2072 Set E Q.No. 5 Calculate the values of quantum numbers m and l of electrons for 3d and 3p orbitals.** [1+1]

For 3d

Azimuthal quantum number (l) = 0 to (n – 1) = 0 to (3 – 1) = 0 to 2 = 0, 1, 2

For d-orbital value of $l = 2$

Magnetic quantum number (m) = –2, –1, 0, +1, +2

For 3p

Azimuthal quantum number (l) = 0 to (n – 1) = 0 to (3 – 1) = 0 to 2 = 0, 1, 2

For p-orbital value of (l) = 1

Magnetic quantum number (m) = $+l$ to $-l$ = +1 to –1 = +1, 0, –1

26. 2072 Set E Q.No. 6 Write down electronic configuration of (i) Cr (ii) K^+.

Please refer to 2072 Set C Q.No.5

27. 2071 Supp Q. No. 5 Why is Hund's rule called rule of maximum multiplicity?

"Electrons have the general tendency to remain unpaired in an incompletely filled orbital s to have maximum spin multiplicity, minimum energy and maximum stability."

28. 2071 Supp Q. No. 6 What are the limitations of Bohr's model of atom?

Two limitation of Bohr's theory are:

i. A single line of hydrogen spectrum is found to be composed of several closely packed l under better resolving instrument. These lines are called hyperlines. The origin of these line hydrogen spectra is not explained by Bohr.

ii. It fails to explain the splitting of spectral lines into very fine lines under magnetic field external electric field.

29. 2071 (Set C) Q.No. 5 Give the values of n, l and m for outer most electron of sodium.

The electronic configuration of sodium is

$Na_{11} = 1s^2 2s^2 2p^6 3s^1$

The outermost electron present is 3s orbital. The values of all four quantum number are

Principal quantum number (n) = 3

Azimuthal quantum number (l) = 0

Magnetic quantum number (m) = 0

Spin quantum number (s) = $+\frac{1}{2}$

30. 2071 (Set C) Q.No. 7 2071 (Set D) Q.No. 6 Which principle goes against the concept of Bohr's fixed orbi State the principle.

Heisenberg's Uncertainty principle goes against the concept of Bohr's fixed orbits.

Statement: It is impossible to measure simultaneously both the position and the momentum a microscopic moving particle like electrons.

31. 2071 (Set D) Q.No. 5 Write the electronic configuration for the atom having atomic number 19. What are t values of n and l of its outermost electron?

The element having atomic number 19 must be potassium. The electronic configuration potassium (K) is $K_{19} = 1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$

The outermost electron present is 4s orbital. The values of n and l quantum number are

Principal quantum number (n) = 4

Azimuthal quantum number (l) = 0

32. 2070 Supp. Q.No. 5 Mention any two limitation of Bohr's theory.

Please refer to 2071 Supp Q. No 6

33. 2070 Supp. Q.No. 6 What is Hund's rule?

Hund's rule of maximum multiplicity: "Electrons have the general tendency to rem unpaired in an incompletely filled orbital so as to have maximum spin multiplicity, minim energy and maximum stability."

34. 2070 Set C Q.No. 6 2070 Set D Q.No. 5 An atom 'A' has atomic number (Z= 29). Calculate the total number o electrons of A^{++}.

An atom 'A' has atomic number 29. So, A must be copper.

When A lose two electrons it change into A^{++} ion

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$A \longrightarrow A^{++} + 2e^-$

Hence, A^{++} ion has electron (29 – 2) = 27

The electronic configuration of A^{++} ion is

$A^{++} = 1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^7$

Thus, the total s- electron in A^{++} is (2 + 2+ 2+2) = 8

35. 2070 Set C Q.No. 8 **What is Hund's rule?** [2]

Please refer to 2070 Supp. Q.No. 6

36. 2070 Set D Q.No. 6 **State Pauli- exclusion principle.** [2]

Statement: If three of the quantum numbers for two electrons in an atom are identical, the fourth quantum number for the two electrons should differ.

37. 2069 (Set A) Q. No. 5 **Write the electronic configuration of the element with atomic number 18 and 26.** [2]

Atomic number 18 is element Argon: $Ar_{18} = 1s^2 2s^2 2p^6 3s^2 3p^6$

Atomic number 26 is element Iron: $Fe_{26} = 1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^6$

38. 2069 (Set A) Q. No. 6 **Name the spectral series which appears visual part of the electromagnetic spectrum. How is such seris originated?** [2]

The spectral series which appears visual part of the electromagnetic spectrum is Balmer series. When electron jumps to 2nd orbit from different higher energy levels then Balmer series is originated.

39. 2069 (Set B) Q. No. 5 **An element has 2 electrons sin 'K' shell, 8 electrons in 'L' shell and 9 electrons in 'M' shell. Write its electronic configuration and calculate the total numbers of p-electrons.** [1+1]

Potassium element has electrons 2 in K, 8 in L and 9 in M shell. The electronic configuration of potassium is $K_{19} = 1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$

The total number of p-electrons in potassium is 12.

40. 2069 (Set B) Q. No. 6 **How are Balmer Series and Paschen Series orginated in hydrogen spectra?** [1+1]

Balmer Series: When electrons jumps to 2nd orbit from different higher energy levels then Balmer series is obtained. It lies in visible region.

Paschen series: When the electrons jump to 3rd orbit from different higher energy levels then Paschen series is obtained. It lies in infrared region.

41. 2068 Q.No. 5 **Give the values of all four quantum number of 11th electron of Magnesium (Atomic number= 12)** [2]

The element Magnesium has atomic number 12 and electronic configuration is

$Mg_{12} = 1s^2 2s^2 2p^6 3s^2$

The 11th electron goes to 3s orbital and having the values of four quantum numbers are

Principal number (n) = 3

Azimuthal quantum number (l) = 0

Magnetic quantum number (m) = 0

Spin quantum number (s) = $+\frac{1}{2}$

42. 2068 Q.No. 6 **What observations did Rutherford make the following conclusions?**

i. **The atomic centre is positively charged.**

ii. **Most of the space inside the atom is hollow.** [1+1=2]

i. **The atomic centre is positively charged.**

In α-particle scattering experiment, few particles were deviated by a large angle. It made Rutherford concluded that the atomic centre is positively charged.

ii. **Most of the space inside the atom is hollow.**

In α-particle scattering experiment, most of the particles were passed straight without any deviation. It made Rutherford concluded that the most of the space inside the atom is hollow.

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43. 2067 Q.No. 7 **Write down all four quantum number for outermost electron of sodium atom. (Z = 11)**

Please refer to 2071 (Set C) Q.No. 5

44. 2067 Q.No. 8 **What is Bohr's-Bury rule?**

The maximum number of electrons present in any shell of an atom is given by the formula $2n^2$ rule which is given by Bohr Bury and called Bohr Bury rule. Where, n = number of shell.
Example: For K –shell n = 1. So, number of electrons =2
L –shell n = 2. So, number of electrons = 8

45. 2066 Q.No. 6 **What are the values of Principal quantum number (n) and azimuthal quantum number (l) for following orbitals:** [1+
i. 3s ii. 4p

i. 3s
Principal quantum number (n) = 3
Azimuthal quantum number-(l) = 0 to (n – 1) = 0 to (3 – 1) = 0, 1,2
For s-orbital value of l = 0

ii. 4p
Principal quantum number (n) = 4
Azimuthal quantum number (l) = 0 to (n – 1) = 0 to (4 –1) = 0, 1, 2 ,3
For p-orbital value of l = 1

46. 2066 Q.No. 7 **An atom of an element has 24 electrons, what is the total number of s-electrons?**

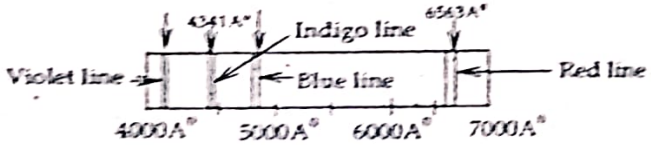
An element having 24 electrons is chromium and electronic configuration of chromium is C
$=1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^5$
The total number of s-electrons is 7

47. 2065 Q. No. 5 **Why is it that electron does not jump into the nucleus?**

We know that electrons revolve around the positively charged nucleus of an atom in particu orbit and it does not loose or gain energy while revolving around the nucleus. The centripe force is balanced by centrifugal force. Therefore, electrons do not jump into the nucleus.

48. 2065 Q. No. 6 **What is meant by atomic spectrum?**

When an electric discharge is passed through H_2 gas, atomic hydrogen is generated and it em light. When beam of this light is passed through prism and the emerging beam is focused o screen or a photographic plate then instead of continuous colored bands, a number of lines a produced. This is called atomic spectrum of hydrogen atoms.



Atomic spectrum of hydrogen in visible region

49. 2064 Q.No. 5 **What observation did Rutherford lead to conclude that the nucleus of atom is very small heavy mass?**

In α-particle scattering experiment, few particles were deviated by a large angle. It ma Rutherford concluded that the atomic centre is positively charged i.e. very small but heavy mass

50. 2063 Q.No. 5 **Write the ground state electronic configuration of Cu (Z = 29) and Cr (Z = 24) in terms of s and d orbitals.**

The electronic configuration of copper is
$Cu_{29} = 1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^{10}$
The electronic configuration of chromium is
$Cr_{24} = 1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^5$

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51. 2062 Q.No. 9 **Write the atomic number of elements whose outermost electronic configuration are represented by (a) $3s^1$ (b) $3p^6$.** [2]

a. The outermost Electronic configuration $3s^1$
$X = 1s^2 2s^2 2p^6 3s^1$. The element X having 11 protons and having $3s^1$ outermost electrons. So, the atomic number of element is 11 i.e. Sodium (Na) , Z = 11

b. The outermost Electronic configuration $3p^6$
$Y = 1s^2 2s^2 2p^6 3s^2 3p^6$. The element Y having 18 protons and having $3p^6$ outermost electron. So, the atomic number of element is 18 i.e. Argon (Ar), Z = 18

52. 2060 Q.No. 6 **An electron of an atom possesses the quantum numbers $n = 2$, $l = 0$ and $m = 0$. What do they mean?** [2]

n =2 indicates the principal quantum number = 2 i.e. 2nd orbit or L shell
$l = 0$ indicates the azimuthal quantum number = 0 i.e. s-orbital
m= 0 indicates the magnetic quantum number = 0 i.e. shape of s-orbital is spherical.
Thus, the electron is in 2s orbital.

53. 2057 Q.No. 7 **Write the electronic configuration of chromium (Atomic number 24) and copper (Atomic no. 29).** [2]

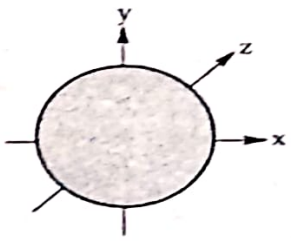
The electronic configuration of chromium is
$Cr_{24} = 1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^5$

54. 2057 Q.No. 11 **What are values for n, l and m for 2 p_x orbital?** [2]

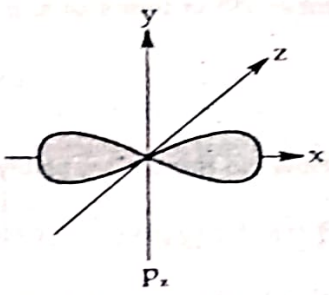
For 2px
Principal quantum (n) = 2
Azimuthal quantum (l) = 0 to (n – 1) = 0 to 1
Magnetic quantum (m) = $-l$ to $+l$ = + 1, 0 , –1

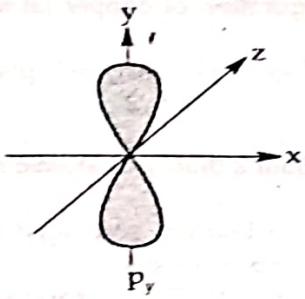
55. 2055 Q.No. 1 **What is an atomic orbital? What are shapes of a s-orbital and p-orbital?** [1.5]

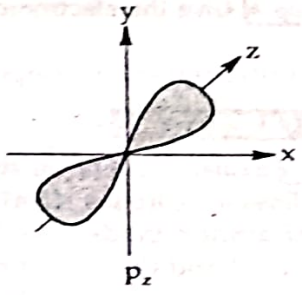
Atomic orbital: The three dimensional space around the nucleus where there is maximum probability of finding an electron is known as atomic orbital.
The shape of s-orbital is spherical.



The shape of p-orbital is dumb bell. i.e. px, py, pz







56. 2054 Q.No. 19 **An atomic orbital has n = 3, what are the possible values of l and m?** [2]

If the value of principal quantum number (n) = 3 , then the value of azimuthal (l) and magnetic (m) quantum number are

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n = 3

l = 0 to (n - 1) = 0 to (3 – 1) = 0 to 2 = 0,1,2

m= (2 l + 1) i.e. – l to + l

If l = 1

m = –1, 0, +1

If l = 2

m = +2, +1, 0, –1, +2

57. **2053 Q.No. 9 Group A** **Write the electron configuration of chromium (atomic number 24) in terms of s,p,d orbitals.** [1.5]

Electronic configuration of chromium is $Cr_{24} = 1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^5$

58. **2052 Q.No. 2 Group A** **Write the shapes of s and p orbital.** [1.5]

Please refer to 2055 Q.No. 1

59. **2052 Q.No. 3 Group A** **Give the electronic configuration of silver (atomic number 47) in terms of s, p and d orbitals.** [1.5]

The electronic configuration of silver is $Ag_{47} = 1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^1 4d^{10}$

60. **2052 Q.No. 9 Group A** **A scientist investigating the electron structure of the element concluded that the K, L and M shells were all full and that the N shell contained four electrons. What is the atomic number of that electron?** [1.5]

The element having full K, L and M shell

K = 2

L = 8

M = 18

And N shell contain 4 electrons

So, the total electrons in an atom is 32

The atomic number of an atom is 32 and the element is Germanium (Ge)

61. **2052 Q.No. 19 Group A** **For n = 4, write all possible values of l and m.** [1.5]

If the value of principle quantum number (n) = 4 then the value of azimuthal and magnetic quantum number are

l = 0 to (n – 1) = 0 to (4 – 1) = 0 to 3 = 0, 1, 2, 3

If l = 1

m = (2 × 1+1) = (2 +1) = 3 = +1, 0, –1

If l = 2

m = (4 + 1) = 5 = +2, +1, 0, –1, –2

If l = 3

m = (2 l + 1) = (2 × 3 + 1) = 7

m = +3, +2, +1, 0, –1, –2, –3

62. **2051 Q.No. 5 Group A** **Give the electronic configuration of copper (atomic number 29) in terms of s, p, d, orbitals.** [2]

The electronic configuration of copper is $Cu_{29} = 1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^{10}$

SHORT ANSWER QUESTIONS

63. **2076 Set B Q.No. 24** **Explain main postulates of Bohr's theory of atomic model. How did this theory justify the origin of spectral lines in hydrogen atom?** [4+1]

Bohr's theory of atomic model: Neil Bohr, a Danish physicist in 1913 tried to solve the defects of Rutherford model and the aim of modification were:

i. To overcome the objection labelled against Rutherford's model of atom regarding the stability of atom.

ii. To explain the origin of line spectra of hydrogen atom.

The basic assumptions of Bohr's atomic model are:

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i. An atom consists of + vely charged nucleus in the centre which is surrounded by – vely charged electrons.

ii. There are definite numbers of circular paths or orbit or shell where electrons are revolved. Each orbit have fixed amount of energy. Such orbits with definite amount of energy are known as stationary energy state or energy level. They are represented by number 1, 2, 3, 4 ... or by symbol K, L, M, N ... etc. The stationary energy defines the stability of an atom.

iii. Only those circular orbits are allowed for the revolution of electrons around the nucleus which having angular momentum of an electron is whole number multiple of $\frac{nh}{4\pi}$.

$$mvr = \frac{nh}{4\pi}$$

Where, m= mass of electron
v = velocity of electron
r = radius of orbit
n = any integer 1, 2, 3 ...
h = Planck's constant

iv. The energy of an orbit or electrons increases with increasing the distance of orbit from the nucleus of atom. $E_2 > E_1$, $E_3 > E_2$

v. The centrifugal force arising from the motion of the electrons and acting away from the nucleus is balanced by the centripetal force acting towards the center of an atom.

vi. Energy is radiated or absorbed only when an electron is jump from one orbit to another. An electron absorb energy when it jumps from low energy level to higher energy level while it radiates energy in the form of electromagnetic waves while it jumps back from higher level to lower level. The magnitude of energy radiated or absorbed is equal to the difference in energy of two different energy levels.

$E_2 - E_1 = h\upsilon$ Where, E_1 = energy level 1
E_2 = energy level 2

$$\text{or, } \upsilon = \frac{E_2 - E_1}{h}$$

$$\text{or, } \frac{c}{\lambda} = \frac{E_2 - E_1}{h} \left[\upsilon = \frac{\text{Volecity of light (c)}}{\text{Wave length } (\lambda)}\right]$$

Corresponding to the wave length or frequency of each quantum of light radiated gives characteristic line spectra or emission spectra.

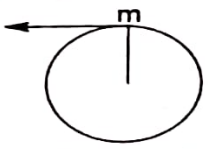


Fig : Electron in Bohr's stationary orbit

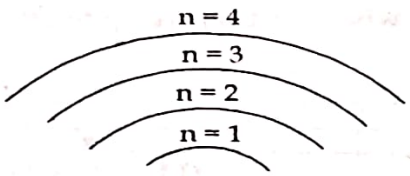


Fig : Distance of the orbits from the nucleus

Main success of Bohr's atomic model

i. It describes the stability of an atom by introducing stationary energy level.

ii. It explains the origin of hydrogen spectra in beautiful manner by the concept of stationary state of electrons.

iii. It gives the idea of quantization of energy.

Limitation of Bohr's atomic model

i. A single line of hydrogen spectrum is found to be composed of several closely packed lines under better resolving instrument. These lines are called hyperlines. The origin of these lines in hydrogen spectra is not explained by Bohr.

ii. It fails to explain the splitting of spectral lines into very fine lines under magnetic field and external electric field.

iii. It fails to explain the splitting of spectral lines for the atoms having large of electrons.

When energy is supplied, electron of different hydrogen atoms absorb different amount of energy and jumps to different energy levels. When transition of electron takes place from higher energy level to lower energy level, energy is transmitted in the form of electromagnetic radiation of particular wavelength, which gives a particular spectral lines. The series of such spectral lines is called spectral series.

64. 2076 Set C Q.No. 24 Why does hydrogen atom produce so many spectral lines eventhough it contains only electron? Draw a well-labelled diagram to explain the various spectral series observed in it. [1+4]

Ans The origin of hydrogen spectra can be explained on the basis of Bohr's atomic theory. Energy is radiated or absorbed only when an electron is jump from one orbit to another. An electron absorb energy when it jumps from low energy level to higher energy level while it radiates energy in the form of electromagnetic waves while it jumps back from higher level to lower level. The magnitude of energy radiated or absorbed is equal to the difference in energy of two different energy levels.

$E_2 - E_1 = h\upsilon$ Where, E_1 = energy level 1
E_2 = energy level 2
h = Planck's constant
υ = Frequency of photon emitted or absorbed.

The electrons in hydrogen atom at ordinary temperature reside in the first orbit and is in the lowest energy state. When electric discharge is passed through hydrogen gas at low pressure then all hydrogen molecules split into atoms. Hydrogen atoms absorb energy and electron moves to higher energy state. The electrons in higher energy state are unstable, hence the electrons jumps to lower energy level emitting electromagnetic radiations which gives rise to five lines spectra. The series of lines obtained when electron jump from higher level (n_2 = 2,3,4,...) to first energy level.

The spectral lines are grouped into five series which is described as:

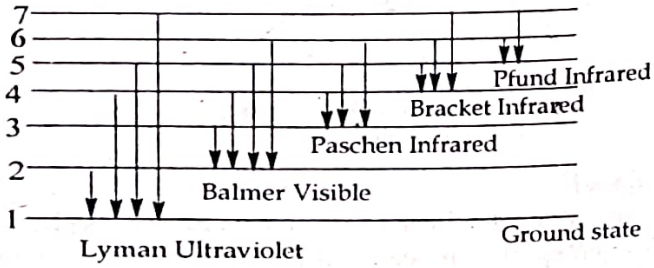
Lyman Series: Lyman series is obtained when the electrons are returned to first orbit from the different higher energy level i.e. 2nd ,3rd ,4th , etc. It lies in ultraviolet region.

Balmer Series: It is obtained when electrons jump to 2nd orbit from different higher energy level. It lies in visible region.

Paschen Series: It is obtained when electrons jump to 3rd orbit from different higher energy level. It lies in infrared region.

Bracket Series: It is obtained when electrons jump to 4th orbit from different higher energy level. It lies in infrared region.

Pfund Series: It is obtained when electrons jump to 5th orbit from different higher energy level. It also lies in infrared region.



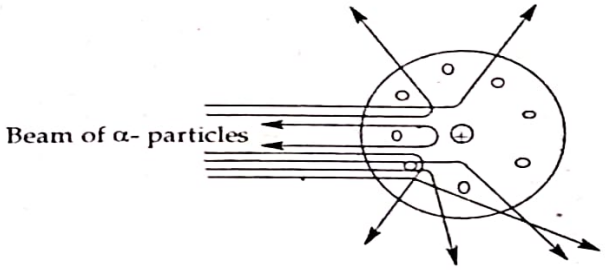
65. 2075 GIE Q.No. 23 What are the conclusions made by Rutherferd's ∝-ray scattering experiments about the structure of atom. Point out the defect of this model. [4+1]

Ans Following conclusions are obtained from these observations:

i. Most of α - particles are passed through the gold foil without any deflection it means there large empty space inside the atom.

ii. Some of particles are deflected by small angle this shows that an atom consists of heavily charged body at the centre of nucleus.

iii. Few particles are returned back in the same direction it means the size or volume of nucleus is very small as compared to the total volume of an atom.



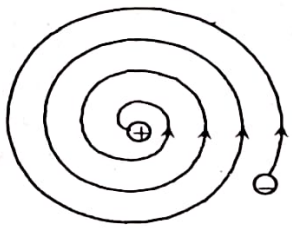
On the basis of the α particle scattering experiment and conclusions made from it, Rutherford proposed a nuclear model of an atom.

The main points of this model are:

i. Atom consists of + vely charged nucleus where the mass of atom is concentrated and the size is very small compared to the size of an atom.
ii. Whole atom is neutral because total number of proton is equal to the total number of electrons.
iii. The + vely charged nucleus is surrounded by the –vely charged electrons.
iv. The motions of electrons are not stationary but are revolving around the nucleus at very high speed.
iv. There are many empty spaces between the nucleus and the revolving electrons.

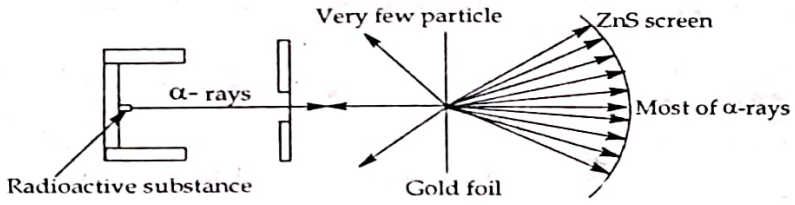
Defects/ Drawbacks of Rutherford's atomic model

i. The electron is revolving around the nucleus under the influence of attractive force and loses the energy in the form of electromagnetic radiations. Due to loss of energy, the speed of electron would slow down and its orbit becomes smaller and smaller and finally the electrons would fall into the nucleus. But electrons actually doesn't fall into the nucleus i.e. atoms are found to be stable.
ii. It doesn't explain atomic spectra of hydrogen.
iii. It doesn't explain how and where electrons are arranged.



66. 2075 Set A Q.No. 23 **Describe Rutherford's nuclear model of an atom. Point out its limitations.** **[4+1]**

In order to determine the position of electron, proton in an atom, Rutherford and his co-workers performed a series of experiment called Rutherford α -scattering experiment.



In this experiment a thin stream of α- particle coming from the radioactive substance i.e. uranium or thorium etc are bombarded on a thin gold foil and the path of α - particles are observed by placing a movable screen coated with ZnS that produces flash of light.

Following are the observations that are obtained:

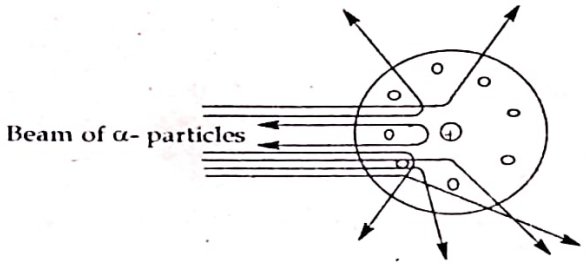
i. Most of the α- particles are assed straight through the gold foil without any deflection.
ii. Some of the α - particles are deflected through the small angles.
iii. Very few particles is returned back in the same direction.

Following conclusions are obtained from these observations:

i. Most of α - particles are passed through the gold foil without any deflection it means there is large empty space inside the atom.

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ii. Some of particles deflected by small angle this shows that an atom consists of heavy + ve charged body at the centre of nucleus.
iii. Few particles are returned back in the same direction it means the size or volume of nucleus is very small as compared to the total volume of an atom.



On the basis of the α particle scattering experiment and conclusions made from it, Rutherford proposed a nuclear model of an atom.

The main points of this model are:

i. Atom consists of + vely charged nucleus where the mass of atom is concentrated and the size is very small compared to the size of an atom.
ii. Whole atom is neutral because total number of proton is equal to the total number of electrons.
iii. The + vely charged nucleus is surrounded by the –vely charged electrons.
iv. The motions of electrons are not stationary but are revolving around the nucleus at very high speed.
iv. There are many empty spaces between the nucleus and the revolving electrons.

Limitations/ Drawbacks of Rutherford's atomic model

i. The electron is revolving around the nucleus under the influence of attractive force and loses the energy in the form of electromagnetic radiations. Due to loss of energy, the speed of electron would slow down and its orbit becomes smaller and smaller and finally the electrons would fall into the nucleus. But electrons actually doesn't fall into the nucleus i.e. atoms are found to be stable.
ii. It doesn't explain atomic spectra of hydrogen.
iii. It doesn't explain how and where electrons are arranged.



67. 2075 Set B Q.No. 23 What are the differences between an atomic orbit and an atomic orbital? Draw the shape of s and p orbitals. [2.5+2.5]

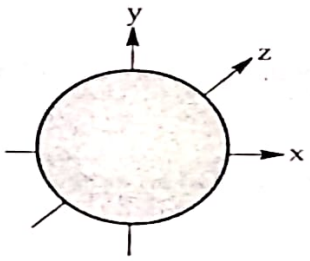
Following are the difference between an atomic orbit and an atomic orbital:

Atomic orbit	Atomic orbital
The paths on which the electrons revolve are called orbits.	An orbital is a shape resulting in the combination of all probable orbits.
It is well-defined circular path followed by electron around nucleus.	It is a region of space around the nucleus where the probability of finding an electron is maximum.
It represents two dimensional motion of electron around nucleus.	It represents three dimensional motion of electron around nucleus.
An orbit can accommodate $2n^2$ electrons in it.	Orbital can accommodate 2, 6, 10 and 14 electrons. It is categorized with s, p, d and f type orbital.
It exists for any two bodies having some mass.	It exists only for an atom and an electron.

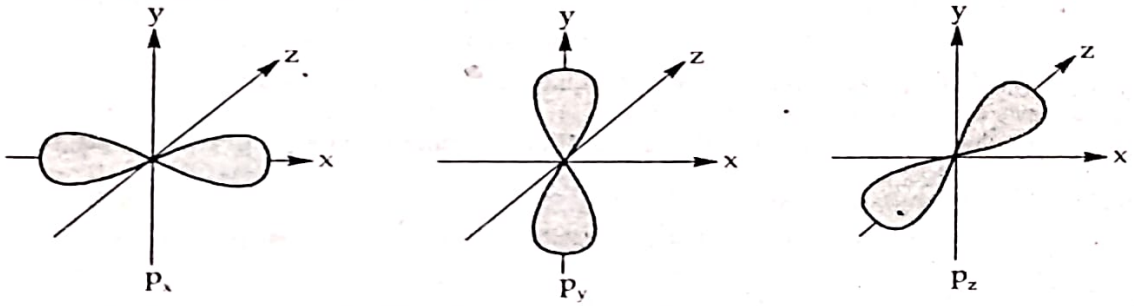
It is circular in shape.	It has different shapes. s-orbital = Spherical shape p-orbital = Dumb bell shape d-orbital = Double dumb bell shape f-orbital = Complex shape
This concept is developed from Bohr's atomic model.	This concept is developed from Heisenberg's uncertainty principle.
It can't explain the geometry of molecules.	It explains the geometry of molecules.

The shape of s-orbital and p-orbital are:

The shape of s-orbital is spherical.



The shape of p-orbital is dumb bell.



68. 2074 Supp Q.No. 23 **Write down the essential postulates of Bohr's model of atom. How did it explain the stability of an atom?** **[5]**

Please refer to 2076 Set B Q.No 24

69. 2074 Set A Q.No. 23 **What are the observations of Rutherford's α-ray scattering experiment? Write down the conclusions drawn from it about the structure of an atom.** **[2.5+2.5]**

Please refer to 2075 Set A Q No 23

70. 2074 Set B Q.No. 23 **Give the essential postulates of Bohr's atomic model.** **[2.5+2.5]**

Please refer to 2076 Set B Q No 24

71. 2072 Supp Q. No. 24 **What are quantum number? An atom has 20 electron. Find out:**
   i. **Its atomic number and total number of p-electrons.**
   ii. **The values of azimuthal quantum number (l) and magnetic quantum number (m) of 19th electron.**
   iii. **Its group position in the periodic table.** **[1+1.5+1.5+1]**

Quantum number: The number that identify the position and energy of an electron in an atom is known as quantum number.

An atom has electrons 20 that mean atomic number of an atom is 20. We know that in an neutral atom the number of electron is equal to number of proton which is equal to atomic number. The atom must be calcium ($_{20}Ca^{40}$).

Electronic configuration of Calcium = $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$

i. Atom number is 20 and number of p-electrons are 12.

ii. The value of azimuthal quantum number (l) of 19th electron is 0 and magnetic quantum number (m) of 19th electron is also 0.

iii. The position of calcium in periodic table is IIA.

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72. 2072 Set C Q.No. 23 What are the basic postulates of Bohr's atomic mode? How is it applied to explain origin of hydrogen spectra?

Please refer to 2076 Set B Q No. 24

73. 2072 Set D Q.No. 23 How did Bohr's atomic model explain the origin of hydrogen spectra? Sketch and various spectral species observed in the atomic spectrum of hydrogen.

Please refer to 2076 Set C Q No. 24

74. 2072 Set E Q.No. 23 What are the observations of Rutherford's scattering experiment? And, write conclusions drawn from the observations. [2.5+

Please refer to 2075 Set A Q No. 23

75. 2071 Supp Q. No. 25 Describe Rutherford's α–ray scattering experiment which led to the discover nucleus. What are the defects of Rutherford's model of atom?

Please refer to 2075 Set A Q No. 23

76. 2071 (Set C) Q.No. 23 What are the postulates of nuclear model of atomic structure according to Rutherfo α-particle scattering experiment? Point out it's limitation.

Please refer to 2075 Set A Q No. 23

77. 2071 (Set D) Q.No. 23 Write down the essential postulates of Bohr's model of an atom. How does this mo correct the defect of Rutherford's atomic model?

First Part: Please refer to 2076 Set B Q.No. 24

Second Part: Bohr's model explained the origin of hydrogen spectra, stability of an atom introducing permitted circular paths and quantization of energy. Due to this Bohr mo became successful in overcoming the defects of Rutherford's atomic model.

78. 2070 Supp. Q.No. 23 What are quantum number? An atom has 20 electrons. Find out:

i. Its atomic numbers and total number of p-electrons.
ii. The value of azimuthal quantum number (*l*) and magnetic quantum number m of the 19th electron of atom.
iii. Its group position in the periodic table. [1+1.5+1.5+1]

Quantum number: The numbers that identify the position and energy of an electron in an at is known as quantum number.

An atom has 20 electrons. That atom must be calcium (Ca).

i. Atomic number of calcium is 20 i.e. equal to the number of proton or number of electrons.
Electronic configuration of calcium is $Ca_{20} = 1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$
The total number of p-electrons are (6 + 6) = 12

ii. The value of Azimuthal quantum number (l) of 19th electron is 0 and the Magnetic quant number (m) of 19th electron is 0

iii. Calcium atom has two electrons in outer most shell. The valence electrons in calcium are 2 a last electrons are filled in s – orbital. So, the calcium lies in Group IIA of periodic table.

79. 2070 Set C Q.No. 23 How does Bohr's theory explain the origin of hydrogen spectra? Name the differ spectral lines with labelled diagram.

Please refer to 2076 Set C Q No. 24

80. 2070 Set D Q.No. 25 What are the conclusions made by Rutherford from his ∝-ray scattering experim about the structure of atom? Mention its limitation.

Please refer to 2075 Set A Q No. 23

81. 2069 (Set A) Q. No. 25 State and explain Hund's rule of maximum multiplicity.

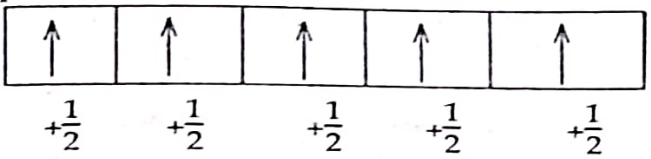
Hund's rule of maximum multiplicity: "Electrons have the general tendency to rem unpaired in an incompletely filled orbital so as to have maximum spin multiplicity, minim energy and maximum stability."

Example:

The electronic configuration of Mn is $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^5$ .All orbitals are completely fi with electrons in this atom except 3d orbital which contains five electrons. According to Hun rule these five electrons should occupy five d-orbitals singly as shown below:

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Example: A

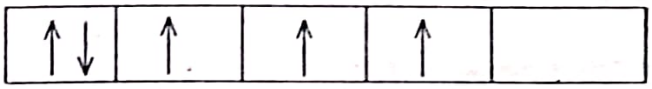


$+\frac{1}{2}$ $+\frac{1}{2}$ $+\frac{1}{2}$ $+\frac{1}{2}$ $+\frac{1}{2}$

The total spin $S = \frac{1}{2} + \frac{1}{2} + \frac{1}{2} + \frac{1}{2} + \frac{1}{2} = \frac{1}{5}$

So, spin multiplicity = $2S + 1 = 2 \times \frac{5}{2} + 1 = 6$. However, if the arrangement of five electrons is done as in case B and C as shown below:

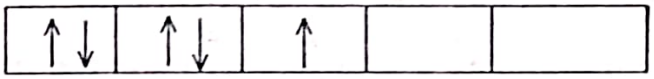
B



0 $+\frac{1}{2}$ $+\frac{1}{2}$ $+\frac{1}{2}$

Then, total spin $S = 0 + \frac{1}{2} + \frac{1}{2} + \frac{1}{2} = \frac{3}{2}$ and spin multiplicity $= 2 \times \frac{3}{2} + 1 = 4$

C



0 0 $+\frac{1}{2}$

Then, total spin $S = + \frac{1}{2}$ and spin multiplicity $= 2 \times \frac{1}{2} + 1 = 2$

Thus, arrangement shown in case A is the correct configuration of 5 electrons in d-orbitals because it has maximum spin multiplicity, minimum energy and maximum stability.

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82. 2069 (Set B) Q. No. 24 **What are the conclusions made by Rutherford's α-ray scattering experiment about the structure of atom. Point out its drawbacks.** **[4+1]**

Please refer to 2075 GIE Q.No. 23

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83. 2068 Q.No. 23 **How does Bohr's theory explain the origin of hydrogen spectra? Name the various Spectral Series observed in the atomic spectrum of hydrogen with a well labeled diagram.** **[1+4]**

Please refer to 2076 Set C Q No. 24

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84. 2067 Q.No. 25 **Write down the essential postulates of Bohr's atomic mode. How did it overcome the Limitation of Rutherford's atomic model?** **[4 + 1]**

First Part: Please refer to 2076 Set B Q.No. 24

Second Part: Please refer to 2071 Set D Q.No. 23

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85. 2066 Q.No. 24 **How does Bohr's theory explain the Origin of hydrogen spectra? Name the different spectral limes with a labelled diagram.** **[1+4]**

Please refer to 2076 Set C Q No. 24

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86. 2065 Q. No. 24 **Define Aufbau Principle. An atom has 2 electrons in first (K) shell, 8 electrons in second (L) shell and 2 electrons in third (M) shell. If so, find out the following:** **[1+1+1+1+1]**

a. **Electronic configuration of the atom.**
b. **Total number of principles quantum numbers.**
c. **Total number of sub-shells**
d. **total number of s-electrons**

Aufbau principle: Electrons are filled in atomic orbital in order of their increasing energy according to this principle. An electron occupies the orbital of lowest energy first. When orbital of lowest energy is filled completely with electrons thereafter remaining electrons are accommodated to orbital of next higher energy. The orbital having highest energy is filled last. The order of filling up of atomic orbital with electron which is called Aufbau principle.

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An atom has

K = 2 L = 8 M = 2

The total electrons in atom is 12 and element is Mg

a. The electronic configuration of Mg is
$Mg_{12} = 1s^2 2s^2 2p^6 3s^2$
b. The principle quantum number (n) is 3
c. Total number of sub-shell = 2 i.e s and p
d. Total number of s-electrons = 6

87. 2064 Q.No. 23 Explain hydrogen spectra in light of Bohr's theory. Why does hydrogen gas show large number of line spectra though H-atom contains one electron?

Please refer to 2076 Set C Q.No. 24

88. 2063 Q.No. 25 How does Bohr's atomic theory explain the origin of hydrogen spectra?

Please refer to 2076 Set C Q.No. 24

89. 2062 Q.No. 24 Write down the main postulates of Bohr's atomic model.

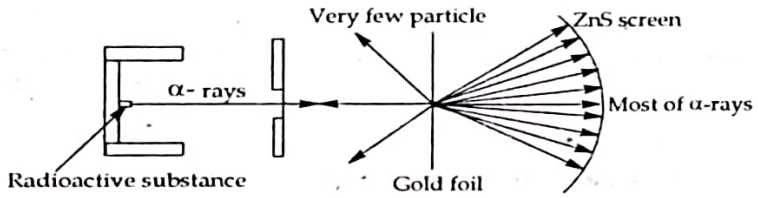
First Part: Please refer to 2076 Set B Q.No. 24

90. 2059 Q.No. 25 How does Bohr's theory predict the origin of line spectra of hydrogen atom?

Please refer to 2076 Set C Q.No. 24

91. 2055 Q.No. 21 Group B What experimental evidence led Rutherford to conclude that (a) the nucleus of the atom contains most of the atomic mass? (b) the nucleus of the atom is positively charged? (c) the atom consists of mostly empty space.

In order to determine the position of electron, proton in an atom, Rutherford and his co-workers performed a series of experiment called Rutherford α -scattering experiment.



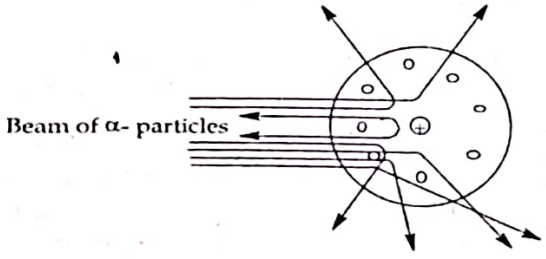
In this experiment a thin stream of α - particle coming from the radioactive substance i.e. uranium or thorium etc are bombarded on a thin gold foil and the path of α -particles are observed by placing a movable screen coated with ZnS that produces flash of light.

Following are the observations that are obtained:

i. Most of the α- particles are passed straight through the gold foil without any deflection.
ii. Some of the α- particles are deflected through the small angles.
iii. Very few particles is returned back in the same direction.

Following conclusions are obtained from these observations:

a. Few particles are returned back in the same direction it means the nucleus of the atom contains most of the atomic mass.
b. Some of particles deflected by small angles this shows that an atom consists of heavy + ve charged body at the centre of nucleus.
c. Most of α- particles are passed through the gold foil without any deflection it means there is large empty space inside the atom.



92. 2052 Q.No. 2 Group B Discuss how Bohr's was able to predict the line spectra of a hydrogen atom. [5]

➢ Please refer to 2076 Set C Q.No. 24

93. 2051 Q.No. 1 Group B Describe Bohr's model of the atom. Draw a picture labelling pertinent parts. [5]

➢ Bohr's theory of atomic model: Please refer to 2076 Set B Q.No. 24

LONG QUESTION ANSWER [10 MARKS]

94. 2060 Q.No. 31

i. Discuss how Rutherford's nuclear model of atom is introduced on the basis of alpha particular scattering experiment. Point out the limitation of the model.
ii. How is the nuclear model of atom improved by Bohr?
iii. Why is Bohr's atomic model appeared to be defective in the light of Heisenberg's uncertainty principle? [4+1+3+2]

➢

i. **Rutherford's nuclear model of atom:** Please refer to 2075 Set A Q.No. 23

ii. **Neil Bohr, a Danish physicist in 1913 tried to solve the defects of Rutherford model and the aim of modification were:**

i. To overcome the objection labelled against Rutherford's model of atom regarding the stability of atom.
ii. To explain the origin of line spectra of hydrogen atom.

The basic assumptions of Bohr's atomic model are:

i. An atom consists of +vely charged nucleus in the centre which is surrounded by –vely charged electrons.
ii. There are definite numbers of circular paths or orbit or shell where electrons are revolved. Each orbit have fixed amount of energy. Such orbits with definite amount of energy are known as stationary energy state or energy level. They are represented by number 1, 2, 3, 4, ... or by symbol K, L, M, N, ... etc. The stationary energy defines the stability of an atom.
iii. Only those circular orbits are allowed for the revolution of electrons around the nucleus which having angular momentum of an electron is whole number multiple of $\frac{nh}{4\pi}$.

According to Bohr

$$mvr = \frac{nh}{4\pi}$$

Where,
m= mass of electron
v = velocity of electron
r = radius of orbit
n = any integer 1,2,3 ...
h = Planck's constant

iv. The energy of an orbit or electrons increases with increasing the distance of orbit from the nucleus of atom. $E_2 > E_1$, $E_3 > E_2$
v. The centrifugal force arising from the motion of the electrons and acting away from the nucleus is balanced by the centripetal force acting towards the center of an atom.
vi. Energy is radiated or absorbed only when an electron is jump from one orbit to another. An electron absorbs energy when it jumps from low energy level to higher energy level while it radiates energy in the form of electromagnetic waves while it jumps back from higher level to lower level. The magnitude of energy radiated or absorbed is equal to the difference in energy of two different energy levels.

$E_2 - E_1 = h\upsilon$ Where, E_1 = energy level 1
E_2 = energy level 2

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or, $\upsilon = \frac{E_2 - E_1}{h}$

or, $\frac{c}{\lambda} = \frac{E_2 - E_1}{h}$ $\left[\upsilon = \frac{\text{Volecity of light (c)}}{\text{Wave length } (\lambda)}\right]$

Corresponding to the wave length or frequency of each quantum of light radiated gives characteristic line spectra or emission spectra.

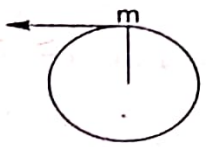


Fig : Electron in Bohr's stationary orbit

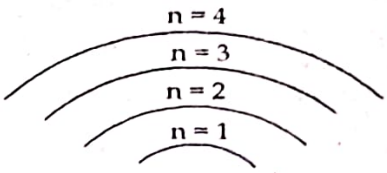


Fig : Distance of the orbits from the nucleus

Main success of Bohr's atomic model

i. It describes the stability of an atom by introducing stationary energy level.
ii. It explains the origin of hydrogen spectra in beautiful manner by the concept of stationary state of electrons.
iii. It gives the idea of quantization of energy.

iii. Heisenberg's Uncertainty principle: This principle can be stated as follows: It is impossible to measure the position and momentum of a subatomic particle in an atom accurately. If Δp be the error in measuring momentum and Δx be the error in measuring position of a subatomic particle of an atom then according to Heisenberg's uncertainty principle,

$$\Delta x \,.\, \Delta p \geq \frac{h}{4\pi}$$

Bohr's atomic model gives the information of

i. Concept of electronic transition from one orbit to another orbit inside an atom.
ii. Concept of quantization of angular momentum of atomic electrons and idea of permissible orbit.

Thus, Bohr's atomic model is defective in the light of Heisenberg's uncertainty principle.

WRITE SHORT NOTES ON

95. 2073 Supp Q.No. 33iv **Postulates of Bohr's atomic model.**

Please refer to 2076 Set B Q.No. 24

96. 2073 Set C Q. No. 33i **Rutherford's α-Scattering experiment and its conclusion**

Please refer to 2075 Set A Q.No. 23

97. 2073 Set D Q. No. 33 i **Rutherford's atomic model**

Please refer to 2075 Set A Q.No. 23

98. 2055 Q.No. 31a **Quantum numbers**

a. Quantum number

The numbers that identify the position and energy of an electron in an atom is known as quantum number. There are four quantum numbers which are described below.

i. Principle quantum number: It represents principle energy level i.e. orbit or shell. It also represents the average distance of an electron from the nucleus and hence determines the energy of an electron and the size of the different shells. Higher the value of principle quantum number, higher is its energy and larger the size of an atom. It is denoted by 'n' and represented by number 1, 2, 3, 4, 5, 6 etc. or by letter K, L, M, N etc.

ii. Azimuthal quantum number: It represents the sub-shell or orbit of an atom. It is denoted by l the value of l ranges from 0 to $(n - 1)$.

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Example:

For $n = 1$(K shell) $l = 0$ to $(1 - 1)$ i.e 0 to 0 and contains one orbital i.e. s-orbital

For $n = 2$ (M shell) $l = 0$ to $(2 - 1)$ i.e. 0 to 1 and contains two orbital i.e. s- and p-orbital

For $n = 3$ (N shell) $l = 0$ to $(3 - 1)$ i.e. 0 to 2 and contains three orbital i.e. s-,p- and d-orbital

iii. **Magnetic quantum number:** It represents the orientation of orbital in three dimensional spaces i.e. the number of orbital that are present for a particular value of principle quantum number and denoted by 'm'. The value ranges from $+l$ to $-l$ i.e. $m = \pm l$ and the formula $m = (2l + 1)$.

Example:

$n = 1$, $l = 0$ to 0 i.e. 0, $m = \pm l = \pm 0$ i.e. 0 i.e. s- orbital

$n = 2$,

$l = 0$ (2s)	$l = 1$ (2p)
$m = \pm l = \pm 0$ i.e. 0	$m = \pm l$ i.e. +1 , 0 , -1
$m = 2l + 1 = 1$	$m = 2l + 1$ i.e. 3

iv. **Spin quantum number:** It represents the spin orientation of the electron about its own axis during its motion in an orbit around the nucleus. It is denoted by 's' .The electron can spin in two ways i.e. clock wise rotation and anti clock wise rotation and represented by $+\frac{1}{2}$ or $-\frac{1}{2}$. It is also denoted by arrow pointing up (↑) an down (↓).

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99. 2058 Q.No. 33b **Bohr's model and explanation of hydrogen spectrum.** [5]

Please refer to 2076 Set C Q.No. 24

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Unit 5

Nuclear Chemistry

VERY SHORT ANSWER QUESTIONS [2 MARKS]

1. 2076 Set B Q.No. 7 | 2074 Set A Q.No. 7 **What is meant by controlled nuclear fission? Write an important application of it.** [1+1]

To maintain a sustained controlled nuclear reaction, for every 2 or 3 neutrons released, only one must be allowed to strike another uranium nucleus. If this ratio is less than one then the reaction will die out; if it is greater than one it will grow uncontrolled (an atomic explosion). A neutron absorbing element must be present to control the amount of free neutrons in the reaction space is called controlled nuclear reaction. Most reactors are controlled by means of control rods that are made of a strongly neutron-absorbent material such as boron or cadmium.

2. 2076 Set C Q.No. 7 **Give an use of each of the following:** [1+1]
   i. **Controlled nuclear fission reaction**
   ii. **Uncontrolled nuclear fission reaction.**

i. Controlled nuclear fission reaction is used in nuclear power plants to generate electricity.
ii. Uncontrolled nuclear fission reaction is used as nuclear weapons or nuclear explosion (bomb).

3. 2075 GIE Q.No. 7 | 2072 Set C Q.No.7 **What is meant by artificial radioactivity? Give an example of it.** [1+1]

The transformation of stable element into another unstable nucleids by bombarding it with high energy particles like α-particles, β-particles, protones and deuterons is called artificial radioactivity or induced radioactivity. Example:

$$_{12}Mg^{24} + {}_{2}He^{4} \longrightarrow {}_{14}Si^{27} + {}_{0}n^{1}$$

Radioactive

$$_{14}Si^{27} \longrightarrow {}_{13}Al^{27} + 1\ e^{0}$$

Stable Positron

4. 2075 Set A Q.No. 7 **Distinguish between artificial radioactivity and natural radioactivity.** [1+1]

Following are the difference between artificial radioactivity and natural radioactivity:

Artificial radioactivity	Natural radioactivity
The process of emission of radiations from naturally occurring isotopes when they are bombarded with sub-atomic particles or high levels of x-rays or gamma rays.	The spontaneous emission of radiations from an unstable nuclei is known as natural radioactivity.
Artificial radioactive elements usually have short half-life.	The most of elements which undergo natural radioactivity usually have long half life.
Artificial radioactivity can be induced even in elements with low atomic numbers.	Natural radioactivity usually occurs in elements with atomic number greater than 82 which are naturally unstable.
$_{92}U^{235} \longrightarrow {}_{90}Th^{231} + {}_{2}He^{4}$	$_{7}N^{14} + {}_{2}He^{4} \longrightarrow {}_{9}F^{18} \longrightarrow {}_{8}O^{17} + {}_{1}H^{1}$

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5. 2075 Set B Q.No. 7 **What are nuclear isotopes? Write an example of it.** [1+1]

Radioactive isotope is also called nuclear isotope, any of several species of the same chemical element with different masses whose nuclei are unstable and dissipate excess energy by spontaneously emitting radiation in the form of alpha, beta, and gamma rays. Example: Cobalt-60, Iodine-131, Carbon-14 etc.

6. 2074 Supp Q.No. 7 **What is meant by nuclear fission reaction? Write an example of it.** [1+1]

Nuclear reaction in which a heavy nucleus splits into two or more lighter nuclei of nearly equal size is called nuclear fission reaction. Here huge amount of energy is liberated.

$_{92}U^{235} + {}_0n^1 \longrightarrow {}_{56}Ba^{144} + {}_{36}Kr^{90} + 2{}_0n^1 + \text{energy}$

7. 2074 Set B Q.No. 7 **Distinguish between controlled nuclear fission and uncontrolled nuclear fission.** [2]

Following are the difference between dontrolled fission and uncontrolled nuclear fission:

Controlled nuclear fission	Uncontrolled nuclear fission
A nuclear fission reaction, whereby the rate of reaction can be moderated externally by allowing just enough number of neutrons to keep the fission reaction rate constant is called a controlled fission reaction.	A fission reaction whereby the reaction is allowed to proceed without any moderation (by removal of neutrons) is called an uncontrolled fission reaction.
Controlled Nuclear fission is used in nuclear reactors and harnessed for electricity where uncontrolled nuclear fission is used for war and nuclear weapons.	An uncontrolled fission reaction is used for nuclear bombs.

8. 2073 Supp Q.No. 7 **Give any two differences between α-particles and β-particles.** [1+1]

Following are the difference:

α-particles	β-particles
The α-particle is the nuleus of helium atom, with two protons and two neutrons inside the nucleus.	The β-particle is nothing but an energetic electron.
The α-particle has two units of positive charge and 4 amu of mass.	The β-particle is just carrying one unit of negative charge and mass is $\frac{1}{4}\times 1836$ than that of an α-particle.

9. 2073 Set C Q. No. 7 **How is natural radioactivity differed from artificial radioactivity?** [2]

The spontaneous emission of radiations from an unstable nuclei is known as natural radioactivity where as the process of emission of radiations from naturally accruing isotopes when they are bombarded with X-rays or γ-rays is called artificial radioactivity.

10. 2073 Set D Q. No. 7 **Define nuclear fusion reaction giving an example.** [1+1]

Nuclear reaction in which two lighter nuclei combine with each other to give stable nucleus with higher mass is called nuclear fusion. Here, large amount of energy is liberated.

$_1H^2 + {}_1H^3 \longrightarrow {}_2He^4 + {}_0n^1 + \text{energy}$

11. 2072 Supp Q. No. 7 **Write fission and fusion reaction giving one example of each.** [1+1]

Nulear fission reaction: The nuclear reaction in which a heavy nucleus splits into two or more lighter nucleus is called nuclear fission reaction. Example:

$_{92}U^{235} + {}_0n^1 \longrightarrow {}_{56}Ba^{144} + {}_{36}Kr^{90} + 2\,{}_0n^1 + \text{Energy}$

Nuclear fusion reaction: The nuclear in which two lighter nucleus combine with each other to give stable nucleus with higher mass is called nuclear fusion reaction. Example:

$_1H^2 + {}_1H^2 \longrightarrow {}_2He^4 + \text{Energy}$

12. 2072 Set D Q.No. 7 2071 Set C Q.No. 6 2071 Set D Q.No. 7 **What is meant by thermonuclear reaction? Write a correct example of it.** [1+1]

A nuclear fusion reaction that takes place between the nuclei of a gas, especially hydrogen, heated to a temperature of several million degrees is called thermonuclear reaction. Example: Nuclear fusion reaction occurs at very high temperature in the sun.

$^3He + {}^4He \longrightarrow {}^7Be + \gamma$

$^{7}Be + e^{-} \longrightarrow {}^{7}Li + \gamma$

$p + {}^{7}Li \longrightarrow 2{}^{4}He$

13. 2072 Set E Q.No. 7 How does natural radioactivity differ from artificial radioactivity? [1+1]

In natural radioactivity, the naturally occurring heavier elements like uranium, polonium, radium etc. are constantly disintegrate spontaneously by emitting α–, β- and γ-rays to change smaller nucleus.

$_{92}U^{238} \longrightarrow {}_{90}Th^{234} + {}_{2}\alpha^{4}$

In the artificial radioactivity, a stable nuclei are converted into radioactive nuclei by bombarding α- particle or neutron.

$_{7}N^{14} + {}_{2}\alpha^{4} \longrightarrow {}_{8}O^{17} + {}_{1}p^{1}$

proton

14. 2071 Supp Q. No.7 What is the difference between nuclear fission and nuclear fusion? [2]

Following are the differences between nuclear fission and nuclear fusion reaction.

Nuclear fusion	Nuclear fission
A reaction in which smaller nuclei fuse together to form heavier nuclei is known as nuclear fusion	A reaction in which heavier nuclei is broken down into smaller nuclei is known as nuclear fission.
$_{1}H^{2} + {}_{1}H^{2} \longrightarrow {}_{2}He^{4} + \gamma$–ray	$_{92}U^{238} \longrightarrow {}_{90}Th^{234} + {}_{2}He^{4}$

15. 2070 Supp. Q.No. 7 2070 Set C Q.No. 11 Define nuclear fission reaction and write an example for it. [1+1]

Please refer to 2074 Supp Q.No. 7

16. 2070 Set D Q.No. 7 What is meant by nuclear reaction? Give an example of it. [1+1]

The type of reaction in which nuclei can be converted into new nuclei. In nuclear reaction one element is converted into another element.

Example:

$_{7}N^{14} + {}_{2}He^{4} \longrightarrow {}_{8}O^{17} + {}_{1}H^{1}$

α-particle proton

17. 2069 Supp Q.No. 9 Give any two differences between nuclear reaction and chemical reactions. [2]

Following are the difference between nuclear reaction and chemical reaction:

Nuclear reaction	Chemical reaction
In nuclear reaction, nucleus of the reacting species are involved.	In chemical reaction, valence electrons of the reacting species are involved.
It does not change with changing in temperature, pressure and catalyst.	It changes with changing in temperature, pressure and catalyst.

18. 2069 (Set A) Q. No. 7 OR Write any two applications of each of the following isotope: ^{60}Co and ^{131}I. [2]

Two application of isotope ^{60}Co are

i. It is used for food irradiation.

ii. It is used in cancer therapy.

Two application of isotope ^{131}I

i. It is used for thyroid disorders (Graves's disease).

ii. It is used to treat goitre.

19. 2069 (Set B) Q. No. 7 Define Nuclear fusion and give an example of it. [1+1]

Please refer to 2073 Set D Q. No. 7

20. 2068 Q.No. 7 What are radioisotopes? State one uses of such isotopes. [1+1]

The isotope of radioactive substance is called radioisotopes. The isotope is the atoms of same element having the same atomic number but different atomic mass. The radioactive substance is the substance which emits radiation i.e α, β, γ –rays. Example:

$^{238}U_{92}$, $^{239}U_{92}$

Use : It is used to produce high amount of heat energy and also used for the treatment of cancer disease.

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Unit 6

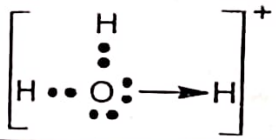
Electronic Theory of Valency and Bonding

VERY SHORT ANSWER QUESTIONS [2 MARKS]

1. 2076 Set B Q.No. 8 Write down the Lewis structure of each of the following: [1+1]
   i. H_2O^+ ii. N_2O

Ans

i. Lewis structure of H_2O^+



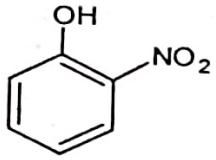
ii. Lewis structure of N_2O



2. 2076 Set B Q.No. 9 2072 Set C Q.No.9 Give an example of each of such molecule having [1+1]
   i. Polar covalent bond ii. Non-polar covalent bond
   iii. Intermolecular hydrogen bond iv. Intramolecular hydrogen bond.

Ans

i. Water (H_2O)
ii. Methane (CH_4)
iii. Ammonia (NH_3)
iv. o-nitro phenol

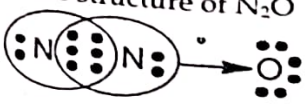


o-nitro phenol

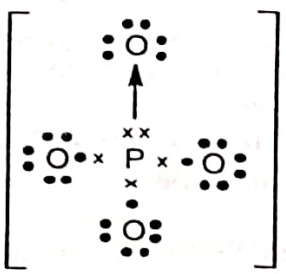
3. 2076 Set C Q.No. 8 Write down the Lewis structure of the following species: [1+1]
   i. N_2O ii. PO_4^{3-}

Ans

i. Lewis structure of N_2O



ii. Lewis structure of PO_4^{3-}



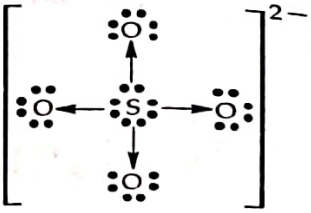
4. 2075 GIE Q.No. 8 Write Lewis structure of i) CO_2 ii) SO_4^{--}

Ans

i. Lewis electron dot formula of CO_2 is



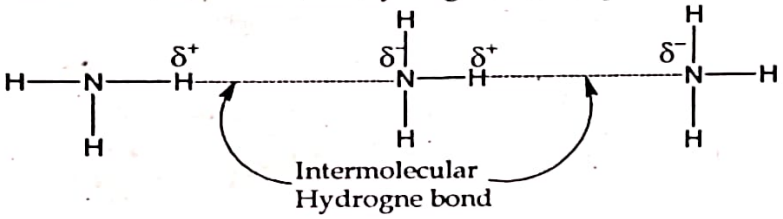
ii. Lewis structure of SO_4^{-2}



5. 2075 GIE Q.No. 9 Give an important applications of each of the followings:
i. Hydrogen bond ii. Dipole moment

Ans

i. **Hydrogen bond:** The electrostatic force of attraction exerted by hydrogen of one molecule to the electronegative atom of another molecule is known as hydrogen bond.
In ammonia molecule intermolecular hydrogen bond is present.

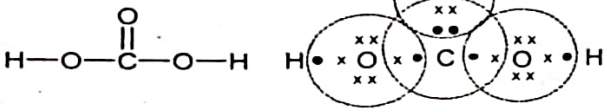


ii. **Dipole moment:** The degree of polarity or ionic character in a bond is expressed in terms of dipole moment (μ). It depends upon the electronegativity difference of the two atoms forming the bond. Thus, it is defined as the product of the magnitude of the charge developed (e) on any one atom and the distance of separation between the charges (d).
i.e. $\mu = e \times d$

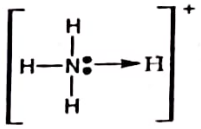
6. 2075 Set A Q.No. 8 Write down the Lewis structure of
i. H_2CO_3 ii. NH_4^+

Ans

i. Lewis structure of H_2CO_3:



ii. Lewis structure of NH_4^+



7. 2075 Set A Q.No. 9 Mention two important applications of dipole moment.

Ans Two applications of dipole moment are:

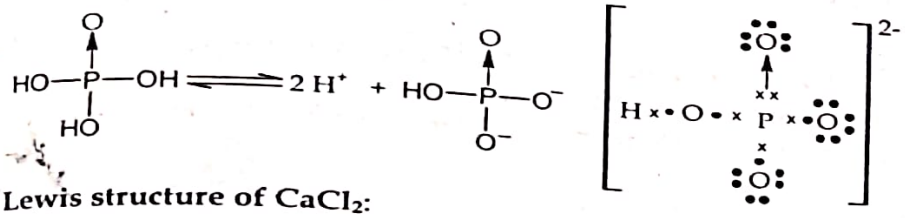
i. **Distinction between polar and non-polar molecules:** The molecules having dipole moment are called polar molecules whereas molecules having zero dipole moment are said to be non-polar molecules. Example: O_2, H_2, Cl_2, N_2 are non-polar molecule and have zero dipole moment. H_2O, NH_3, HF are polar molecules and have dipole moment greater than zero.

ii. **Ionic character in a molecule:** Dipole moment gives an idea about the ionic character in a bond or a molecule. Example: The dipole moment of HCl is 1.03D and the charge separation takes place between H and Cl atom. Therefore, it is ionic molecule.

8. 2075 Set B Q.No. 8 **Draw Lewis structure of:** **[1+1]**
i. HPO_4^{2-} ii. $CaCl_2$

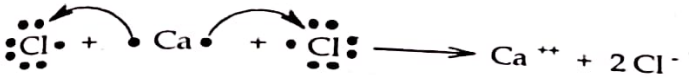
i. **Lewis structure of HPO_4^{2-}:**

$$H_3PO_4 \rightleftharpoons 2H^+ + HPO_4^{2-}$$



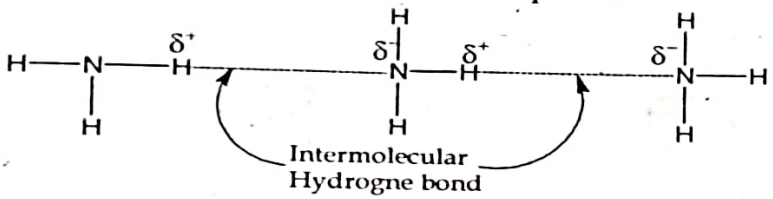
ii. **Lewis structure of $CaCl_2$:**

$$CaCl_2 \rightleftharpoons Ca^{++} + 2Cl^-$$



9. 2075 Set B Q.No. 9 **Define hydrogen bonding and write its two major effects on physical properties of the compounds.** **[1+1]**

Hydrogen bonding: The electrostatic force of attraction exerted by hydrogen of one molecule to the electronegative atom of another molecule is known as hydrogen bond.
In ammonia molecule intermolecular hydrogen bond is present.



Two major effects: Affect of Hydrogen Bond on Physical properties:

a. **Melting point and boiling point:** Stronger the hydrogen bond, greater the intermolecular attraction and larger heat energy is required to separate the molecule before they melt or boil. So the compound having hydrogen bond possess high melting or boiling point. Example: alcohols have high boiling than ether.

b. **Density, surface tension, viscosity:** Strength of hydrogen bond measures the strength of density, surface tension and viscosity of compound. Example: glycerol is more viscous liquid due to larger number of H-bond.

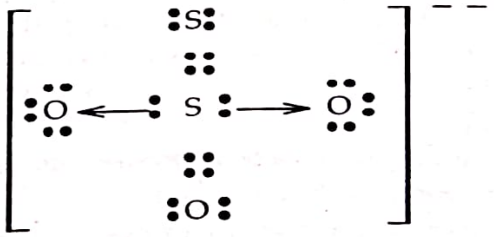
10. 2074 Supp Q.No. 8 2074 Set B Q.No. 8 **Write down the Lewis structure of** **[1+1]**
i. $Na_2S_2O_3$ ii. O_3

i. Lewis structure of $Na_2S_2O_3$

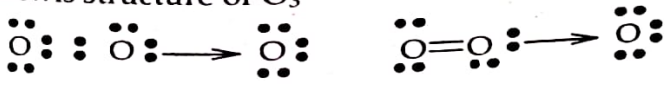
$$Na_2S_2O_3 \rightleftharpoons 2Na^+ + S_2O_3^{--}$$

$$2Na \longrightarrow 2Na^+ + 2e^-$$

$$S + 2e^- \longrightarrow S^{--}$$

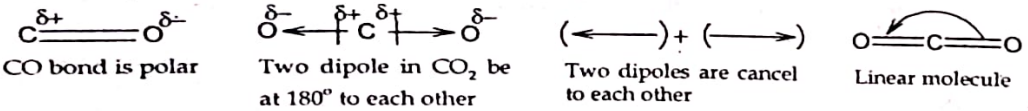


i. Lewis structure of O_3



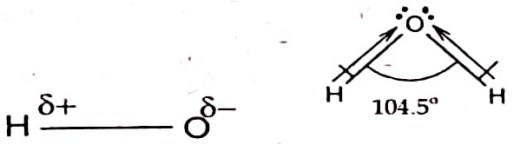
11. 2074 Supp Q.No. 9 H_2O gets angular structure whereas CO_2 gets linear, Why?

Carbondioxide



The two C—O bond in CO_2 is polar due to unequal electronegativity of C and O- atom but dipole moment is zero. This is due to the two polar bond are oriented in such a way that polarity is cancelled each other and the dipole moment is zero. The bond angle of CO_2 is 18 so, have linear structure.

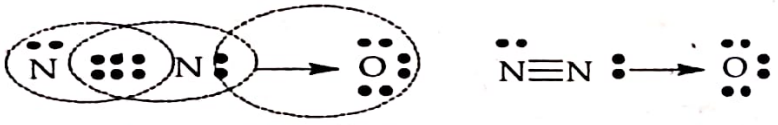
Water



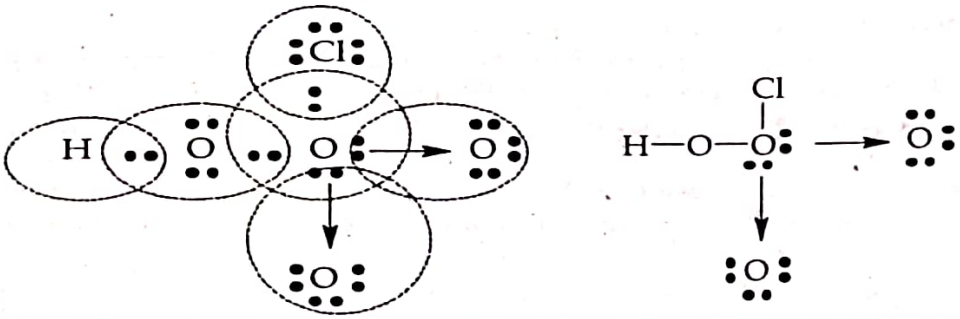
In H_2O the two O—H bond are polar, these bond are not orient opposite to each other since lone pair of electron present on oxygen atom repel the bond pair of electrons and make bond some what angular. That is why CO_2 got linear and H_2O got angular.

12. 2074 Set A Q.No. 8 Write down the Lewis structure of:
i. N_2O ii. $HClO_4$

i. Lewis structure of N_2O is



ii. Lewis structure of $HClO_4$ is



13. 2074 Set A Q.No. 9 How would you explain the polarity of a molecule on the basis of dipole moment?

The polarity of covalent bonds are expressed in terms of dipole moments. Dipole moment is victor quantity. It depends upon the geometry of molecule. The dipole moment of the mole is the resultant of dipole moments of all the bonds involved in the molecules. If dipole mom of a molecule is zero, the molecule is said to be non-polar. If the dipole moment of molecule greater than zero, the molecule is said to be a polar. Example: CO_2 is non-polar mole ($\mu CO_2 = 0D$) but H_2O is polar molecule ($\mu H_2O = 1.8$ D)

14. 2074 Set B Q.No. 9 Define dipole moment and give its an important application.

Dipole moment: Please refer to 2075 GIE Q.No. 9

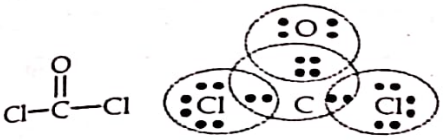
Distinction of polar and non-polar molecules: Non-polar molecules have zero dipole mom but polar molecules have some value of dipole moment.

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15. 2073 Supp Q.No. 8 Draw the Lewis structure of [1+1]
i. $COCl_2$ ii. $KClO_3$

Lewis structure of:

i. $COCl_2$ (carbonyl chloride):

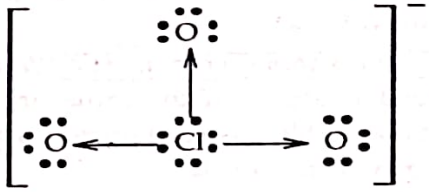


ii. $KClO_3$(Pot. Chlorate):

$$KClO_3 \rightleftharpoons K^+ + ClO_3^-$$

$$K \longrightarrow K^+ + e^-$$

$$Cl^{\bullet} + e^- \longrightarrow Cl^-$$



16. 2073 Supp Q.No. 9 What is meant by intermolecular hydrogen bond? Give its an application. [2]

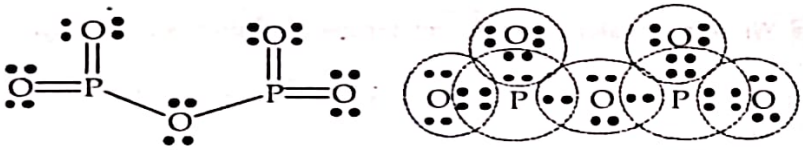
Intermolecular hydrogen bond: The force of attraction between hydrogen atom and more electronegative atom like F,O,N of different molecules is called intermolecular hydrogen bond. Due to hydrogen bond, the solubility and boiling point of compounds are increased.

17. 2073 Set C Q. No. 8 Draw the Lewis structure of (i) KNO_3 (ii) P_2O_5 [1+1]

Lewis structure of

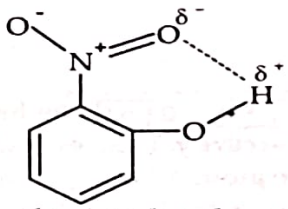
i. KNO_3 = Please refer to 2069 Set – B Q. No. 8

ii. P_2O_5 (diphosphorous pentoxide)



18. 2073 Set C Q. No. 9 What is hydrogen bond? Give an example of intra-molecular hydrogen bond. [1+1]

Hydrogen bond: The electrostatic force of attraction exerted by hydrogen of one molecule to the electronegative atom of another molecule is known as hydrogen bond. Example of intra-molecular hydrogen bond is orthonitrophenol.

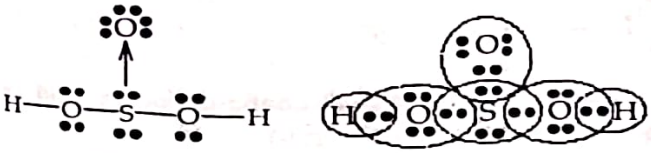


orthonitrophenol

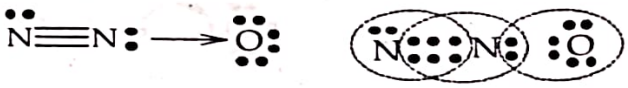
19. 2073 Set D Q. No. 8 Draw the Lewis structure of [1+1]
i. H_2SO_3 ii. N_2O

Lewis structure of

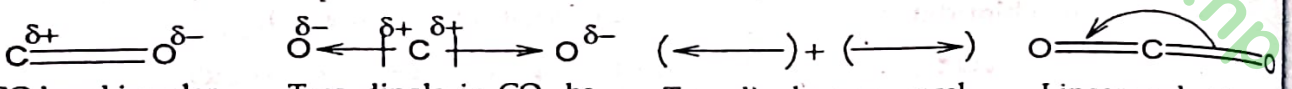
i. H_2SO_3:



ii. N_2O:



20. 2073 Set D Q. No. 9 Each carbon-oxygen bond in CO_2 is polar but CO_2 molecule is non-polar. Explain prop reason.



CO bond is polar | Two dipole in CO_2 be at 180° to each other | Two dipoles are cancel to each other | Linear molecule

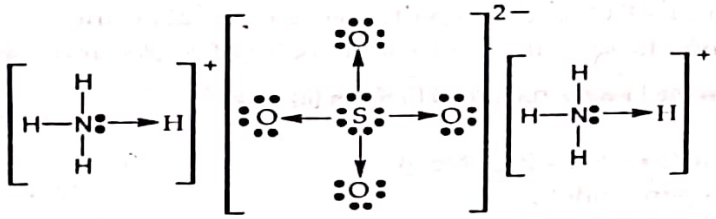
The two C—O bond in CO_2 is polar due to unequal electro negativity of C and O- atom but th dipole moment is zero. This is due the two polar bond are oriented in such a way that th polarity is cancelled each other and the dipole moment is zero. The bond angle of CO_2 is 180 so, have linear structure

21. 2072 Supp Q. No. 8 2070 Set C Q.No. 11 Or What is Octet rule? Write the Lewis structure of $(NH_4)_2SO_4$. [1+

Octet rule: The atoms of the same or different elements, during chemical combination try t achieve stable noble gas configuration having a set of eight electrons in their outermost orbit This is known as octet rule.

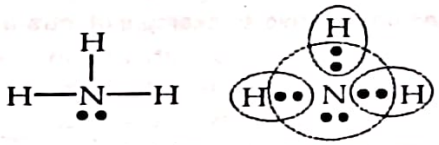
Lewis structure of $(NH_4)_2SO_4$:

$(NH_4)_2SO_4 \rightleftharpoons 2\,NH_4^+ + SO_4^{--}$



22. 2072 Supp Q. No. 9 Write a covalent compound formed by nitrogen and hydrogen. What is its Lewi structure? [2

The covalent compound which is formed by nitrogen and hydrogen is ammonia (NH_3). Th Lewis structure of NH_3 is



23. 2072 Set C Q.No.8 The hypothetical atoms X and Y having outermost shell configuration $3s^2$ and $3s^2\,3p$ respectively. Then, write Lewis structure of the compound formed between X and Y. [2

The atom X having outermost shell configuration $3S^2$. The atom X must be magnesium

$Mg_{12} = 1s^2\,2s^2\,2p^6\,3s^2$

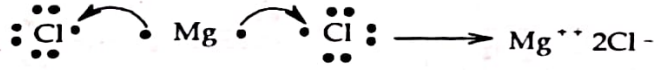
The atom Y having outermost shell configuration $3s^2\,3p^5$. The atom must be chlorine

$Cl_{17} = 1s^2\,2s^2\,2p^6\,3s^2\,3p^5$

The compound formed by magnesium and chlorine is magnesium chloride

$Mg + Cl_2 \longrightarrow Mg\,Cl_2$

The Lewis structure of $MgCl_2$ is



24. 2072 Set D Q.No. 8 Two hypothetical atoms X and Y having outermost shell configuration $3s^2$ and $3s^2 3p$ respectively. Then, write Lewis structure of the compound formed between X and Y. [2

The atom X having outermost shell configuration $3s^2$. The atom X must be magnesium

$Mg = 1s^2\,2s^2\,2p^6\,3s^2$

The atom Y having outermost shell configuration $3s^2\,3p^5$. The atom must be chlorine

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Cl = $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$

The compound formed by magnesium and chlorine is magnesium chloride

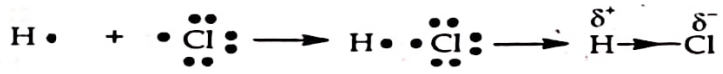
$Mg + Cl_2 \longrightarrow Mg\ Cl_2$

The Lewis structure of $MgCl_2$ is



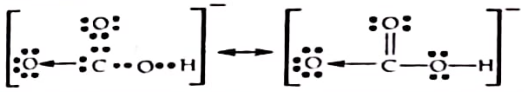
25. **2072 Set D Q.No. 9** **What is meant by the term polar covalent bond? Name any one compound having polar covalent bond.** **[1+1]**

Polar covalent bond: The covalent bond in which the shared pair of electrons are not at equal distance between two atoms or the atoms having different electro negativity is called polar covalent bond. This results in the development of fractional positive and negative charge in them. Example:



26. **2072 Set E Q.No. 8** **Write down Lewis structure of** **[1+1]**
(i) HCO_3^- (ii) $MgCl_2$

i. HCO_3^-



ii. $MgCl_2$



27. **2072 Set E Q.No. 9** **Define dipole moment and write its two major applications.** **[1+1]**

Dipole moment: The degree of polarity or ionic character in a bond is expressed in terms of dipole moment (μ). It depends upon the electronegativity difference of the two atoms forming the bond. Thus, it is defined as the product of the magnitude of the charge developed (e) on any one atom and the distance of separation between the charges (d).

i.e. $\mu = e \times d$

Dipole moment is a vector quantity and is represented by an arrow (⟶) showing the direction from the positive end to the negative end of the dipole. The length of arrow represents the magnitude of dipole moment.



For a non-polar bond, there is no any charge separation i.e. δ = 0. So, dipole moment of non-polar bond is zero.

Applications of dipole moment: Two applications of dipole moments are:

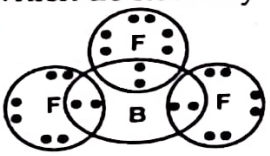
a. **Distinction of polar and non-polar molecules:** Non-polar molecules have zero dipole moment but polar molecules have some value of dipole moment.

b. **Shape of a molecules:** CO_2 molecule is linear due to zero dipole moment, H_2O is angular due to 1.84D, NH_3 is trigonal pyramidal due to 1.49D.

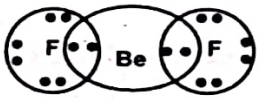
28. **2071 Supp Q. No. 7 OR** **What is octet rule? Name the two compounds in which octet rule is not followed.** **[1+1]**

Octet rule: The atoms of the same or different elements, during chemical combination try to achieve stable noble gas configuration having a set of eight electrons in their outermost orbits. This is known as octet rule.

The compound which do not obey octet rule are BF_3, BeF_2



B = 6 electron

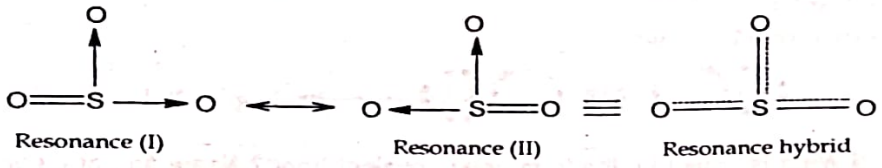


Be = 4 electron

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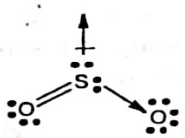
29. 2071 Supp Q. No. 8 What is the resonance structure of SO_3 molecule?

The resonance of SO_3 molecule is



30. 2071 Supp Q. No. 9 The SO_2 molecule has a dipole moment. Is the molecule linear or bent? Explain your reasoning.

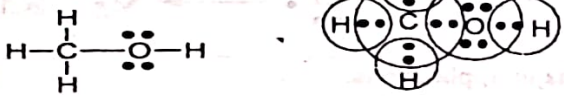
The central atom suphur has lone pair of electron and having some value of dipole moment. Due to this it has bent structure not linear.



31. 2071 (Set C) Q.No. 8 Write the Lewis structure of:

a. CH_3OH b. $CaCO_3$

a. CH_3OH

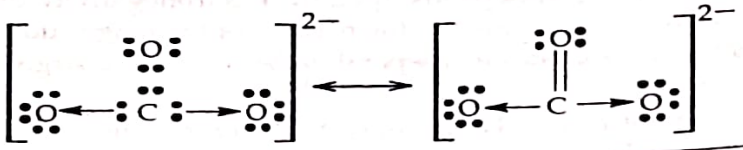


b. $CaCO_3$

$$CaCO_3 \rightleftharpoons Ca^{++} + CO_3^{2-}$$

$$Ca \longrightarrow Ca^{++} + 2e^-$$

$$C + 2e^- \longrightarrow C^{2-}$$



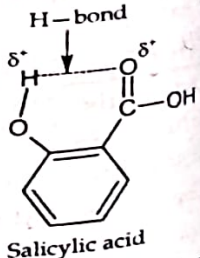
32. 2071 (Set C) Q.No. 9 Differentiate between polar and non-polar covalent bonds with an example of each.

Following are the difference between polar and non-polar covalent bond:

Polar covalent bond	Non-polar covalent bond
It is formed by the combination of two different electronegative atom.	It is formed by the combination of two same electronegative atom.
Polar covalent bonded compound has some value of dipole moment. Example: HCl	Non-polar covalent bonded compound has zero dipole moment. Example: CO_2

33. 2071 (Set D) Q.No. 8 What is meant by intra-molecular hydrogen bonding? Give an example of it.

Hydrogen bond formed between the hydrogen atom and the highly electronegative atom like N, O, F present in the same molecule is called intramolecular hydrogen bond. It is normally observed in organic compound. Example: salicylic acid

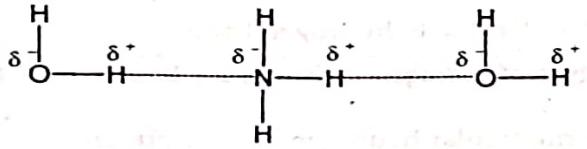


34. 2070 Supp. Q.No. 8 Give any two applications of dipole moment.

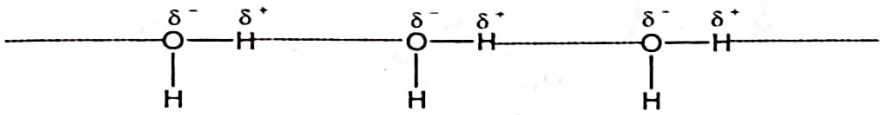
Please refer to 2072 Set E Q.No. 9

35. 2070 Supp. Q.No. 9 **Explain why:**
i. Ammonia is highly soluble in water.
ii. H_2O is liquid where as H_2S is gas. **[1+1]**

i. Ammonia forms hydrogen bond with water molecules. Due to the formation of hydrogen bond ammonia is highly soluble in water.



ii. Water molecules form hydrogen bond with own molecules but hydrogen sulphide molecules do not form hydrogen bond. Due to this water (H_2O) is in liquid state whereas hydrogen sulphide (H_2S) is in gas state.



36. 2070 Set C Q.No. 13 **Write any two applications of dipole moment.** **[1+1]**

Please refer to 2072 Set E Q.No. 9

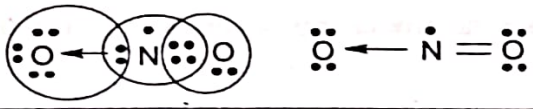
37. 2070 Set C Q.No. 16 **Mention the requirements for a molecule to fulfil for the formation of hydrogen bond.** **[2]**

Requirements for the formation of hydrogen bon:

a. Atom which is attached to hydrogen should have high electro negativity.
b. Electro negative atom should have small size.
c. The electronegative atoms are fluorine, oxygen and nitrogen.

38. 2070 Set D Q.No. 7 Or **Write a Covalent Compound formed by nitrogen and oxygen. What is its Lewis structure?** **[1+1]**

The covalent compound formed by the nitrogen and oxygen is NO_2. The Lewis structure of NO_2 is



39. 2070 Set D Q.No. 8 **Define Polar Covalent bond and give an example of it.** **[1+1]**

The appearance of a small positive charge (δ^+) on the atom having less electro negativity and small negative charge (δ^-) on the atom having more electro negativity due to displacement of shared pair of electron towards more electronegative atom is called polarity and the covalent bond which has such a polar character is called polar covalent bond. Example: $H^{\delta+}—Cl^{\delta-}$

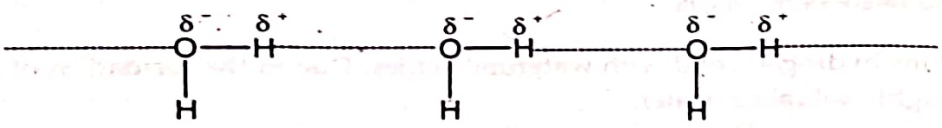
40. 2070 Set D Q.No. 9 **How does hydrogen bond affect the physical properties of compound?** **[2]**

Affect of Hydrogen Bond on Physical properties:

a. **Melting point and boiling point:** Stronger the hydrogen bond, greater the intermolecular attraction and larger heat energy is required to separate the molecule before they melt or boil. So the compound having hydrogen bond possess high melting or boiling point. Example: alcohols have high boiling than ether.
b. **Density, surface tension, viscosity:** Strength of hydrogen bond measures the strength of density, surface tension and viscosity of compound. Example: glycerol is more viscous liquid due to larger number of H-bond.
c. **Physical state:** Water exists in liquid state and hydrogen sulphide exist in gaseous state.
d. **Solubility:** Hydrogen bonding affects the solubility of one substance in another. Example: alcohol and carboxylic acid dissolve in water.

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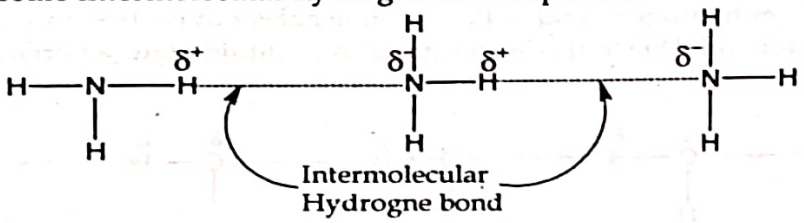
e. **Molecular association:** Some molecule undergoes molecular association due to hydrogen bonding.



Molecular association in water due to hydrogen bond

41. 2069 (Set A) Q. No. 7 **What type of hydrogen bond is found in ammonia? Give any one important use of hydrogen bond.**

In ammonia molecule intermolecular hydrogen bond is present.



Use: it is used to find the compound is polar or non- polar.

42. 2069 (Set A) Q. No. 8 2060 Q.No. 10 **Define dipole moment. What is its unit?** [1+

Dipole moment: The degree of polarity or ionic character in a bond is expressed in terms of dipole moment (μ). It depends upon the electronegativity difference of the two atoms forming the bond. Thus, it is defined as the product of the magnitude of the charge developed (e) on any one atom and the distance of separation between the charges (d).

i.e. $\mu = e \times d$

Dipole moment is a vector quantity and is represented by an arrow (→) showing the direction from the positive end to the negative end of the dipole. The length of arrow represents the magnitude of dipole moment.



For a non-polar bond, there is no any charge separation i.e. δ = 0. So, dipole moment of non-polar bond is zero.

Unit of Dipole Moment:

It is expressed in the unit of Debye (D) 1 Debye=1×10^{-18}esu cm=3.338×10^{-30}Coulomb m.

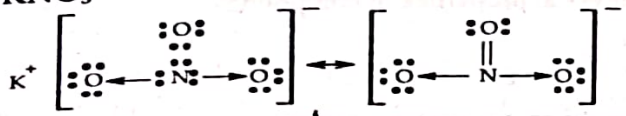
Example: HF = 1.91D, H_2O = 1.84D, HI = 0.38D, HCl = 1.03D, H_2S = 0.90 D

43. 2069 (Set B) Q. No. 8 **Write down the Lewis structure of:**

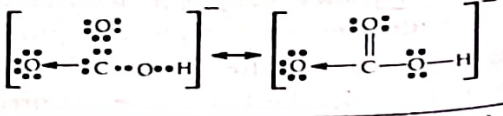
j. KNO_3 ii. HCO_3^-

Lewis structure of

i. KNO_3



ii. HCO_3^-



44. 2069 (Set B) Q. No. 9 **What is hydrogen bond? Given an example of intermolecular hydrogen bond.** [1+

Hydrogen bonding: Please refer to 2075 Set B Q.No. 9

45. 2068 Q.No. 7 OR **Define Octet rule. Name the two compounds in which Octet rule is not obeyed.** [1+

The atoms of the same or different elements, during chemical combination try to achieve stable noble gas configuration having a set of eight electrons in their outermost orbits. This is known as octet rule.

The compound which do not obey octet rule is $AlCl_3$ and PCl_5.

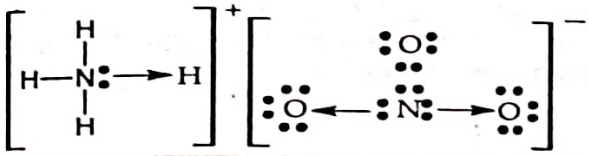
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46. 2068 Q.No. 9 **Write down the Lewis structure of:**
i. NH_4NO_3 ii. H_2O_2 **[1+1]**

i. Lewis structure

$NH_4NO_3 \rightleftharpoons NH_4^+ + NO_3^-$

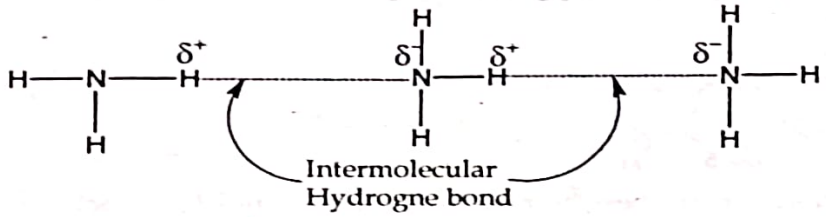


ii. H_2O_2

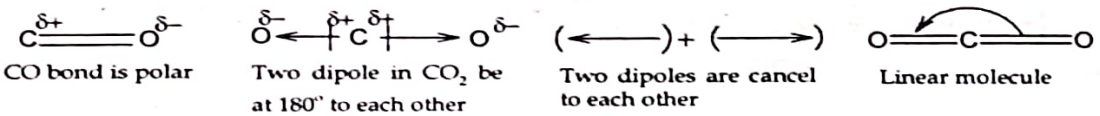


47. 2068 Q.No. 10 **Give reason:**
i. Ammonia has higher boiling point than Phosphine.
ii. CO_2 molecule gets linear structure. **[1+1=2]**

i. Ammonia forms hydrogen bond with each other but phosphine does not form hydrogen bond. Due to this reason ammonia has higher boiling point than phosphine.



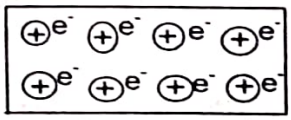
ii. Carbondioxide CO_2 molecule gets linear structure



The two C—O bond in CO_2 is polar due to unequal electronegativity of C and O- atom but the dipole moment is zero. This is due the two polar bond are oriented in such a way that the polarity is cancelled each other and the dipole moment is zero. The bond angle of CO_2 is 180°. So, have linear structure.

48. 2067 Q.No. 10 **How would you explain metallic bond in light of electron-sea model?** **[2]**

Atoms of metal in a solid piece of metal are bonded strongly together by means of very strong bonds called metallic bond. In a metal atom there are more hybrid orbitals than number of valence electrons. Hence the valence electrons become mobile. They can move from one orbital to another and from one atom to another in a solid piece of metal. Thus atoms become positively charged by losing their valence electrons. These positive ions are held in the three dimensional space in a definite pattern in the sea of mobile electrons. Thus, this model is known as electron sea model.



Electron sea model

49. 2067 Q.No. 11 **Explain why:** **[1 +1]**
i. HCl has polar character though it has covalent bond.
ii. CO_2 is a linear molecule but H_2O is not.

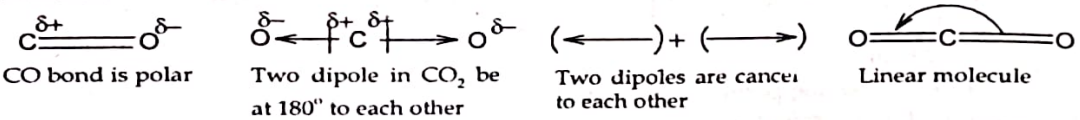
i. If a covalent bond is formed by sharing electron of two different atoms, the shared pair of electron will slightly be displaced towards the atom with more electronegativity. Example: in HCl, the electronegativity of Cl is more than that of H. The shared pair of electron is attracted

towards Cl^- atoms than H-atoms. Due to this partial –ve charge is developed on Cl^- atoms and partial +ve charge is developed on H- atom.

$$H^{\delta+}\text{——}Cl^{\delta-}$$

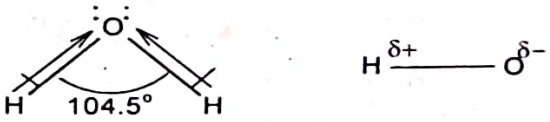
The appearance of a small positive charge(δ^+) on the atom having less electronegativity and small negative charge(δ^-) on the atom having more electronegativity due to displacement of shared pair of electron towards more electronegative atom is called polarity and the covalent bond which has such a polar character is called polar covalent bond.

ii. Carbondioxide



The two C—O bond in CO_2 is polar due to unequal electronegativity of C and O- atom but the dipole moment is zero. This is due the two polar bond are oriented in such a way that the polarity is cancelled each other and the dipole moment is zero. The bond angle of CO_2 is 180° so, have linear structure.

Water



$$H^{\delta+}\text{——}O^{\delta-}$$

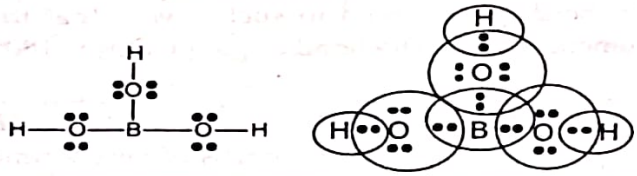
In H_2O the two O—H bond are polar, these bond are not orient opposite to each other since the lone pair of electron present on oxygen atom repel the bond pair of electrons and make the bond some what angular. That is why CO_2 got linear and H_2O got angular.

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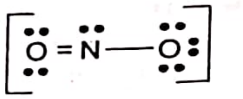
50. 2067 Q.No. 13 Write down the Lewis structure of: [1+1]

i. H_3BO_3 **ii. NO_2^-**

Lewis structure of H_3BO_3



Lewis structure of NO_2^-



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51. 2066 Q.No. 9 Write one important property of the compound formed by the two atoms X and Y whose valence shell electronic configurations are $3s^1$ and $3s^23p^5$ respectively. [2]

X has valence electronic configuration is $3s^1$ that must be sodium Na atom.

Similarly,

Y has valence electronic configuration is $3s^23p^5$ that must be chlorine Cl atom.

When these two element i.e. X and Y i.e. sodium and chlorine combine together to form NaCl salt which is ionic salt.

One important property: It is highly soluble in water.

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52. 2066 Q.No. 11 What is dipole moment? Mention its one important application. [1+1]

Dipole moment: The degree of polarity or ionic character in a bond is expressed in terms of dipole moment (μ). It depends upon the electronegativity difference of the two atoms forming the bond. Thus, it is defined as the product of the magnitude of the charge developed (e) on any one atom and the distance of separation between the charges (d).

i.e. $\mu = e \times d$

Dipole moment is a vector quantity and is represented by an arrow (→) showing the direction from the positive end to the negative end of the dipole. The length of arrow represents the magnitude of dipole moment.

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$H^{\delta+}—F^{\delta-}$ $H^{\delta+}\rightarrow F^{\delta-}$

For a non-polar bond, there is no any charge separation i.e. $\delta = 0$. So, dipole moment of non-polar bond is zero.

Distinction of polar and non-polar molecules: Non-polar molecules have zero dipole moment but polar molecules have some value of dipole moment.

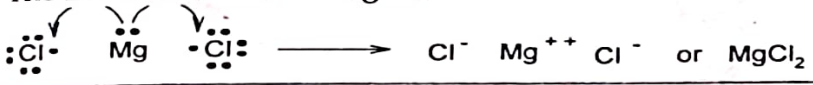
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53. **2065 Q. No. 8 Write the Lewis structure of the compound formed by two elements A and B whose atomic numbers are 12 and 17 respectively.** [2]

Atomic number 12 is magnesium element and atomic number 17 is chlorine element. When these two elements are react then magnesium chloride is formed.

$Mg + Cl_2 \longrightarrow MgCl_2$

The Lewis structure of $MgCl_2$ is



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54. **2065 Q. No. 11 What is hydrogen bond? Write an example.** [2]

Please refer to 2075 GIE Q.No. 9

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55. **2064 Q.No. 7 Each carbon-oxygen bond in CO_2 is polar but CO_2 molecule is non-polar. Give reason.** [2]

Please refer to 2073 Set D Q. No. 9

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56. **2064 Q.No. 9 Two elements A and B have outer most shell electronic configuration $3s^1$ and $2s^2\ 2p^4$ respectively, then name the chemical formed between them.** [2]

The element A has outermost shell electronic configuration $3s^1$. So, the element must be Sodium (Na). $Na_{11} = 1s^2 2s^2 2p^6 3s^1$

The element B has outer mostshell electronic configuration $2s^2 2p^4$. So, the element must be Oxygen (O). $O_8 = 1s^2 2s^2 2p^4$.

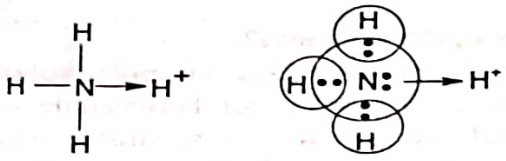
Sodium (Na) reacts with oxygen (O_2), sodium oxide (Na_2O) is formed.

$4\ Na + O_2 \longrightarrow 2\ Na_2O$

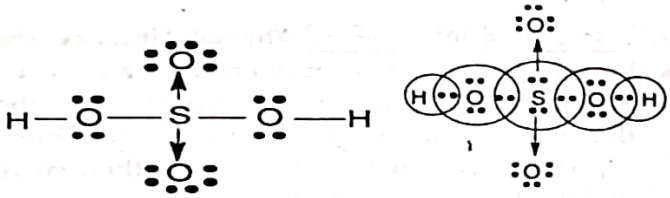
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57. **2063 Q.No. 8 Write the Lewis structure for NH_4^+ and H_2SO_4.** [2]

Lewis structure of NH_4^+



Lewis structure of H_2SO_4

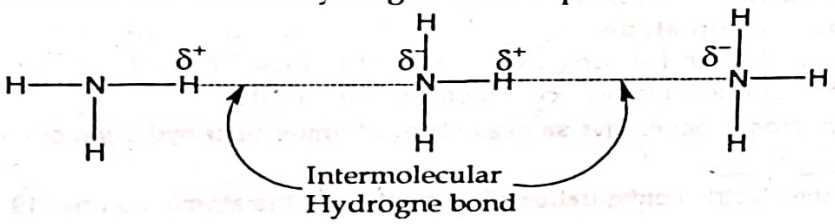


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58. **2063 Q.No. 11 What is meant by hydrogen bonding? Give an example of intermolecular hydrogen bonding.** [2]

The electrostatic force of attraction exerted by hydrogen of one molecule to the electronegative atom of another molecule is known as hydrogen bond.

In ammonia molecule intermolecular hydrogen bond is present.

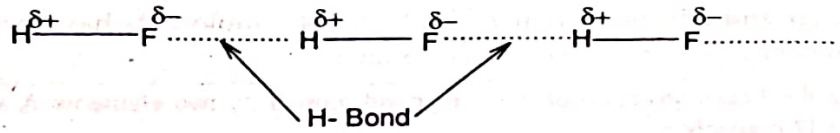


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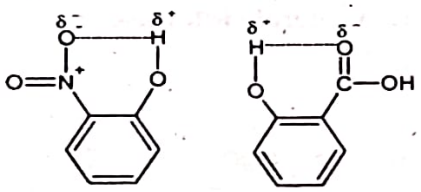
59. 2062 Q.No. 4 Write an example of intermolecular and intramolecular hydrogen bondings.

Intermolecular H-bond

Hydrogenfluoride



Intramolecular H- bond

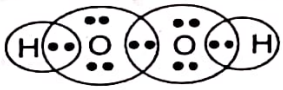


o-nitrophenol Salicylic acid (o-hydroxybenzoic acid)

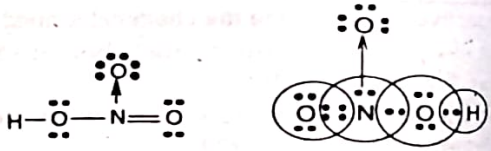
60. 2062 Q.No. 7 Write the Lewis Structure of:

a. H_2O_2 b. HNO_3

a. H_2O_2



b. HNO_3



61. 2062 Q.No. 11 What is meant by metallic bond?

Metal possesses special type of bond known as metallic bond. In this type of bond, metal ion are held together in a metal crystal by the pool of mobile electrons. Therefore, metallic bond defined as the attractive force that binds the metal ions and sea of mobile electrons in the met crystals.

62. 2061 Q.No. 4 2054 Q.No. 12 Why water is an excellent solvent for a polar substance?

Presence of a dipole moment in water, it acts as a good solvent for ionic i.e. polar substanc When an ionic substance is kept in water, the electrostatic force of attraction between the ions the crystal is accompanied by water. Thus, the +ve and –ve ions will be separated from th crystal lattice. These, ions will be then surrounded by water dipoles. That is why water is a excellent solvent for polar substance.

63. 2061 Q.No. 6 Why are solid sodium chloride and diamond non-conductor of electricity?

Solid sodium chloride is an ionic compound and ions present in sodium chloride are strongl held together by an electrostatic force of attraction. They are strongly fixed in crystal lattic Hence, there is no mobile electron or free electron in solid state of sodium chloride. So, sodiu chloride is non-conductor of electricity.

In diamond, all four carbon atoms are sp^3 hybridized and are arranged tetrahedrally. All fo valence electrons are used in forming four covalent bonds. Thus, there are no free electrons i mobile electrons. So, diamond is non-conductor of electricity.

64. 2061 Q.No. 7 Define hydrogen bond. Give an example of intermolecular hydrogen bond.

Please refer to 2063 Q.No. 11

65. 2061 Q.No. 12 Write the electric configuration of elements with the atomic number 19 and 24. Give the na of these elements.

An element having atomic number 19 must be potassium i.e. K

The electronic configuration of K is

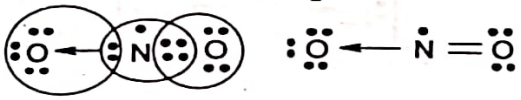
$K_{19} = 1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$

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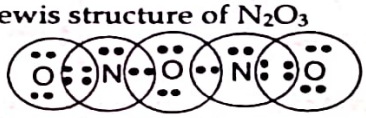
An element having atomic number 24 must be chromium i.e. Cr
The electronic configuration of Cr is
$Cr_{24} = 1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^5$

66. 2061 Q.No. 16 **Write Lewis structure of NO_2 and N_2O_3.** [2]

Lewis structure of NO_2



Lewis structure of N_2O_3



or,



67. 2060 Q.No. 7 **Why are metals malleable and ductile?** [2]

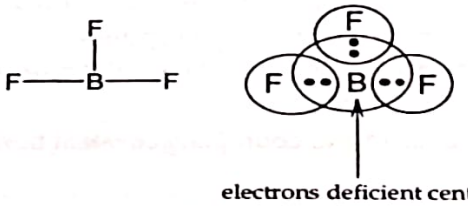
In metal the positive ions of metals are surrounded by sea of mobile electrons and the force of attraction occur between metal ion and mobile electrons which is placed uniform in all directions. The metal ions are held together by strong force in crystal lattice. Due to this one layer of metal can slide over other when they are stretched and hammered. That is why metals are malleable and ductile.

68. 2059 Q.No. 4 **Why is solid sodium chloride a non conductor of electricity?** [2]

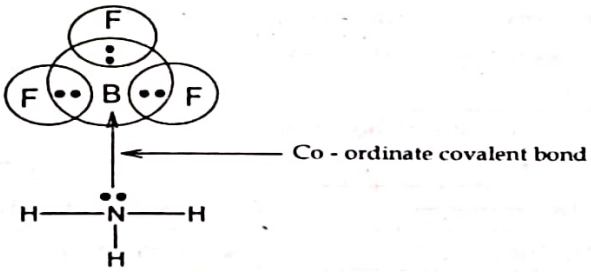
Solid sodium chloride is an ionic compound and ions present in sodium chloride is strongly held together by an electrostatic force of attraction. They are strongly fixed in crystal lattice. Hence, there are no mobile electrons or free electrons in solid state of sodium chloride. So, sodium chloride is non-conductor of electricity.

69. 2058 Q.No. 8 **Write the Lewis dot structure of BF_3 molecule and justify the formulation of coordinate covalent compounds by BF_3.** [2]

Lewis dot structure of BF_3

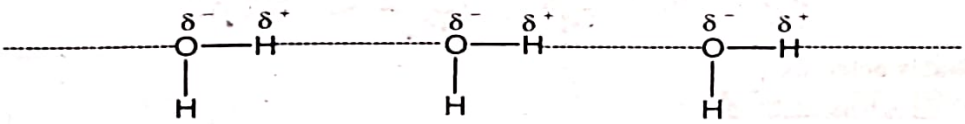


The central atom B atom has electron deficient centre in BF_3 molecule and it can accept a lone pair of electrons from donor atom to be stable and can form co – ordinate covalent bond.



70. 2058 Q.No. 11 **Why does water have such a relatively high boiling point?** [2]

Stronger the hydrogen bond, greater the intermolecular attraction and larger heat energy is required to separate the molecule before they boil. So the compound having hydrogen bond possess high boiling point. That is why water have a relatively high boiling point.



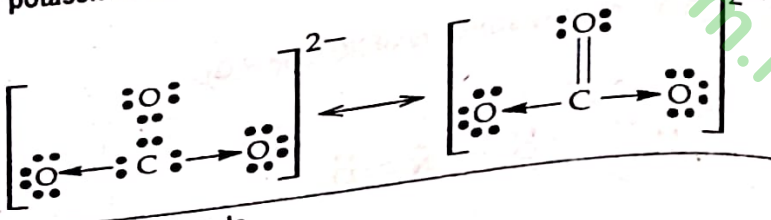
71. 2057 Q.No. 8 Give Lewis structure of potassium carbonate.

Lewis structure of

$$K_2CO_3 \rightleftharpoons 2K^+ + CO_3^{2-}$$

$$2K \longrightarrow 2K^+ + 2e^-$$

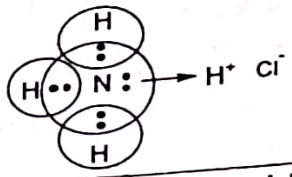
$$C + 2e^- \longrightarrow C^{2-}$$



72. 2056 Q.No. 4 Write the Lewis structure of NH_4Cl molecule.

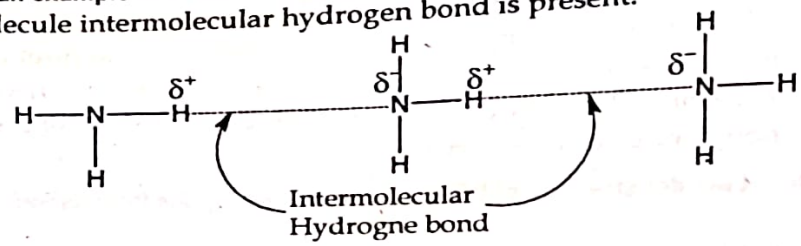
Lewis structure of NH_4Cl

$$NH_4Cl \rightleftharpoons NH_4^+ + Cl^-$$



73. 2056 Q.No. 9 Give an example of intermolecular hydrogen bond. How is it originated?

In ammonia molecule intermolecular hydrogen bond is present.



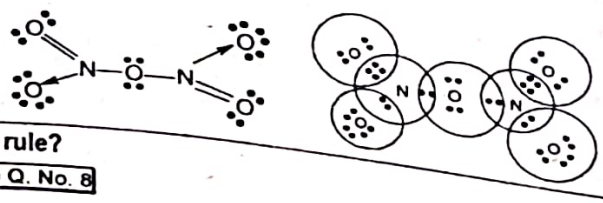
The partially positive charge is developed on the H-atom and negative charged or electronegative element. The +ve pole of H and –ve pole of more electronegative elements are held together by electrostatic force of attraction which is known as H-bonding. Thus H-bonding is originated.

74. 2055 Q.No. 3 Distinguish between a covalent and coordinate covalent bond.

Following are the difference

Covalent	Coordinate covalent
1. This type of bond is formed by the mutual sharing of electrons between any two combining atom of same or different element.	1. This type of bond is formed by the transfer of lone pair of electrons from one atom to another.
2. The compound formed by covalent bond is generally low m.p. and b.p.	2. The compound formed by covalent bond is generally high m.p. and b.p.
3. It is denoted by dash line ——	3. It is denoted by arrow ⟶
4. It may be polar or non-polar.	4. It is semipolar.

75. 2055 Q.No. 16 Draw Lewis structure of N_2O_5.



76. 2054 Q.No. 5 What is octet rule?

Please refer to 2072 Supp Q. No. 8

77. 2054 Q.No. 17 **Write the Lewis structure of SO_2, molecule.** [2]

Lewis structure of SO_2



78. 2053 Q.No. 3 Group A **Write Lewis electron dot formula for carbon dioxide.** [1.5]

Please refer to 2075 GIE Q.No. 8

79. 2053 Q.No. 11 Group A **What types of bonds are involved in oxygen and calcium floride molecules?** [1.5]

In oxygen molecule (O_2) double covalent bond is involved

O=O

In calcium fluoride molecule electrovalent bond is involved



80. 2053 Q.No. 12 Group A **Write the Lewis structure of SO_4^{-2}.** [1.5]

Please refer to 2075 GIE Q.No. 8

81. 2052 Q.No. 6 Group A **Explain why CO_2 got linear structure while H_2O got angular structure.** [1.5]

Please refer to 2074 Supp Q.No. 9

82. 2052 Q.No. 13 Group A **Write the Lewis structure of CCl_4.** [1.5]

Lewis structure of CCl_4



83. 2052 Q.No. 16 Group A 2051 Q.No. 2 Group A **Define Lewis base. Give an example of Lewis base.** [1.5]

The chemical substance which can donate one or more lone pair of electrons to the electron deficient species so as to form co – ordinate covalent bond is known as Lewis base. Example: NH_3

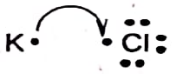
84. 2052 Q.No. 25 Group A **How does a covalent bond differ from an ionic bond?** [1.5]

Covalent bond is formed by the mutual sharing of electrons between any two combining atom but ionic bond is formed by the transfer of electron from one atom to another atom. So, covalent bond is differed from ionic bond.

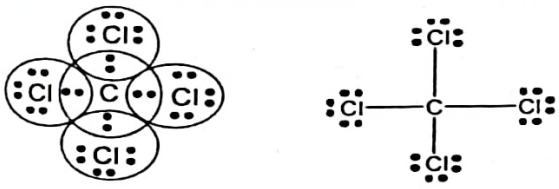
SHORT ANSWER QUESTIONS

85. 2060 Q.No. 23 **Discuss the formation of potassium chloride and carbon tetrachloride molecules on the basis of electronic theory of valency. Give any two characteristics of ionic and covalent compounds.** [5]

Potassium chloride is ionic compound which is formed by the transfer of electron from one atom to another atom i.e. K atom loses one electron and Cl atom gains one electron.



In carbon tetrachloride i.e. CCl_4 , the four valence electrons of carbon atom share to the four chlorine atom to form four covalent bond between carbon and chlorine atom.



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Two characteristic of
Ionic compound

i. They are held together by strong electrostatic force of attraction.
ii. They have high m.p. and b.p.

Covalent compound

i. They are held together by weak electrostatic force of attraction.
ii. They have low m.p. and b.p.

---

86. 2059 Q.No. 23 The elements X and Y have the atomic numbers 11 and 17 respectively.

i. Write the electric configuration of the elements.
ii. State the type of bond when they combine to form a compound.
iii. In which group of periodic table do they belong?

i. X having atomic number 11. So, the element must be sodium. The electron configuration sodium is

$Na_{11} = 1s^2 2s^2 2p^6 3s^1$

Y having atomic number 17. So, the element must be chlorine. The electronic configuration chlorine is

$Cl_{17} = 1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$

ii. When sodium combines with chlorine then ionic compound sodium chloride is formed whi contains ionic bond.



iii. Sodium belongs to the group IA of periodic table but chlorine belongs to the group VIIA periodic table.

---

87. 2053 Q.No. 3 Group B X, Y and Z represent elements of atomic number 1, 6 and 17 respectively.

a. Write the electron structure of X, Y and Z.
b. Place the elements in the appropriate group of the periodic table.
c. Write the formula and the Lewis structures of the covalent compounds formed between: (i) X and Y (ii) and Z

Atomic number 1 i.e. X is hydrogen element
Atomic number 6 i.e. Y is carbon element
Atomic number 17 i.e. Z is chlorine element

a. The electronic configuration of hydrogen i.e. X is

$H_1 = 1s^1$

The electronic configuration of carbon i.e. Y is

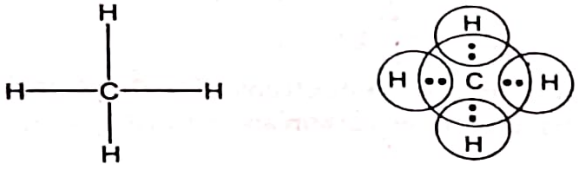
$C_6 = 1s^2 2s^2 2p^2$

The electronic configuration of chlorine i.e. Y is

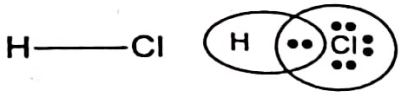
$Cl_{17} = 1s^2 2s^2 2p^6 3s^2 3p^5$

b. The element X i.e. hydrogen is in group IA
The element Y i.e. carbon is in group IVA
The element Z i.e. chlorine is in group VIIA

c. The compound formed by X and Y i.e. H and carbon is CH_4
Lewis structure of CH_4



The compound formed by X and Z is HCl
The Lewis structure of HCl is



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WRITE SHORT NOTES ON

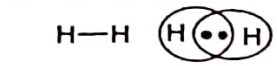
88. 2063 Q.No. 33(b) **Covalent bonding.** [5]

Covalent Bond : The bond which is formed between two or more atoms of the same or different elements by equal sharing of electron between any two combining atom is known as covalent bond. It may be polar or non polar. It is denoted by dash line (—).

Types of covalent bond:

Depending up on the number of electrons are shared. There are types of covalent bond.

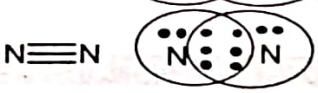
Single covalent bond: It is formed by the sharing of one electron between the two combining atoms. Example: H_2, F_2 etc.



Double covalent bond: It is formed by the sharing of two electrons between the two combining atoms. Example: O_2, CO_2 etc.



Triple covalent bond: It is formed by the sharing of three electrons between two combining atoms. N_2, C_2H_2 etc.



Some common properties of covalent compounds:

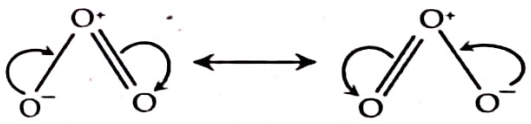
i. They are made up of molecules not ions. They do not have strong intermolecular force. They generally exist in liquid and gas.
ii. They have generally low melting and boiling point.
iii. They are generally soluble in polar solvent.
iv. They do not conduct electricity.
v. The reaction of covalent compounds is very slow.
vi. They can show the isomerism.

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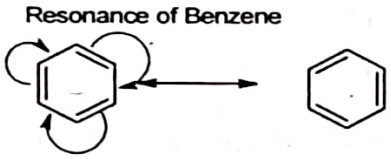
89. 2060 Q.No. 33b **Resonance**

Some molecules cannot be represented by a single Lewis structure. Two or more electronic structures of equivalent energy are written for such molecules. The actual structure is regarded as a contribution of these various structures. Such phenomenon is called resonance. It is defined as the electronic effect which arises due to delocalization of pie (π) electron i.e. the electron of a multiple bond and lone pair of electron. Due to this effect, a molecule can be written in two or more electronic structure. Such electronic structures are called resonance or canonical structure and these structures are inter convertible to each other, none of these structure is a true of stable structure. Hence, the actual structure is regarded as a hybrid of all these canonical form, called resonance hybrid. It is denoted by a straight double headed arrow (↔). Example:

Resonance of O_3



Resonance of Benzene



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Unit 7

Periodic Classification of Elements

VERY SHORT ANSWER QUESTIONS [2 MARKS]

1. 2076 Set B Q.No. 10 **Which one has greater electron affinity and why? Cl or F.**

Fluorine (F) is in the 2nd period whereas Chlorine (Cl) is in 3rd in periodic table. The atomic size Fluorine, is smaller than that of chlorine. This makes the fluoride anion so formed unstable (high reactive) due to a very high charge/mass ratio. As a result, chlorine has an electron affinity grea than that of fluorine.

2. 2076 Set C Q.No. 10 **Which one has greater ionization energy and why? Na^+ or Ne**

The ionization energy of Na^+ ion is more than that of Ne. The Na^+ ion has higher effective nucl charge than Ne. So, the electrons in the outer shell ($2s^2\ 2p^6$) are more tightly bound to the nucleus Na^+ ion than in the neutral Ne atom. Higher the effective nuclear charge, higher will be the ioniza energy.

3. 2075 GIE Q.No. 10 | 2073 Supp Q.No. 10 | 2072 Set D Q.No. 10 | 2067 Q.No. 9 | 2066 Q.No. 8 | 2063 Q.No. 10 **State modern periodic law.**

In 1912, Mosley developed a periodic law modifying Mendeleev's periodic law. It states th the physical and chemical properties of the elements are the periodic function of their atom numbers.

4. 2075 Set A Q.No. 10 | 2074 Set A Q.No. 10 **Which ion would you expect to have larger size and why? Mg^{++} or Na^+**

Mg^{++}	Na^+
$p^+ = 12$	$p^+ = 11$
$e^- = 10$	$e^- = 10$

The number of electrons are equal in both ion Mg^{++} and Na^+ but the number of protons different i.e. 12 and 11 respectively. The nuclear charge per electron in Mg^{++} is greater than N We know that higher the number of proton, higher the nuclear charge. Due to this, the size Mg^{++} is smaller than Na^+.

5. 2075 Set B Q.No. 10 **Which of the following is the smallest in size? N^{3-}, O^{2-}, F^-, and Na^+ Give appropr reason.**

N^{3-}	O^{2-}	F^-	Na^+
$p^+ = 7$	$p^+ = 8$	$p^+ = 9$	$p^+ = 11$
$e^- = 10$	$e^- = 10$	$e^- = 10$	$e^- = 10$

In N^{3-}, O^{2-}, F^- and Na^+ the number of electrons are same but the number of protons are differ i.e. 7,8,9,11 respectively. The nuclear charge per electrons in each case is different. The gre the number of protons, greater the attraction of electrons to the nucleus and harder it i remove the electrons. The number of protons in the nucleus is known as nuclear charge. Hig the nuclear charge, smaller the size. The nuclear charge per electron are in the order $Na^+ < O^{2-} < N^{3-}$. Therefore the size are in order $Na^+ < F^- < O^{2-} < N^{3-}$.

6. 2074 Supp Q.No. 10 **Which ion would you expect to have smaller size and why? Mg^{++} or Na^{+}** **[1+1]**

Please refer to 2075 Set A Q.No. 10

7. 2074 Set B Q.No. 10 **Which ion would you expect to have smaller size and why? Na^{+} or Ne** **[2]**

Na^{+}	Ne
$p^{+} = 11$	$p^{+} = 10$
$e^{-} = 10$	$e^{-} = 10$

The number of electrons are equal in both ion Na^{+} and Ne but the number of protons are different i.e. 11 and 10 respectively. The nuclear charge per electron in Na^{+} is greater than Ne. We know that higher the number of proton, higher the nuclear charge. Due to this, the size of Na^{+} is smaller than Ne.

8. 2073 Set C Q. No. 10 2072 Set C Q.No. 10 2070 Set C Q.No. 5 **State Mendeleev's Periodic law.** **[2]**

Statement: Physical and chemical properties of the elements are the periodic function of their atomic mass.

9. 2073 Set D Q. No. 10 **Predict which of the following pair has larger electron affinity and why? O and F.** **[2]**

The size of fluorine is less than size of oxygen. The value of nuclear charge per electron is fluorine is higher than that of oxygen. So, the value of electron affinity of fluorine is higher than oxygen. We know that higher the nuclear charge, higher the electron affinity.

10. 2072 Supp Q. No. 10 2070 Supp. Q.No. 10 **Which ion would you expect to have smaller size and why Be^{++} or Li^{+}.** **[2]**

Be^{++}	Li^{+}
$P^{+} = 4$	$P^{+} = 3$
$e^{-} = 2$	$e^{-} = 2$

In both the ion the number of electrons are same i.e 2 but both having different number of proton i.e. 4 and 3. The nuclear charge per electron in Be^{++} is greater than Li^{+} ion. So, the size of Be^{++} ion is smaller than Li^{+} ion.

11. 2072 Set E Q.No. 10 **Which of the following is the smallest in size?** **[1+1]**
N^{3-}, O^{2-}, I^{-1} and Na^{+}. Give appropriate reason. **[2]**

N^{3-}	O^{2-}	I^{-1}	Na^{+}
$p^{+} = 7$	$p^{+} = 8$	$p^{+} = 53$	$p^{+} = 11$
$e^{-} = 10$	$e^{-} = 10$	$e^{-} = 54$	$e^{-} = 10$

In N^{3-}, O^{2-} Na^{+} the number of electrons are same but the number of protons are different i.e. 7, 8, 11 respectively. The nuclear charge per electrons in each case is different. The greater the number of protons, greater the attraction of electrons to the nucleus and harder it is to remove the electrons. The number of protons in the nucleus is known as the nuclear charge. Higher the nuclear charge, smaller the size. The nuclear charge per electron in the order $Na^{+} < O^{2-} < N^{3-}$ so, the size are $Na^{+} < O^{2-} < N^{3-}$.

In the case of I^{-1} the number of p^{+} is smaller than e^{-}, the nuclear charge per electron is lesser than other. The size of ions are in order $Na^{+} < O^{2-} < N^{3-} < I^{-1}$.

12. 2071 Supp Q. No. 10 **What is electron affinity? Give one important factor which influences the magnitude of electron affinity.** **[2]**

Electron Affinity

The amount of energy which is released when an electron is added to an isolated gaseous atom in its ground state in order to change into the negatively charged ion is called electron affinity.

$F(g) + e^{-} \longrightarrow F^{-}(g) + E.A.$

The factor which influences the magnitude of electron affinity is nuclear charge. The value of electron affinity increases with increase in nuclear charge.

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13. 2071 (Set C) Q.No. 10 Why is first ionization energy of Mg is greater than that of Na?

The electronic configuration of Mg is $1s^2 2s^2 2p^6 3s^2$

The electronic configuration of Na is $1s^2 2s^2 2p^6 3s^1$

In the case of Mg atom two electrons are present in the outer most shell where as in Na at one electron is present in outer shell. The shielding effect (i.e. outer most electron is attracted inner electron) of Mg is greater than Na atom. So, first ionization energy of Mg is greater th Na.

14. 2071 (Set D) Q.No. 10 Which one N or O has more electron affinity and why?

The electronic configuration of N is $1s^2 2s^2 2p^3$

The electronic configuration of O is $1s^2 2s^2 2p^4$

In the case of N atom outermost orbital is half filled but in case of O atom outermost orbital more than half filled. The electronic configuration of N atom is more stable than O atom. So, t electron affinity of N atom is higher than O atom.

15. 2070 Set D Q.No. 10 On what basis does Mendeleev's periodic Law differ from Modern periodic Law?

Elements are arranged in Modern periodic table according to atomic number whereas eleme are arranged in Mendeleev's periodic table according atomic mass. This is the basic differen between Modern and Mendeleev periodic table.

16. 2069 (Set A) Q. No. 10 Define ionization energy and atomic radius.

Ionization energy: Electron of an atom can be removed by supplying energy. This energy known as ionization energy or ionization potential or ionization enthalpy. Thus it is defined "the minimum energy which is required to remove the most loosely bounded electron (valen electron) from an isolated gaseous atom in its ground state".

Atomic radius: The distance from the center of nucleus to the outermost electron of an atom called atomic radius.

17. 2069 (Set B) Q. No. 10 Write any two demerits of Mendeleev's periodic table.

Following are the two demerits:

i. There is no position of the isotopes of an element.

ii. There is no place for Lanthanide and Actinide series of an element.

18. 2068 Q.No. 8 What is the basic difference between modern periodic table and Mendeleev's periodic table?

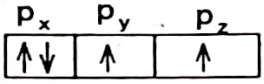
Please refer to 2070 Set D Q.No. 10

19. 2065 Q. No. 7 Why is ionization energy of oxygen less than that of nitrogen?

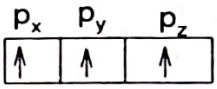
The E.C. of oxygen and nitrogen are

$O_8 = 1s^2 2s^2 2p^4$ $\quad N_7 = 1s^2 2s^2 2p^3$

The box diagram of $2p^4$



The box diagram of $2p^3$



The electronic configuration of nitrogen has half filled electron in the outermost orbital bu the case of oxygen atom more than half electron in the outermost orbital. We know that element having half filled electron in the outermost orbital is more stable than other atom. value of ionization energy of nitrogen is greater than oxygen because nitrogen have stable than oxygen. The energy required for the removal of electron from nitrogen is higher t oxygen.

20. 2064 Q.No. 6 The first ionization energy of noble gases is higher than that of halogens. Explain.

The electronic configuration of noble gases are very stable due to the fulfilled electrons pre in the outer most orbital. So, very high amount of energy is required to remove electrons f the outermost orbital and the value of ionization is very high. But in the case of halogens,

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are seven electrons in the outermost orbital i.e. less than fulfilled. That is why ionization energy of noble gases are higher than that of halogens.

21. 2062 Q.No. 6 **Why is the size of Cl^- ion is larger than Cl atom where as size of K^+ ion is smaller than that of K atom?** [2]

Cl^- ion is formed by the gain of one electron. After the gain of electron the effective nuclear charge is decreased. Due to decrease the nuclear charge, the force of attraction between electron and nucleus is slightly decreased and the outermost orbit expands slightly. That is why Cl^- ion is larger than Cl atom.

$Cl + e^- \longrightarrow Cl^-$

Atom Chloride ion

K^+ ion is formed when K-atom loose one electron. After the loose of electron the effective nuclear charge is increased. Due to increase the nuclear charge, the force of attraction between electron and nucleus is slightly increased and the outermost orbit contracts slightly resulting in decrease in size of K^+ ion than K atom.

$K \longrightarrow K^+ + e^-$

Atom potassium ion

22. 2060 Q.No. 8 **Compare the size of F^- and Na^+ with the atomic size of Neon.** [2]

F^-	Na^+	Ne
$P^+ = 9$	$P^+ = 11$	$P^+ = 10$
$e^- = 10$	$e^- = 10$	$e^- = 10$

In all species i.e. F^-, Na^+ and Ne the number of electrons are equal but the number of protons are different i.e. 9, 11, 10 respectively. The nuclear charges per electrons in all case are different. The nuclear charge per electron in Na^+ is greater than Ne having the same electrons. So, the size of Na^+ is smaller than Ne atom. In the case of F^- ion which is formed by the gain of one electron and having greater inter electronic repulsion between electrons due to smaller size. So, the size of F^- is larger than Ne atom having the same electrons. The orders are:

$F^- > Ne > Na^+$

23. 2059 Q.No. 6 **Why is the ionisation energy of lithium greater than sodium?** [2]

The atomic size of Lithium is smaller than that of Sodium. We know that smaller the size of atom stronger the force of attraction between nucleus and outermost electron and greater the ionization energy. So, Lithium has greater ionization energy than Sodium.

24. 2058 Q.No. 9 2055 Q.No. 8 **What was the basis of the classification of elements in Mendeleev's periodic table?** [2]

In 1869 a Russian Scientist **Dmitri Mendeleev** brought a broad concept of a systematic classification and arrangement of elements. Mendeleev's periodic law states that "The physical and chemical properties of all elements are the periodic function of their atomic masses. i.e. all the elements are arranged in the order of increasing atomic mass and the table based on this law is known as Mendeleev's periodic table.

25. 2057 Q.No. 12 **Arrange the elements Na, Li and K in the increasing order of first ionization energy.** [2]

The elements Na, Li, K are placed in the same group of periodic table. Li lies in 2nd period, Na lies in 3rd period and K lies in 4th period in periodic table. We know that when we move from top to bottom of group in periodic table then the value of ionization energy is decreased due to increasing the size of atom. The order of increasing ionization energy of the element is

$K < Na < Li$

26. 2056 Q.No. 7 **Why do atomic radii decrease across a period and increase in a group with the increase of atomic number?** [2]

When we move from left to right of period in periodic table, atomic number increase with increasing proton and electron number in the same shell number. Due to increase in both proton i.e. +ve charge and electron i.e. –ve charge, the force of attraction between electron and proton are increased and atomic size of atom is decreased

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27. 2055 Q.No. 4 **Why do the Oxide, O^{2-} and sulphide, S^{2-} have negative charge?**

The O^{2-} ion(oxide) is formed by the gaining of two electron.

$$O + 2e^- \longrightarrow O^{2-}$$

Atom ion

When O-atom gain two electrons to complete octet then O^{2-} ion is formed and O^{2-} have two more electron than number of proton and charge is not canceled and developed two negative charge.

The S^{2-} ion (sulphide) is also formed by gaining two electrons because both O-atom and S-atom are placed in the same group of periodic table. So, the S^{2-} ion has also two more electron than number of proton number.

28. 2054 Q.No. 6 **Why Ionization energies of alkalis metals decreases as the atomic number increases.**

Alkali metals are placed in same group of periodic table. We know that when we move from top to bottom of group in periodic table then atomic number and shell number is increased. Due to this the shielding effect is increased and nuclear charge is decreased. That is why ionization energies of alkali metal is decreased while the atomic number is increased.

29. 2053 Q.No. 1 2052 Q.No. 14 Group A **Why do metals form positive ions and non-metals form negative ions?**

Ionization energy and electron affinity both are low in case of metal. Due to this metals can easily loose electron from its outermost orbit and forms positive charged ions. But in case of non-metals both ionization energy and electron affinity are high. Due to this non-metals can easily gain electron and forms negative charge ions.

30. 2053 Q.No. 10 Group A **Which of the following pairs would have a larger size and why?**
a. K or K^+ b. F or F^-

a. K and K^+

K atom K^+ ion

2, 8, 8, 1 1, 8, 8

When K atom is lost one electron from its outer most orbit then K^+ ion is formed. The nuclear charge of K^+ ion is greater than K atom. So, size of K atom is larger than K^+ atom.

b. F and F^-

F atom F^- ion

2, 7 2, 8

When F atom is gained one electron then F^- ion is formed. The nuclear charge of F atom is greater than F^- ion. So, size of F^- ion is larger than F atom.

31. 2053 Q.No. 14 Group A **Why does the first ionization energy increase from left to right in a given period of the periodic table?**

When we move from left to right of period in periodic table then atomic number and number of electron in the same shell is increased. Due to this nuclear charge is increased and atomic size is decreased. That is why the first ionization energy is increased from left to right in a given period of periodic table.

32. 2052 Q.No. 5 Group A **Ar comes before K in the periodic table, but Ar has a larger relative atomic mass than K. Explain.**

In Modern periodic table all elements are arranged in increasing order of their atomic number. So, argon comes before potassium because atomic number of argon is 18 and that of potassium is 19. Elements are not arranged according to atomic mass. Therefore, argon comes before potassium in the periodic table.

33. 2052 Q.No. 11 Group A **Why does the atomic size increase in going down any family of the periodic table?**

When we move from top to bottom of period in periodic table then atomic number and number of shell is also increased. Due to this shielding effect is increased by suppressing the nuclear charge. That is why atomic size is increased in going down any family of period in periodic table.

34. 2051 Q.No. 11 Group A **Is a potassium atom larger, smaller or the same size as a potassium ion? Explain. [2]**

$K \longrightarrow K^+ + e^-$

Atom	ion
$p^+ = 19$	$p^+ = 19$
$e^- = 19$	$e^- = 18$

K^+ ion can be formed by the loss of one electron. The nuclear charge per electron in K^+ ion is greater than K atom i.e. the attraction force in K^+ ion is greater than K atom. So the size of K^+ ion is smaller than K atom.

SHORT ANSWER QUESTIONS [5 MARKS]

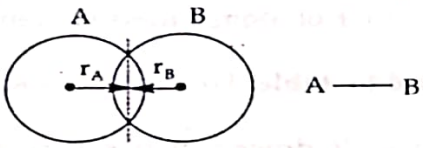
35. 2073 Supp Q.No. 23 **What is periodicity and its causes? How do atomic radii vary in a group and why? [1+4]**

Periodicity: The reoccurrence of similar properties of the element after the certain regular intervals when they are arranged in the order of increasing atomic number is called periodicity.

Variation atomic radii in group: The value of atomic radii increase from top to bottom in group, due to increase in nuclear charge and increase in principle quantum number.

There are two types of atomic radii.

i. **Covalent radii:** The distance between the centre of the nucleus of an atom and the mean position of the shared pair of electrons between the bonded atoms is called covalent radius.



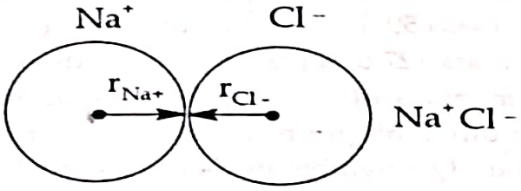
r_A = Radius of atom A

r_B = Radius of atom B

ii. **Ionic Radii:** The distance between the nucleus and outermost shell or an ion is called ionic radii. There are two ions (a) cation (b) Anion.

Cation: The ion which is formed by the loss of electron are called cation. It bears positive charge.

Anion: The ion is formed by the gain of electrons are called anion. It bears negative charge.



r_{Na^+} = Radius of Na^+ ion (cation)

r_{Cl^-} = radius of Cl^- ion (anion)

Variation of atomic radii in a period

The atomic radii i.e. covalent radii or ionic radii is decreased in period. This is due to the increase in nuclear charge per electron if we move from left to right in period.

36. 2073 Set C Q. No. 23 **What is periodicity and its causes? How do atomic radii vary in a period and why? [2.5+2.5]**

Periodicity: Please refer to 2073 Supp Q.No. 23

Cause of periodicity:

According to Modern periodic Law, the properties of elements are repeated after certain regular intervals when they are arranged in order of their increasing atomic number. Further, critical examination of electronic configuration of the various elements indicates that with a gradual increase in atomic number there occurs a repetition of similar outer electronic configuration after certain regular intervals. By correlating these two observations, we can say that "the cause

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of periodicity in properties of element is due to the repetition of similar outer electronic configuration at certain regular intervals."

All the elements of group IA i.e. alkali metals have similar outermost electronic configuration i.e. ns^1. Where, n = number of principal quantum number.

Example:

$Li_3 = 1s^2 2s^1$

$Na_{11} = 1s^2 2s^2 2p^6 3s^1$

$K_{19} = 1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$

Variation of atomic radii in period:

Atomic radii is decreased with increase in atomic number when we move from left to right in period of periodic table. This is due to the increase in nuclear charge per electron if we move from left to right in period.

It can be concluded from above reason:

a. The alkali metals have larger size than other elements.
b. The halogens elements have smaller size than other elements.
c. The size of atoms of inert gases are larger than other elements.

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37. **2073 Set D Q. No. 23 What property did Mendeleev's use to classify the element in his periodic table? Point out the anamolies in the Mendeleev's periodic table.** [1+4]

Mendeleev used the increasing order of atomic mass of element to classify the element in his periodic table.

Anamolies of Mendeleev's periodic table: Following are some disadvantage of Mendeleev's periodic table:

a. **Position of hydrogen:** Position of hydrogen in this periodic table is controversial because hydrogen behaves like alkali metals as well as like halogens. Thus it can be placed with alkali metals as well as with halogens.
b. **Position of isotopes:** The atoms of same element having same atomic number but different in mass number are called isotopes. Example- hydrogen will need three positions because there are three isotope of hydrogen but it is not in periodic table.
c. **Fault of the periodic law:** Certain elements like Ar and K, Ni and Co and Te and I do not obey this law. Argon (Ar) having atomic mass 40, is placed before Potassium (K) having atomic mass 39. Cobalt(Co) having atomic mass 59, is placed before Nickel(Ni) having atomic mass 58.6 and Tellurium(Te) having atomic mass 127.6, is placed before Iodine(I) having atomic mass 127.
d. **Separation of identical elements and grouping of dissimilar elements:** Elements having similar properties are kept in different group while some dissimilar elements are placed in the same group. Example: Cu and Hg resemble in their properties but they are separated. Alkali metals like Li, Na and K were grouped with coinage metals Cu, Ag and Au.
e. **Position of lanthanides and actinides:** Mendeleev's periodic table has not given a separate place for the lanthanides and actinides series from the main body of the periodic table.

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38. **2072 Supp Q. No. 25 State Mendeleev's periodic law. What are the anomalies of Mendeleev's periodic table? How are these anomalies removed in modern periodic table?** [5]

Mendeleev's periodic law: The physical and chemical properties of all elements are the periodic function of their atomic mass i.e. all the elements are arranged in the order of increasing atomic mass and the table based on this law is known as Mendeleev's periodic law.

Anomalies or defects of Mendeleev's periodic law: Please refer to 2070 Set-D Q.No. 33(d)

Modern periodic table has overcome the defects of Mendeleev's of periodic table which are explained below:

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i. **Removal of fault of periodic law:** The position of Ar and K, Ni and Co, Te and I brought by Mendeleev's periodic law. This defect has been removed when elements are arranged on the basis of increasing order of atomic number.

ii. **Separation of sub-groups:** Modern periodic table has given separate position of sub-group i.e. A and B. The defect in position of alkali metals and coinage metals in the same group has been removed.

iii. **Position of isotopes:** The elements are arranged according to increasing order of atomic number. The position of isotopes is removed.

iv. **Division of elements into s,p,d,f-blocks:** The elements are divided into s,p,d,f-blocks according to the electronic configuration.

v. **Explanation of periodic properties:** Modern periodic table has become to explain the periodic properties like atomic radius, ionization energy, electron affinity, electronegativity.

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39. 2071 Supp Q. No. 23 **What is periodicity? How do atomic radii vary in a group and in a period?** [1+2+2]

First Part: Please refer to 2073 Supp Q No. 23

Second Part: Please refer to 2073 Set C Q No. 23

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40. 2069 Set A Q. No. 24 **State Modern Periodic law. What are the advantages of modern periodic table?** [5]

Modern Periodic Law: In 1912, Mosley developed a periodic law modifying Mendeleev's periodic law. It states that the physical and chemical properties of the elements are the periodic function of their atomic numbers.

Advantages of Modern periodic table are:

i. **Position of isotopes:** The classification is based on the atomic numbers, the position of isotopes is fully justified.

ii. **Explanation of atomic properties:** This periodic table has become successful to define the atomic properties like atomic radius, ionization of energy, electronegativity etc.

iii. **Division of the elements into s, p, d and f blocks:** The division of the elements into s, p, d, f blocks according to their electronic configuration has made the study simpler.

iv. **Beauty of periodic law:** The arrangement of the elements according to the atomic number is more scientific way to arranging the elements.

v. **Separation of sub-groups:** This table has given separate positions for sub-group A and sub-group B.

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41. 2068 Q.No. 24 **Define ionization energy. How do 'Nuclear charge' and Size of the atom' influence the magnitude of the ionization energy? Ionization energy of 'N' is higher than that of 'O'. Give reason.** [5]

Ionization potential or energy: Electron of an atom can be removed by supplying energy. This energy is known as ionization energy or ionization potential or ionization enthalpy. Thus it is defined as "the minimum energy which is required to remove the most loosely bounded electron (valence electron) from an isolated gaseous atom in its ground state". It is denoted by I.E. or I.P. and expressed in electron volt (eV).

1eV per atom = 96.3 kJ/mole

$A \longrightarrow A^{+} + e^{-}$

$Na + I.E. \longrightarrow Na^{+} + e^{-}$

$Mg + I.E. \longrightarrow Mg^{2+} + 2e^{-}$

Atomic Size: I.E. decrease with increase in atomic size because the larger the distance from the nucleus, the lesser will be the attraction between the nucleus and the valence electrons.

Nuclear Charge: The greater the number of protons, the greater the attraction of the electrons to the nucleus and the harder it is to remove the electrons. The number of protons in the nucleus is known as the **nuclear charge**. So, the greater the value of nuclear charge, more difficult will it be to remove an electron.

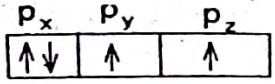
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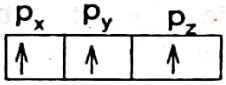
The E.C. of oxygen and nitrogen are

$O_8 = 1s^2 2s^2 2p^4$ $N_7 = 1s^2 2s^2 2p^3$

The box diagram of $2p^4$



The box diagram of $2p^3$



The electronic configuration of nitrogen have half filled electron in the outermost orbital but in the case of oxygen atom more than half electron in the outermost orbital. We know that the element having half filled electron in the outermost orbital is more stable than other atom. The value of ionization energy of nitrogen is greater than oxygen because nitrogen have stable E.C than oxygen. The energy required for the removal of electron from nitrogen is higher than oxygen.

42. 2058 Q.No. 25

a. How does atomic size vary within a horizontal row of the periodic table? Explain how this variation arises?

b. The Mg^{2+} and Na^{+} have same number of electrons (ten). Which ion would you expect to have the smaller radius? Explain. [5]

a. We know that when we move from left to right i.e. horizontally in period in periodic table then atomic size is decreased due to increase in number of electron in the same shell of an atom and increase in nuclear charge. The atomic radius is also decreased and attraction force between electron and protons are increased and electrons are strongly attracted toward the nucleus. Therefore, size of atom and atomic radius is decreased in period in periodic table.

b. Mg^{2+} ion is formed by the loss of 2 electrons from Mg atom

$$\underset{\text{Atom}}{Mg} \longrightarrow \underset{\text{ion}}{Mg^{2+}} + 2e^-$$

2,8,2 2,8

Na^+ ion is formed by the loss of one electron from Na atom

$$\underset{\text{Atom}}{Na} \longrightarrow \underset{\text{ion}}{Na^+} + e^-$$

2,8,1 2,8

Both Mg^{+2} and Na^+ ion have the same electron i.e. 10 electrons. The number of protons in Mg^{+2} has 12 but Na^+ has 11. So, the attraction force between electron and proton is stronger in Mg^{+2} than Na^+ ion. The larger the attraction force i.e. nuclear charge, smaller the radius and ionic size. Therefore, Mg^{+2} ion has smaller than Na^+ ion.

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43. 2076 Set B Q.No. 33ii 2075 Set A Q.No. 33i 2074 Supp Q.No. 33(iv) 2071 (Set D) Q.No. 33 (b) 2069 (Set B) Q. No. 33c [5]

Advantages of modern periodic table.

Please refer to 2069 Set A Q. No. 24

44. 2076 Set C Q.No. 33iii 2075 Set B Q.No. 33ii [5]

Defect of Mendeleev's Periodic table.

Please refer to 2073 Set D Q. No. 23

45. 2075 GIE Q.No. 33iv [5]

Mendeleev's periodic table and its demerits.

Mendeleev's periodic table: In 1869 a Russian Scientist Dmitri Mendeleev brought a broad concept of a systematic classification and arrangement of elements. Mendeleev's periodic law states that "The physical and chemical properties of all elements are the periodic function of their atomic masses. i.e. all the elements are arranged in the order of increasing atomic mass and the table based on this law is known as Mendeleev's periodic table.

Following are the anomalies of Mendeleev's periodic table:

a. **Position of hydrogen:** Position of hydrogen in this periodic table is controversial because hydrogen behaves like alkali metals as well as like halogens. Thus it can be placed with alkali metals as well as with halogens.

b. **Position of isotopes:** The atoms of same element having same atomic number but different in mass number are called isotopes. Example- hydrogen will need three positions because there are three isotope of hydrogen but it is not in periodic table.

c. **Fault of the periodic law:** Certain elements like Ar & K, Ni & Co and Te & I do not obey this law. Argon (Ar) having atomic mass 40, is placed before Potassium (K) having atomic mass 39. Cobalt(Co) having atomic mass 59, is placed before Nickel(Ni) having atomic mass 58.6 and Tellurium(Te) having atomic mass 127.6, is placed before Iodine(I) having atomic mass 127.

d. **Separation of identical elements and grouping of dissimilar elements:** Elements having similar properties are kept in different group while some dissimilar elements are placed in the same group. Example: Cu and Hg resemble in their properties but they are separated. Alkali metals like Li, Na and K were grouped with coinage metals Cu, Ag and Au.

e. **Position of lanthanides and actinides:** Mendeleev's periodic table has not given a separate place for the lanthanides and actinides series from the main body of the periodic table.

46. 2074 Set A Q.No. 33iii 2074 Set B Q.No. 33i 2071 (Set C) Q.No. 33 (d) **Mendeleev's periodic table and its anomalies** **[5]**

Please refer to 2075 GIE Q.No. 33iv

47. 2072 Set C Q.No. 33a 2071 Supp Q. No. 33a **Characteristic of s, p, d and f blocks of element** **[5]**

s-block elements

i. They are very soft metals.
ii. They act as reducing agent.
iii. They impart particular colour to the flame.
iv. They form ionic compound.
v. They have low m.p. and b.p.
vi. They have outermost electronic configuration ns^{1-2}

p-block elements

i. They have outermost electronic configuration ns^2np^{1-6}.
ii. They may be metals as well as non-metals.
iii. They generally form covalent compounds.
iv. Examples: Al, C, N, S, Cl, etc.

d-block elements

i. The outermost electronic configuration is $(n-1)\ d^{1-10}\ ns^{1-2}$.
ii. They are metals.
iii. They have high m.p. and b.p.
iv. They are used for making alloys.
v. They are used as catalyst.
vi. They have high variable valency and oxidation states.

f-block elements

i. The outermost electronic configuration is $(n-2)\ f^{1-14}$, $(n-1)\ d^1$, ns^2
ii. They have high m.p and b.p.
iii. They are radioactive.
iv. They form complex compound.
v. They show many oxidation states.

48. 2072 Set D Q.No. 33a **Affecting factors on magnitude of ionization energy.** **[5]**

Please refer to 2067 Q.No. 33a

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49. 2072 Set E Q.No. 33i Merits of modern periodic table.

Please refer to 2069 Set A Q. No. 24 [5]

50. 2070 Supp. Q.No. 33 (b) 2064 Q.No. 33a 2053 Q.No. 4a Group C Modern periodic table [5]

Modern Periodic Law

In 1912, Mosley developed a periodic law modifying Mendeleev's periodic law. It states that the physical and chemical properties of the elements are the periodic function of their atomic numbers.

Cause of Periodicity

The reoccurrence of similar properties of the elements after the certain regular intervals when they are arranged in the order of increasing atomic numbers is called periodicity.

Description of long form of the Periodic Table

Period: The horizontal row of periodic table is known as period. There are seven period. Each period starts with a different principal quantum number.

- **First period:** Here, n = 1 and it contains only two elements i.e. hydrogen and helium. So it is called very short period.
- **Second period:** Here, n = 2 and it contains eight elements. It starts from Li (Z=3) to Neon (Z=10). It is called short period.
- **Third period:** Here, n = 3 and it also contains eight elements. It starts from Na (Z=11) to Ar (Z=18). It is also called short period.
- **Fourth period:** Here, n = 4 and it contains eighteen elements from K (Z=19) to Kr (Z=36). It is called long period.
- **Fifth period:** Here, n = 5 and contains eighteen elements from Rubidium (Z=37) to Xenon (Z=54).It is also called long period.
- **Sixth period:** Here, n = 6 and contains 32 elements from Cesium (Z=55) to Radon (Z=86). It is called very long period.
- **Seventh period:** Here, n = 7 and expected 32 elements. It is also called very long period.
- **Group:** The vertical column of periodic table is known as a group. There are eighteen groups in a periodic table. According to IUPAC system, these groups are numbered from 1 to 18, but in the USA system, these are named as group IA to VIIA and group VIII. Similarly, group IB to VIIB and zero (0) group.

Representative or normal elements: The elements having electrons in *s* and *p* orbital are known as representative elements.

Transition elements: The elements having electron in d-orbital are known as transition elements.

Inner-transition elements: The lanthanide and actinide series elements of periodic table are known as inner-transition elements.

Lanthanide Series: Lanthanum (57) to Lutetium (71)

Actinide Series: Actinium (89) to Lawrencium (103)

Division of Elements into *s*, *p*, *d* and *f* Blocks

There are four blocks of Modern periodic table. These blocks are designated on the basis of electronic configuration of the elements.

s-block elements: The elements having electronic configuration ns^{1-2}. Elements of group IA and IIA (alkali and alkaline earth metal). e.g. H, He, Na, Ca, K, Rb, Sr etc.

p-block elements: The elements having electronic configuration ns^2np^{1-6}. Elements of group IIIA to VIIA and zero group (except He). e.g. Al, C, N, S, Cl, Ar etc.

d-block elements: The elements having E.C.$(n-1)d^{1-10},ns^{1-2}$ .They are generally used as catalyst e.g. Fe, Mo, Ni, Co, Cr, V etc.

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f-blocks elements: The elements having E.C. $(n-2)f^{1-14}$, $(n-1)d^{1-10}, ns^2$ They form colored ions and actinides are radioactive in nature. It includes Lanthanide and Actinide.

51. 2070 Set C Q.No. 33a 2066 Q.No. 33 b **Periodic properties of elements.** [5]

Periodic properties:

Various atomic properties like ionization potential, electron affinity, atomic size etc. are directly related to electronic configuration but properties like boiling point, melting point, density etc. are indirectly related to the E.C. These properties of an element are called periodic properties. The variation of these properties along with a group and period are described below.

Ionization potential or energy: Electron of an atom can be removed by supplying energy. This energy is known as ionization energy or ionization potential or ionization enthalpy. Thus it is defined as "the minimum energy which is required to remove the most loosely bounded electron (valence electron) from an isolated gaseous atom in its ground state". It is denoted by I.E. or I.P. and expressed in electron volt (eV).

1eV per atom = 96.3 kJ/mol

$$A \longrightarrow A^+ + e^-$$
$$Na + I.E. \longrightarrow Na^+ + e^-$$
$$Mg + I.E. \longrightarrow Mg^{2+} + 2e^-$$

Successive I.E.: Positive ions may be formed by the loss of one, two, or more electron from the valence shell. The energy required to remove subsequent electron from the isolated gaseous atom in the ground state is known is successive I.E. It is called 1st I.E., 2nd I.E., 3rd I.E.....Which refers to the removal of the 1st, 2nd, 3rd ..... electron respectively. Example:

$A + E_1 \longrightarrow A^+ + e^-$ (E_1 is called 1st I.E.)

$A^+ + E_2 \longrightarrow A^{2+} + e^-$ (E_2 is called 2nd I.E.)

$A^{++} + E_3 \longrightarrow A^{3+} + e^-$ (E_3 is called 3rd I.E.)

The order of successive I.E. is $IE_3 > IE_2 > IE_1$

Ionization Energy depends upon the following factors

1. **Atomic Size:** I.E. decrease with increase in atomic size because the larger the distance from the nucleus, the lesser will be the attraction between the nucleus and the valence electrons.
2. **Nuclear Charge:** The greater the number of protons, the greater the attraction of the electrons to the nucleus and the harder it is to remove the electrons. The number of protons in the nucleus is known as the **nuclear charge**. So the greater the value of nuclear charge, the more difficult will it be to remove an electron.
3. **Screening effect or shielding effect:** The outermost electrons are screened /shielded from the nucleus by inner electrons. This phenomenon is called shielding effect or screening effect. The greater the number of inner electrons, the minimum the value of ionization potential because as a result of screening effect, the electrons are less effectively attracted towards the nucleus. Therefore, it is easier to remove the loosely bound electron.
4. **Electronic configuration:** The more stable the electronic configuration, the greater will be the ionization potential. Elements having half-filled and full-filled orbitals are more stable or have extra stability because it is difficult to remove electron from their shells.
   - Noble gases having E.C. ns^2np^6 and have high I.E.
   - Elements like Mg ($1s^22s^22p^63s^2$) and Be($1s^22s^2$) Which have full-filled orbital possess large value of I.E.
   - Elements like N($1s^22s^22p^3$) and P ($1s^22s^22p^63s^23p^3$) have half-filled E.C. and possess high value of I.E.
   - I.E. in sub-shells: The I.E. required to remove an s-electron would be greater than that required to remove a p-electron and so on. The order of sub-shells are s > p > d > f.

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Variation of I.E. across a period

I.E. increase with increasing atomic number in a particular period. This is due to

1. Increase in nuclear charge from left to right along a period.
2. Decrease in atomic size.

Variation of I.E. along a group

When we move from top to bottom, the I.E. gradually decreases. This is due to

1. Increase in atomic size.
2. Increase in number of inner electrons which brings the increase in shielding effect on the outermost electron.
3. Increase in nuclear charge from top to bottom in a group whose effect is less than the effect of increasing atomic size and shielding effect.

Electron Affinity

The amount of energy which is released when an electron is added to an isolated gaseous atom in its ground state in order to change it into the negatively charged ion is called electron affinity. It is denoted by E.A. and expressed in terms of eV.

$A + e^- \longrightarrow A^- + E.A.$

$F_{(g)} + e^- \longrightarrow F^-_{(g)} + E.A.$

Factors Affecting E.A.

1. **Nuclear Charge:** The value of E.A. increase with increase in nuclear charge.
2. **Size of atom:** Larger the size of atom, lesser the value of E.A.
3. **E.C.:** Stable E.C such half-filled and complete-filled orbital have low value of E.A.

Variation of E.A. across the period

When we move from left to right across the period, the size of an atom decreases and nuclear charge increases. Due to both factor the value of E.A. is increased.

Variation of E.A. along group

When we move from top to bottom along group of periodic table, the value of E.A. is decreased with increase in size of an atom.

Important Trends in E.A.

1. **Halogens have the highest E.A.:** It requires one electron to attain stable E.C.
2. **Noble gases have zero values of E.A :** They have stable E.C. i.e.ns^2np^6
3. **The E.A. of Cl is greater than that of F:** Due to the small size of F-atom. If the size is small the inter-electronic repulsion will be strong. Therefore, the incoming electron does feel much attraction towards the nucleus. Hence, Cl has greater E.A. than F.

Atomic Size

Atom is assumed to be spherical. So, the size of an atom may be explained by comparing the value of atomic radii. Atomic radius is defined as the distance between the centre of the nucleus and the outermost shell of the electrons. However, the determination of exact radius of an atom is so much difficult because,

1. The probability of finding an electron at a distance from the nucleus is never zero. Hence there is not a specific distance from the nucleus to the electron.
2. The distribution of electron in an atom is affected by neighboring atoms. Due to which, size of an atom may change from one state to another state.

To overcome these difficulties, atomic radius can be defined according to bonding situation. So there are two radius.

a. **Covalent Radius:** The distance between the centre of the nucleus of an atom and the mean position of the shared pair of electrons between the bonded atoms.

Variation of atomic radius in period

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When we move from left to right in period, the value of atomic radius decrease, due to decrease in atomic radii with increase in atomic number.

Variation in a group

The value of atomic radii increase from top to bottom in a group, due to increase in nuclear charge and increase in principle quantum number.

b. **Ionic radius:** The distance between the nucleus and outermost shell or an ion. There are two ions (i) Cation (ii) Anion

Cation: The ions formed by loss of electron are called cation and bears +ve charge.

Anion: The ions formed by gain of electrons are called anion and bears –ve charge.

Variation of ionic radii in a group

Ionic radii increase in group if we move from top to bottom due to increase in principle quantum number.

Variation of ionic radii in a period

Ionic radii decrease in period if we move from left to right due to increase in nuclear charge per electron i.e. outermost electron are more effectively attracted towards the nucleus which results in decrease in size.

Electronegativity (E.N.)

The electronegativity of an element is defined as the relative tendency of an atom in a molecule to attract a shared pair of electron towards itself i.e. ability of an atom to attract the shared pair of the electron. It is expressed in number of scales like Pauling's scale, Mulliken's scale but most commonly used scale is Pauling's scale.

Factor Affecting Electronegativity

Following are factors:

1. **Atomic size:** Smaller the size of an atom higher the value of E.N.
2. **Number of inner shells:** Atom having larger number of inner shells has the lower value of E.N.
3. **Number and nature of atoms bonded to it:** E.N. of an element depends upon the number and nature of the atom to which it is bonded. Example- E.N. of P-atom in PCl_5 is higher than that in PF_5 because F is more E.N. than Cl.
4. **Types of hybridization:** E.N of an element increase as the s-character in the hybrid orbital increase. The E.N. value of carbon in methane< ehene < ethyne. This is due to methane (sp^3 . hybridization) = 25% s-character, ethane (sp^2 hybridization) = 33% s-character, ethyne (sp hybridization) = 50% s-character.
5. **Charge of the ion:** Cation is smaller in size as compared to the corresponding atom. As a result, cation should attract electron more readily than its parent atom. So cation has higher E.N. than its parent atom. Cation having higher positive charge is more electronegative. Since, anion is less E.N. than its parent atom.
6. **I.P. and E.A. :** If the value of I.P. and E.A. is high , the E.N. value will also be high.

Variation of E.N. in a group: When we move from top to bottom, the size of an atom increase, due to this the value of E.N. decrease.

Variation of E.N. in a period: The value of E.N. increase when we move from left to right in period due to smaller in size and higher nuclear charge.

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52. 2070 Set D Q.No. 33d **Disadvantage of Mendeleev's periodic table.** [5]

Please refer to 2073 Set D Q. No. 23

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53. 2067 Q.No. 33a **Electron affinity and ionisation potenital.** [5]

Ionization potential or energy: Electron of an atom can be removed by supplying energy. This energy is known as ionization energy or ionization potential or ionization enthalpy. Thus it is defined as "the minimum energy which is required to remove the most loosely bounded

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Successive I.E.: Positive ions may be formed by the loss of one, two, or more electron from the valence shell. The energy required to remove subsequent electron from the isolated gaseous atom in the ground state is known is successive I.E. It is called 1st I.E., 2nd I.E., 3rd I.E.....Which refers to the removal of the 1st, 2nd, 3rd ..... electrons respectively. Example:

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When we move from top to bottom, the I.E. gradually decreases. This is due to

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When we move from left to right across the period, the size of an atom decreases and nuclear charge increases. Due to both factor the value of E.A. is increased.

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Important Trends in E.A.

1. **Halogens have the highest E.A.:** It requires one electron to attain stable E.C.
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54. 2065 Q. No. 33a **Modern Periodic Law and advantages of Modern Periodic Table.** **[5]**

a. Please refer to 2069 Set A Q. No. 24

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Unit 8

Oxidation and Reduction

VERY SHORT ANSWER QUESTIONS [2 MARKS]

1. 2076 Set B Q.No. 11 **Assign oxidation number to the underlined element in each of the following:** [1+1]
   i. $\underline{N_2}O_2$
   ii. $NaH_2\underline{P}O_4$

i. Let O.N. of N in N_2O_2 be x
$2x + 2(-2) = 0$
or, $2x - 4 = 0$
or, $2x = +4$
or, $x = +\frac{4}{2} = +2$
Hence, the O.N. of N in N_2O_2 is +2

ii. Let the oxidation number of P = x
$+1 + 2(+1) + x + 4(-2) = 0$
or, $+1 + 2 + x - 8 = 0$
or, $+3 + x - 8 = 0$
or, $x - 5 = 0$
or, $x = +5$
So, the oxidation number of P in NaH_2PO_4 is +5

2. 2076 Set C Q.No. 11 **Assign the oxidation number to the underlined element in each of the following compound:** [1+1]
   i. $C_2H_5\underline{O}H$
   ii. $\underline{Pb}_3O_4$

i. Let O.N. of C in C_2H_5OH be x
or, $2x + 5(+1) + (-2) = 0$
or, $2x + 5 - 2 = 0$
or, $2x + 3 = 0$
or, $2x = -3$
or, $x = -\frac{3}{2}$
Hence, O.N. of C in C_2H_5OH is $-\frac{3}{2}$

ii. Let O.N. of Pb in $\underline{Pb}_3O_4$ be x
or, $3x + 4(-2) = 0$
or, $3x - 8 = 0$
or, $3x = +8$
or, $x = +\frac{8}{3}$
Hence, O.N. of Pb in Pb_3O_4 is $+\frac{8}{3}$

3. 2075 GIE Q.No. 11 **Calculate the oxidation number of chlorine in** [1+1]
   i. $\underline{Cl}O_3^-$
   ii. $NaO\underline{Cl}$

i. Let the O.N. of Cl in ClO_3^- be X
$X + 3 \times (-2) = -1$
or, $X - 6 = -1$
or, $X = -1 + 6$
$\therefore X = +5$
Hence, the O.N. of Cl in ClO_3^- is +5.

ii. Let the O.N. of Cl in NaOCl be X
$+1 + (-2) + X = 0$
or, $+1 - 2 + X = 0$
or, $-1 + X = 0$
$\therefore X = +1$
Hence, the O.N. of Cl in NaOCl is +1.

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4. **2075 Set A Q.No. 11** **Calculate the oxidation number of** **[1+1]**
   i. **N in NH_4Cl**
   ii. **S in $NaHSO_3$**

i. Let the O.N of N in NH_4Cl be X
$X + 4(+1) + (-1) = 0$
or, $X + 4 - 1 = 0$
or, $X + 3 = 0$
or, $X = -3$
Hence, The O.N. of N in NH_4Cl is – 3.

ii. Let the O.N. of S in $NaHSO_3$ be X
$+1 + 1 + X + 3(-2) = 0$
or, $+2 + X - 6 = 0$
or, $X - 4 = 0$
or, $X = +4$
Hence, the O.N. of S in $NaHSO_3$ is +4

5. **2075 Set B Q.No. 11** **What is meant by the term oxidation number? Calculate the oxidation number of nitrogen in ammonium sulphate.** **[1+1]**

Oxidation number: The residual charge appeared on a single atom when other atoms are removed from the molecule is known as Oxidation Number i.e. O.N. It may be a +ve, -ve or zero. Example: in HCl, the O.N. of Cl is -1 because when hydrogen is removed as an ion from the molecules, the residual charge on Cl^- atom becomes -1.

Oxidation number of B in $Na_2B_4O_7$
Let O.N. of N in $(NH_4)_2SO_4$ be x
$2x + 8(+1) + (-2) = 0$
or, $2x + 8 - 2 = 0$
or, $2x + 6 = 0$
or, $2x = -6$
or, $x = -\frac{6}{2} = -3$
Hence, the O.N. of nitrogen in ammonium sulphate is –3.

6. **2074 Supp Q.No. 11** **2074 Set B Q.No. 11** **Calculate the oxidation number of** **[1+1]**
   i. **C in HCOONa**
   ii. **Cl in $KClO_3$**

i. C in HCOONa
Let the O.N. of C in HCOONa be X
$+1 + X + 2(-2) + (+1) = 0$
or, $+1 + X - 4 + 1 = 0$
or, $X - 2 = 0$
or, $X = +2$
Hence, oxidation number of C in HCOONa is +2.

ii. Cl in $KClO_3$
Let the O.N. of Cl in $KClO_3$ be X
$+1 + X + 3(-2) = 0$
or, $+1 + X - 6 = 0$
or, $X = +5$
Hence, the oxidation number of Cl in $KClO_3$ is +5

7. **2074 Set A Q.No. 11** **Calculate the oxidation number of:** **[1+1]**
   i. **N in NH_4OH**
   ii. **Cr in $K_2Cr_2O_7$**

i. N in NH_4OH
Let O.N. of N in NH_4OH be X
$X + 4(+1) + (-1) = 0$
or, $X + 4 - 1 = 0$
or, $X + 3 = 0$
or, $X = -3$
Hence, oxidation number of N in NH_4OH is -3.

ii. Cr in $K_2Cr_2O_7$
Let O.N. of Cr in $K_2Cr_2O_7H$ be X
$2(+1) + 2X + 7(-2) = 0$
or, $+2 + 2X - 14 = 0$
or, $2X - 12 = 0$
or, $X = +\frac{12}{2} = +6$
Hence, oxidation number of Cr in $K_2Cr_2O_7$ is +6.

8. 2073 Supp Q.No. 11 Define oxidation number, what is the oxidation number of P in $Ca_3(PO_4)_2$?

Oxidation number: Please refer to 2075 Set B Q.No. 11

Oxidation number of B in $Na_2B_4O_7$

Let O.N. of P in $Ca_3(PO_4)_2$ is x

$3 \times Ca + 2 \times P + 8 \times O = 0$

or, $3 \times (+2) + 2 \times x + 8 \times (-2) = 0$

or, $+6 + 2x - 16 = 0$

or, $2x - 10 = 0$

or, $2x = +10$

or, $x = +5$

Hence, O.N. of P in $Ca_3(PO_4)_2$ is +5

9. 2073 Set C Q. No. 11 Define oxidation number. What is the oxidation number of Boron in $Na_2B_4O_7$?

Oxidation number: Please refer to 2075 Set B Q.No. 11

Oxidation number of B in $Na_2B_4O_7$

Let O.N. of B is x

$2(+1) + 4x + 7(-2) = 0$

or, $+2 + 4x - 14 = 0$

or, $4x - 12 = 0$

or, $4x = 12$

or, $x = \frac{12}{4} = +3$

Hence, the O.N. of Boron in $Na_2B_4O_7$ is +3.

10. 2073 Set D Q. No. 11 Define oxidation number. What is the oxidation number of P in NaH_2PO_2?

Oxidation number: Please refer to 2073 Set C Q. No. 11

Oxidation number of P in NaH_2PO_2

Let O.N. of P is x

$+1 + 2(+1) + x + 2(-2) = 0$

or, $+1 + 2 + x - 4 = 0$

or, $+3 + x - 4 = 0$

or, $x = 4 - 3 = +1$

Hence, O.N. of P in NaH_2PO_2 is +1.

11. 2072 Supp Q. No. 11 Calculate the oxidation number of sulphur in (i) $SOCl_2$ (ii) H_2SO_3.

The oxidation number of sulphur in:

i. $SOCl_2$: Let the O.N. of S is x

$x + (-2) + 2(-1) = 0$

or, $x - 2 - 2 = 0$

or, $x - 4 = 0$

or, $x = +4$

Hence, oxidation number of S in $SOCl_2$ is +4.

ii. H_2SO_3: Let the O.N. of S is x

$2(+1) + x + 3(-2) = 0$

or, $+2 + x - 6 = 0$

or, $x - 4 = 0$

or, $x = +4$

Hence, oxidation number of S in H_2SO_3 is +4

12. 2072 Set C Q.No. 11 Define the term oxidation number. What is the oxidation number of Fe in $Na_4[Fe(CN)_6]$

Oxidation number: Please refer to 2075 Set B Q.No. 11

The oxidation number (O.N.) of F_e in $Na_4[Fe(CN)_6]$

Let O.N. of Fe = x

O.N. of Na = +1

O.N. of CN^- = –1

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Then,
$4(+1) + x + 6(-1) = 0$
or, $+4 + x - 6 = 0$
or, $x - 2 = 0$
$\therefore x = +2$
Hence, O.N. of Fe in $Na_4[Fe(CN)_6]$ is +2.

13. **2072 Set D Q.No. 11** **Calculate oxidation number of:** [1+1]
i. **Cl in $KClO_3$**
ii. **P in NaH_2PO_4**

Solution

i. Let the oxidation number of Cl = x
$+1 + x + 3(-2) = 0$
or, $+1 + x - 6 = 0$
or, $x = +5$
So, the oxidation number of Cl in $KClO_4$ is +7.

ii. Let the oxidation number of P = x
$+1 + 2(+1) + x + 4(-2) = 0$
or, $+1 + 2 + x - 8 = 0$
or, $+3 + x - 8 = 0$
or, $x - 5 = 0$
or, $x = +5$
So, the oxidation number of P in NaH_2PO_4 is +5.

14. **2072 Set E Q.No. 11** **Determine oxidation number of the underlined element in the following species.** [1+1]
i. **$H_2\underline{C}_2O_4$**
ii. **$\underline{Cr}_2(SO_4)_3$**

a
i. Let the O.N. of Carbon is x
$2(+1) + 2x + 4(-2) = 0$
or, $+2 + 2x + (-8) = 0$
or, $2x - 6 = 0$
or, $x = +\frac{6}{2} = +3$
Hence, O.N. of carbon in $H_2C_2O_4$ is + 3.

ii. Let the oxidation number of Cr is x
$2x + 3(-2) = 0$
or, $2x - 6 = 0$
or, $2x = +6$
or, $x = +3$
Hence, the oxidation number of Cr in $Cr_2(SO_4)_3$ is +3.

15. **2071 Supp Q. No. 11** **Calculate the oxidation number of Mn atom in MnO_4^-** [2]

Solution
Let the O. N. of Mn = x
$x + 4(-2) = -1$
or $x - 8 = -1$
or, $x = -1 + 8$
or, $x = +7$
Hence, the oxidation number of Mn in MnO_4^- is+ 7.

16. **2071 (Set C) Q.No. 11** **Calculate the oxidation number of nitrogen in** [1+1]
a. **$NaNO_3$**
b. **NH_4^+**

Solution
a. Let the O.N. of N is x
$+1 + x + 3(-2) = 0$
or, $+1 + x - 6 = 0$
or, $x - 5 = 0$
or, $x = +5$

b. Let the O.N. of N is x
$x + 4(+1) = +1$
or, $x + 4 = +1$
or, $x = +1 - 4$
or, $x = -3$

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17. 2071 (Set D) Q.No. 11 **Calculate the oxidation number of underlined atom in the following compounds:** [1+1]

a. $\underline{N}H_4NO_3$ **b.** $\underline{Cr}_2O_7^{-2}$

Solution

a. Let the O.N. of N is x

$x + 4(+1) - 1 = 0$

or, $x + 4 - 1 = 0$

or, $x + 3 = 0$

or, $x = -3$

b. Let the O.N. of Cr is x

$2x + 7(-2) = -2$

or, $2x - 14 = -2$

or, $2x = -2 + 14$

or, $2x = 12$

or, $x = +6$

18. 2070 Supp. Q.No. 11 **Calculate the oxidation number of carbon in** [1+1]

i. CH_3OH **ii.** $C_6H_{12}O_6$

Solution

i. Let the O.N. of C is x

$x + 4(+1) + (-2) = 0$

or, $x + 4 - 2 = 0$

or, $x + 2 = 0$

or, $x = -2$

ii. Let the O.N. of C is x

$6x + 12(+1) + 6(-2) = 0$

or, $6x + 12 - 12 = 0$

or, $6x = 0$

or, $x = 0$

19. 2070 Set C Q.No. 10 **Calculate the oxidation number of:** [1+1]

a. carbon in $H_2C_2O_4$ **b. phosphorous in H_3PO_4**

a. Let the O.N. of Carbon is x

$2(+1) + 2x + 4(-2) = 0$

or, $+2 + 2x + (-8) = 0$

or, $2x - 6 = 0$

or, $x = +\frac{6}{2} = +3$

b. Let the O.N. of phosphrous is x

$3(+1) + X + 4(-2) = 0$

or, $+3 + X + (-8) = 0$

or, $X - 5 = 0$

or, $X = +5$

20. 2070 Set D Q.No. 11 **Find the Oxidation number of nitrogen in** [1+1]

a. Ammonia b. Ammonium Sulphate

a. Ammonia (NH_3):

Let the O.N. of N is x

$x + 3(+1) = 0$

or, $x + 3 = 0$

or, $x = -3$

b. Ammonium sulphate $(NH_4)_2SO_4$:

Let the O.N. of N is x

$2x + 8(+1) + (-2) = 0$

or, $2x + 8 - 2 = 0$

or, $2x = -6$

or, $x = -3$

21. 2069 (Set A) Q. No. 11 **Calculate the oxidation number of :**

i. C in $H_2C_2O_4$ **ii. Mn in MnO^-_4**

Solution

i. $H_2C_2O_4$

Let the O.N. of Carbon is x

$2(+1) + 2x + 4(-2) = 0$

or, $+2 + 2x + (-8) = 0$

or, $2x - 6 = 0$

or, $x = +\frac{6}{2} = +3$

ii. MnO_4^-

Let the O.N. of Mn is x

$x + 4(-2) = -1$

or, $x - 8 = -1$

or, $x = -1 + 8$

or, $x = +7$

22. **2069 (Set B) Q. No. 11** **Calculate the oxidation number of carbon in:**
i. $C_2H_2O_4$
ii. CO_3^{--} **[1+1]**

Solution

i. $H_2C_2O_4$
Let the O.N. of Carbon is x
$2(+1) + 2x + 4(-2) = 0$
or, $+2 + 2x + (-8) = 0$
or, $2x - 6 = 0$
or, $x = +\frac{6}{2} = +3$

ii. CO_3^{--}
Let the O.N. of Carbon is x
$x + 3(-2) = -2$
or, $x - 6 = -2$
or, $x = -2 + 6$
or, $x = +4$

23. **2068 Q.No. 11** **How would you show the following reaction is a redox reaction?**
$Mg + Cl_2 \longrightarrow MgCl_2$ **[2]**

$Mg + Cl_2 \longrightarrow MgCl_2$
In the above reaction, Mg loses two electrons to form Mg^{2+} ion which is called half oxidation
Half oxidation $Mg^{\circ} \longrightarrow Mg^{2+} + 2e^-$
Chlorine gains two electrons which are lost by Mg atom and becomes $2Cl^-$ ion which is called half reduction.
Half reduction $2Cl^{\circ} + 2e^- \longrightarrow 2Cl^-$
The net redox reaction is
$Mg^{\circ} + 2Cl^{\circ} \longrightarrow Mg^{2+} + 2Cl^-$ i.e. $MgCl_2$
Thus, Mg is reducing agent and chlorine is oxidizing agent.

24. **2064 Q.No. 8(a)** **Calculate the oxidation number of Carbon in $H_2C_2O_4$.** **[2]**

Solution
$H_2C_2O_4$
Let the O.N. of Carbon is x
$2(+1) + 2x + 4(-2) = 0$
or, $+2 + 2x + (-8) = 0$
or, $2x - 6 = 0$
or, $x = +\frac{6}{2} = +3$

Hence, O.N. of carbon in $H_2C_2O_4$ is + 3.

25. **2064 Q.No. 8(b)** **Calculate the oxidation number of Phosphorous in H_2PO_4.** **[2]**

Solution
$H_2PO_4^-$
Let the O.N. of P is x
$2(+1) + x + 4(-2) = -1$
or, $+2 + x(-8) = -1$
or, $x = 6 - 1$
or, $x = +5$

Hence, O.N. of carbon in H_2PO_4 is + 5.

26. **2063 Q.No. 7** **Balance the following chemical equation by oxidation number change method or ion electron method.**
$Cu + HNO_3 \longrightarrow Cu(NO_3)_2 + NO_2 + H_2O$ **[2]**

Oxidation number method:
Oxidation number of an element

$$\overset{0}{Cu} + \overset{+5}{HNO_3} \longrightarrow \overset{+2}{Cu(NO_3)_2} + \overset{+4}{NO_2} + H_2O$$

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Change in oxidation number

$Cu + HNO_3 \longrightarrow Cu(NO_3)_2 + NO_2 + H_2O$

(2) (1)

Criss – cross the change in oxidation number

$Cu + 2HNO_3 \longrightarrow Cu(NO_3)_2 + 2NO_2 + H_2O$

To balance N – atom, $2HNO_3$ is multiplied by 2

$Cu + 4HNO_3 \longrightarrow Cu(NO_3)_2 + 2NO_2 + H_2O$

To balance H and O – atom, H_2O is multiplied by 2

$Cu + 4HNO_3 \longrightarrow Cu(NO_3)_2 + 2NO_2 + 2H_2O$

Thus, the redox reaction is balanced.

27. 2062 Q.No. 10 **Calculate the oxidation number of underlined atoms in the following**
(a) $\underline{N}H_4NO_3$ (b) $\underline{Mn}O_4^{-2}$

Solution

a. $\underline{N}H_4NO_3$

Let the O.N. of N is x

$X + 4(+1) + (-1) = 0$

or, $x + 4 - 1 = 0$

or, $x + 3 = 0$

or, $x = -3$

b. $\underline{Mn}O_4^{-2}$

Let the O.N. of Mn is x

$x + 4(-2) = -2$

or, $x - 8 = -2$

or, $x = -2 + 8$

or, $x = +6$

28. 2061 Q.No. 8 **Calculate the oxidation number of S in $Na_2S_2O_3$ and $H_2S_2O_7$.**

Solution

$Na_2S_2O_3$

Let the O.N. of S is x

$2(+1) + 2x + 3(-2) = 0$

or, $+2 + 2x - 6 = 0$

or, $2x - 4 = 0$

or, $2x = 4$

or, $x = +2$

$H_2S_2O_7$

Let the O.N. of S is x

$2(+1) + 2x + 7(-2) = 0$

or, $+2 + 2x - 14 = 0$

or, $2x - 12 = 0$

or, $2x = 12$

or, $x = +6$

29. 2060 Q.No. 9 **How is the following ionic equation a Redox reaction?**
$Cl_2 + 2OH^- \longrightarrow Cl^- + ClO^- + H_2O$

The given reaction is

$\overset{0}{Cl_2} + 2OH^- \longrightarrow \overset{-1}{Cl^-} + \overset{+1}{ClO^-} + H_2O$

The O.N. of chlorine is decreased i.e. 0 to -1 and again the O.N. of chlorine is increased i.e. fro 0 to +1. The reaction in which one species is oxidized i.e. oxidation number is increased a other species is reduced i.e. the oxidation number is decreased, is known as redox reactio Here, the same species i.e. chlorine acts as both oxidizing agent and reducing agent.

30. 2057 Q.No. 10 **Calculate the oxidation number of S in $K_2S_2O_3$ and SO_2Cl_2.**

Solution

$K_2S_2O_3$

Let the O.N. of S is x

$2(+1) + 2x + 3(-2) = 0$

or, $+2 + 2x - 6 = 0$

or, $2x - 4 = 0$

or, $2x = 4$

or, $x = +2$

SO_2Cl_2

Let the O.N. of S is x

$x + 2(-2) + 2(-1) = 0$

or, $x - 4 - 2 = 0$

or, $x = +6$

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31. 2056 Q.No. 8 **Define oxidation number of an element in a compound. Calculate the oxidation number of P in H_3PO_4.** [2]

Oxidation number: Please refer to 2075 Set B Q.No. 11

H_3PO_4

$3(+1) + X + 4(-2) = 0$

or, $+3 + X + (-8) = 0$

or, $X - 5 = 0$

or, $X = +5$

Hence, the O.N. of P in H_3PO_4 is +5

32. 2054 Q.No. 3 **Assign oxidation numbers to the underlined elements in each of the following formulas.** [2]
MnO_4^-, $TiCl_4$, NH_3

Solution

MnO_4^-

Let the O.N. of Mn is x

$X + 4(-2) = -1$

or, $x - 8 = -1$

or, $x = -1 + 8$

or, $x = +7$

$TiCl_4$

Let the O.N. of Ti is x

$x + 4(-1) = 0$

or, $x - 4 = 0$

or, $x = +4$

NH_3

Let, the O.N. of N is x

$x + 3(+1) = 0$

or, $x + 3 = 0$

or, $x = -3$

33. 2053 Q.No. 13 Group A **What is the oxidation number of oxygen in H_2O_2 and Phosphorus in PO_4^{-3}?** [1.5]

Solution

H_2O_2

Let, the O.N. of O is x

$2(+1) + 2x = 0$

or, $+2 + 2x = 0$

or, $2x = -2$

or, $x = -1$

PO_4^{-3}

Let, the O.N. of P is x

$x + 4(-2) = -3$

or, $x - 8 = -3$

or, $x = -3 + 8$

or, $x = +5$

34. 2052 Q.No. 12 Group A **Give the oxidation number of sulphur and chromium in SO_4^{-2} and $Na_2Cr_2O_7$ respectively.** [1.5]

SO_4^{-2}

Let the O.N. of S is x

$x + 4(-2) = -2$

or, $x - 8 = -2$

or, $x = -2 + 8$

or, $x = +6$

$Na_2Cr_2O_7$

Let the O.N. of Cr is x

$2(+1) + 2x + 7(-2) = 0$

or, $+2 + 2x - 14 = 0$

or, $2x - 12 = 0$

or, $2x = +12$

or, $x = \frac{+12}{2} = +6$

35. 2051 Q.No. 4 Group A **What is the oxidation number of Chromium in Potassium chromate?** [2]

K_2CrO_4

Let the O.N. of Cr is x

$2(+1) + x + 4(-2) = 0$

or, $+2 + x - 8 = 0$

or, $x - 6 = 0$

or, $x = +6$

Hence, the oxidation number of chromium in potassium chromate is +6.

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SHORT ANSWER QUESTIONS [5 MARKS]

36. 2076 Set B Q.No. 23 Define reducing agent giving an example. Balance the following redox reaction by oxidation number or ion-electron method: [1+4]

$MnO_2 + HCl \longrightarrow MnCl_2 + Cl_2 + H_2O$

Reducing agent: A reducing agent reduces other substances and loses electrons; therefore, its oxidation state increases. Example: SO_2, H_2S, C, H_2, Cu, Al etc.

Balancing redox reaction:

$\overset{+4}{Mn}O_2 + H\overset{-1}{Cl} \longrightarrow \overset{+2}{Mn}Cl_2 + \overset{0}{Cl_2} + H_2O$

Oxidation half:

$2Cl^- \longrightarrow 2Cl^\circ + 2e^-$ ... (i)

Reduction half:

$Mn^{+4} + 2e^- \longrightarrow Mn^{+2}$ ... (ii)

By adding both the equation.

$2Cl^- \longrightarrow 2Cl^\circ + 2e^-$

$Mn^{+4} + 2e^- \longrightarrow Mn^{+2}$

$Mn^{+4} + 2Cl^- \longrightarrow 2Cl^\circ + Mn^{+2}$

Thus the above redox reaction becomes

$MnO_2 + 2HCl \longrightarrow MnCl_2 + Cl_2 + H_2O$

To balance Cl- atom 2HCl is multiplied by 2

$MnO_2 + 4HCl \longrightarrow MnCl_2 + Cl_2 + H_2O$

To balance H- and O-atom, H_2O is multiplied by 2

$MnO_2 + 4HCl \longrightarrow MnCl_2 + Cl_2 + 2H_2O$

Thus the redox reaction is balanced.

---

37. 2076 Set C Q.No. 23 Define redox reaction. Balance the following equation by oxidation number or ion-electron method. [1+4]

$KMnO_4 + HCl \longrightarrow KCl + MnCl_2 + H_2O + Cl_2$

Redox reaction: The reaction in which both oxidation and reduction reaction occurs simultaneously is known as redox reaction.

Balancing redox reaction: Oxidation number method:

$K\overset{+7}{Mn}O_4 + H\overset{-1}{Cl} \longrightarrow \overset{+2}{Mn}Cl_2 + KCl + H_2O + \overset{0}{Cl_2}$

Change in oxidation number

$KMnO_4 + HCl \longrightarrow MnCl_2 + KCl + H_2O + Cl_2$

(5) (1)

If both the change in oxidation is odd then double them

$KMnO_4 + HCl \longrightarrow MnCl_2 + KCl + H_2O + Cl_2$

(10) (2)

Criss – cross the change in oxidation number

$2\,KMnO_4 + 10\,HCl \longrightarrow 2\,MnCl_2 + KCl + H_2O + 5\,Cl_2$

To balance K – atom, KCl is multiplied by 2

$2KMnO_4 + 10HCl \longrightarrow 2MnCl_2 + 2KCl + H_2O + 5Cl_2$

To balance Cl-atom, HCl is multiplied by 16

$2\,KMnO_4 + 16\,HCl \longrightarrow 2\,MnCl_2 + 2\,KCl + H_2O + 5\,Cl_2$

To balance H and O – atom, H_2O is multiplied by 8

$2\,KMnO_4 + 16\,HCl \longrightarrow 2\,MnCl_2 + 2\,KCl + 8\,H_2O + 5\,Cl_2$

Thus, the redox reaction is balanced.

38. **2075 GIE Q.No. 25 Define electronic concept of oxidation giving an example. Balance the following equation by oxidation number or ion-electron method. [1+4]**

$Zn + HNO_3 \longrightarrow Zn(NO_3)_2 + NO_2 + H_2O$

Oxidation: According to this concept, Oxidation is defined as the chemical process which involves

i. The loss of electron.
ii. The increase in positive charge.
iii. The decrease in negative charge.

Oxidation is also known as **de-electronation**. Example:

i. Loss of electron

$Na \longrightarrow Na^+ + e^-$

$K \longrightarrow K^+ + e^-$

$Ca \longrightarrow Ca^{++} + 2e^-$

ii. Increase in +ve charge.

$Sn^{2+} \longrightarrow Sn^{4+} + 2e^-$

$Fe^{2+} \longrightarrow Fe^{3+} + e^-$

iii. Decrease in –ve charge.

$MnO_4^{--} \longrightarrow MnO_4^- + e^-$

$2Cl^- \longrightarrow Cl_2 + 2e^-$

$S^{2-} \longrightarrow S + 2e^-$

Oxidation number method:

Oxidation number of elements

$\overset{0}{Zn} + \overset{5}{HNO_3} \longrightarrow \overset{+2}{Zn(NO_3)_2} + \overset{+4}{NO_2} + H_2O$

Change in oxidation number of elements

$Zn + HNO_3 \longrightarrow Zn(NO_3)_2 + NO_2 + H_2O$

(2) (1)

Criss-cross the change in oxidation number

$Zn + 2HNO_3 \longrightarrow Zn(NO_3)_2 + 2NO_2 + H_2O$

To balance N-atom, $2HNO_3$ is multiplied by 2

$Zn + 4HNO_3 \longrightarrow Zn(NO_3)_2 + 2NO_2 + H_2O$

To balance H-atom and O-atom, H_2O is multiplied by 2

$Zn + 4HNO_3 \longrightarrow Zn(NO_3)_2 + 2NO_2 + 2H_2O$

Hence, the redox reaction is balanced.

39. **2075 Set A Q.No. 24 Oxidation and Reduction is simultaneous process. Explain Balance the following equation by oxidation number or ion electron method. [5]**

$C + H_2O_2 \longrightarrow CO + H_2O$

Both oxidation and reduction involves in the same chemical reaction. The species which loses the electron in the reaction is said to be oxidized and the species which gains the electron is said to be reduced. In a chemical reaction, oxidation process is always followed by reduction and vice-versa. Both process take place side by side i.e. occur simultaneously which is known as oxidation reduction reaction or Redox reaction.

$\overset{+4}{MnO_2} + \overset{-1}{HCl} \longrightarrow \overset{+2}{MnCl_2} + \overset{0}{Cl_2} + H_2O$

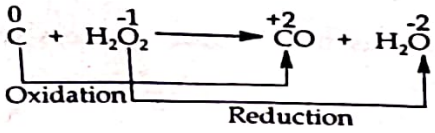
Reduction

Oxidation

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Balancing redox reaction by oxidation number method:

Oxidation number of an element

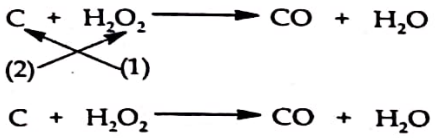


Change in O.N. of an element

$$C + H_2O_2 \longrightarrow CO + H_2O$$

(2) (1)

Criss-cross the change in O.N. of element



$$C + H_2O_2 \longrightarrow CO + H_2O$$

Hydrogen and oxygen element are already balanced.

Thus, the redox reaction is balanced.

40. 2075 Set B Q.No. 24 Distinguish between oxidation and reduction. Balance the following equation by oxida number or ion electron method.

$N_2H_4 + ClO_3^- \longrightarrow NO + Cl^- + H_2O$

Following are the distinction between oxidation and reduction:

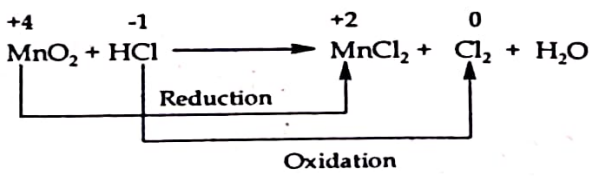
Oxidation	Reduction
Oxidation is the loss of electron or hydrogen atom or gain of oxygen atom.	Reduction is the gain of electron or hydrog atom or loss of oxygen atom.
Removal or loss of electrons. $A \longrightarrow A^+ + e^-$	Addition or gain of electrons. $A + e^- \longrightarrow A^-$
Removal of hydrogen. $AH + B \longrightarrow A + BH$	Addition of hydrogen. $A + BH \longrightarrow AH + B$
Addition of oxygen. $A + BO \longrightarrow AO + B$	Removal of oxygen. $AO + B \longrightarrow A + BO$
All the above reaction release energy.	All the above reaction store energy.

Balance the redox reaction: Please refer to 2072 Set C Q.No. 24

41. 2074 Supp Q.No. 24 Justify by giving and example that oxidation and reduction go side by side. Balanc following equation by oxidation number or ion electron method.

$FeCl_3 + H_2S \longrightarrow FeCl_2 + HCl + S$

Both oxidation and reduction involves in the same chemical reaction. The species which the electron in the reaction is said to be oxidized and the species which gains the electron is to be reduced. In a chemical reaction, oxidation process is always followed by reduction vice-versa. Both process take place side by side i.e. occur simultaneously which is know oxidation reduction reaction or Redox reaction.



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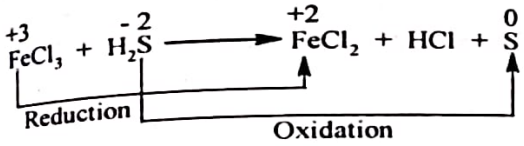
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Balance the redox reaction:

Step: I Skeleton equation

$$FeCl_3 + H_2S \longrightarrow FeCl_2 + HCl + S$$

Step: II Oxidation of an element

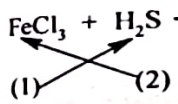


Step: III Change in oxidation number of an element

$$FeCl_3 + H_2S \longrightarrow FeCl_2 + HCl + S$$

(1) (2)

Step: IV Criss-Cross multiplication of change in oxidation number



$$2FeCl_3 + H_2S \longrightarrow 2FeCl_2 + HCl + S$$

Step: V To balance chlorine atom, HCl is multiplied by 2

$$2FeCl_3 + H_2S \longrightarrow 2FeCl_2 + 2HCl + S$$

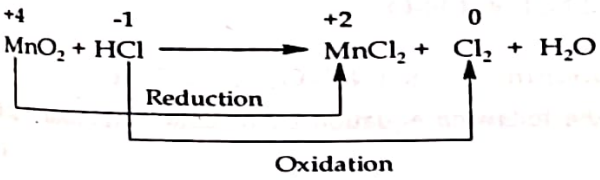
Thus, the given redox reaction is balanced.

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42. **2074 Set A Q.No. 24 Give an example to show oxidation and reduction go simultaneously. Balance the following equation by oxidation number or ion electron method,** **[2+3]**

$HNO_3 + H_2S \longrightarrow SO_2 + NO_2 + H_2O$

Both oxidation and reduction involves in the same chemical reaction. The species which loses the electron in the reaction is said to be oxidized and the species which gains the electron is said to be reduced. In a chemical reaction, oxidation process is always followed by reduction and vice-versa. Both process take place side by side i.e. occur simultaneously which is known as oxidation reduction reaction or Redox reaction.

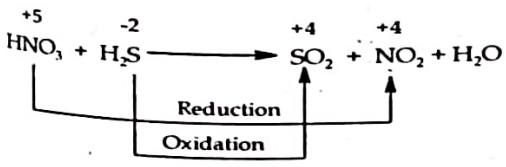


Oxidation number method for balancing redox reaction:

Step: I Skeleton equation

$$HNO_3 + H_2S \longrightarrow SO_2 + NO_2 + H_2O$$

Step: II Oxidation of an element



Step: III Change in oxidation number

$$HNO_3 + H_2S \longrightarrow SO_2 + NO_2 + H_2O$$
(1) (6)

Step: IV Criss-Cross multiplication of change in oxidation number

$$HNO_3 + H_2S \longrightarrow SO_2 + NO_2 + H_2O$$
(1) (6)

$$6\,HNO_3 + H_2S \longrightarrow SO_2 + 6\,NO_2 + H_2O$$

Step: V To balance H and O-atom, H_2O is multiplied by 4.

$$6\,HNO_3 + H_2S \longrightarrow SO_2 + 6\,NO_2 + 4\,H_2O$$

Thus, the given redox reaction is balanced.

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43. 2074 Set B Q.No. 24 **'Oxidation and reduction is simultaneous process.' Explain. Balance the equation by oxidation number or ion electron method.** [2+3]

$HNO_3 + H_2S \longrightarrow SO_2 + NO_2 + H_2O$

Please refer to 2074 Set A Q.No. 24

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44. 2073 Supp Q.No. 24 2073 Set C Q. No. 24 2073 Set D Q. No. 24 **Balance the following equation by oxidation number or ion-electron method and point out oxidant and reductant.** [4+1]

$Zn + NaNO_3 + NaOH \longrightarrow Na_2ZnO_2 + NH_3 + H_2O$

Oxidation number method:

Step-I: Oxidation number of an elements

$$\overset{0}{Zn} + \overset{+5}{NaNO_3} + NaOH \longrightarrow \overset{+2}{Na_2ZnO_2} + \overset{-3}{NH_3} + H_2O$$

Step-II: Change in O.N. of an element

$$\overset{(2)}{Zn} + \overset{(8)}{NaNO_3} + NaOH \longrightarrow Na_2ZnO_2 + NH_3 + H_2O$$

Step-III: Criss-cross multiplification of the change in O.N.

$$8\,Zn + 2\,NaNO_3 + NaOH \longrightarrow 8\,Na_2ZnO_2 + 2\,NH_3 + H_2O$$

Step-IV: To balance Na-atom, NaOH is multiplied by 14.

$$8\,Zn + 2\,NaNO_3 + 14\,NaOH \longrightarrow 8\,Na_2ZnO_2 + 2\,NH_3 + H_2O$$

Step-V: To balance H and O-atom, H_2O is multiplied by 4.

$$8\,Zn + 2\,NaNO_3 + 14\,NaOH \longrightarrow 8\,Na_2ZnO_2 + 2\,NH_3 + 4\,H_2O$$

Thus, the given redox reaction is balanced.

In the given reaction, Zinc (Zn) is reductant and sodium nitrate ($NaNO_3$) is oxidant.

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45. 2072 Supp Q. No. 23 **Define Redox reaction. Balance the following equation by oxidation number method indicating oxidizing and reducing agent:** [1+4]

$C_{12}H_{22}O_{11} + HNO_3 \longrightarrow NO_2 + C_2H_2O_4 + H_2O$

Redox reaction: The reaction in which both oxidation and reduction reaction occurs simultaneously is known as redox reaction.

Oxidation number method:

Oxidation number of an elements

$$\overset{0}{C_{12}H_{22}O_{11}} + \overset{+5}{HNO_3} \longrightarrow \overset{+4}{NO_2} + \overset{+3}{C_2H_2O_4} + H_2O$$

Change in oxidation number of an element

$$\overset{(3)}{C_{12}H_{22}O_{11}} + HNO_3 \longrightarrow \overset{(1)}{NO_2} + C_2H_2O_4 + H_2O$$

If both the change in O. N. are odd then double them.

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$C_{12}H_{22}O_{11} + HNO_3 \longrightarrow NO_2 + C_2H_2O_4 + H_2O$

(6) (2)

(36) (12)

The number of carbon atom in reactant side is already 12. In order to balance carbon atom 6 is multiplied and criss-cross multiplification of change in oxidation number

$C_{12}H_{22}O_{11} + 36HNO_3 \longrightarrow 36NO_2 + 6C_2H_2O_4 + H_2O$

To balance hydrogen and oxygen atom, H_2O is multiplied by 23

$C_{12}H_{22}O_{11} + 36HNO_3 \longrightarrow 36NO_2 + 6C_2H_2O_4 + 23\ H_2O$

Hence, the given redox reaction is balanced.

Here, HNO_3 is oxidizing agent and $C_{12}H_{22}O_{11}$ is reducing agent.

---

46. **2072 Set C Q.No. 24 Define the term (i) oxidant (ii) reductant. Balance the following redox reaction by oxidation number or iron electron method indicating oxidant and reducant: [2+3]**

$N_2H_4 + ClO_3^- \longrightarrow NO + Cl^- + H_2O$

i. **Oxidant (Oxidizing agent):** The substance in a redox reaction which causes oxidation by accepting one or more electron. Example: It undergoes decrease in oxidation number.

$\overset{0}{Zn} + \overset{+1}{H_2}\overset{+2}{S}\overset{0}{O_4} \longrightarrow \overset{+2}{Zn}\overset{+2}{S}\overset{0}{O_4} + \overset{0}{H_2}$

Here, hydrogen atom of sulphuric acid is in +1 state but hydrogen molecule in 0 oxidation state i.e. a hydrogen atom has accepted one electron ($H^+ + e^- \longrightarrow H$). So, H_2SO_4 here acts as an oxidizing agent or oxidant.

ii. **Reductant (Reducing agent):** The substance in a redox reaction which cause reduction by losing one or more electron. It shows the increase in oxidation number. In the above given reaction, the Zn atom has lost 2 electron i.e. its oxidation number is increased from 0 to 2.

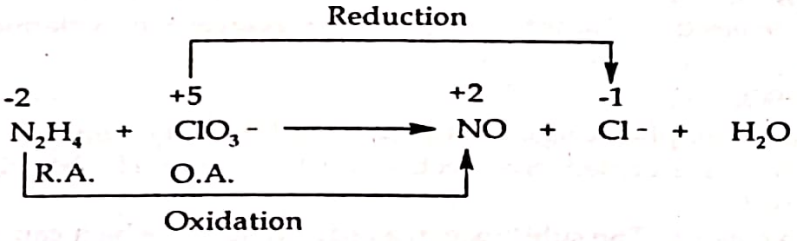
$Zn \longrightarrow Zn^{++} + 2e^-$ Hence, Zn acts as a reducing agent.

The given reaction is

$N_2H_4 + ClO_3^- \longrightarrow NO + Cl^- + H_2O$

Ion Electron Method

The oxidation number of an element



Half oxidation

$N^{-2} \longrightarrow N^{+2} + 4e^-$

$2N^{-2} \longrightarrow 2\ N^{+2} + 8e^-$ ...(i)

Half reduction

$Cl^{+5} + 6e^- \longrightarrow Cl^{-1}$ ...(ii)

To balance electron equation (i) is multiplied by 3 and equation (ii) is multiplied by 4 then adding both equation

$6N^{-2} \longrightarrow 6\ N^{+2} + 24e^-$

$4Cl^{+5} + 24e^- \longrightarrow 4Cl^{-1}$

$6N^{-2} + 4Cl^{+5} \longrightarrow 6N^{+2} + 4Cl^{-1}$

Thus, the above redox reaction becomes

$3N_2N_4 + 4ClO_3^- \longrightarrow 6NO + 4Cl^- + H_2O$

To balance hydrogen and oxygen atom, H_2O is multiplied by 6

$3N_2N_4 + 4ClO_3^- \longrightarrow 6NO + 4Cl^- + 6H_2O$

Hence, the above redox reaction is balanced.

In the given redox reaction

ClO_3^- is oxidizing agent

N_2N_4 is reducing agent.

---

47. 2072 Set D Q.No. 24 Define redox reaction. Balance the following equations by oxidation number or ion electron method. [2+3]

$MnO_4^- + H_2O_2 + H^+ \longrightarrow MnO_2 + O_2 + H_2O$

Redox reaction: The reaction in which both oxidation and reduction reaction occurs simultaneously is known as redox reaction.

Oxidation number method:

$\overset{+7}{Mn}O_4^- + \overset{-1}{H_2O_2} + H^+ \longrightarrow \overset{+4}{Mn}O_2 + \overset{0}{O_2} + H_2O$

Change in oxidation of an element

$MnO_4^- + H_2O_2 + H^+ \longrightarrow MNO_2 + O_2 + H_2O$

(3) (1)

(6) (2)

If both the change in oxidation number is odd, double them.

Criss-cross the change in oxidation number.

$2MnO_4^- + 3H_2O_2 + H^+ \longrightarrow 2MnO_2 + 3O_2 + H_2O$

To balance H and O-atom, H_2O is multiplied by 4 and H^+ is multiplied by 2

$2MnO_4^- + 3H_2O_2 + 2H^+ \longrightarrow 2MnO_2 + 3O_2 + 4H_2O$

Thus, the redox reaction is balanced.

---

48. 2072 Set E Q.No. 24 Distinguish between oxidant and reductant. Balance the following equation.

$C_2H_2O_4 + MnO_4^- + H^+ \longrightarrow CO_2 + Mn^{2+} + H_2O$

i. **Oxidant (Oxidizing agent):** The substance in a redox reaction which causes oxidation by accepting one or more electron. Example: It undergoes decrease in oxidation number.

$\overset{0}{Zn} + H_2\overset{+1}{S}O_4 \longrightarrow \overset{+2}{Zn}SO_4 + \overset{0}{H_2}$

Here, hydrogen atom of sulphuric acid is in +1 state but hydrogen molecule in 0 oxidation state i.e. a hydrogen atom has accepted one electron ($H^+ + e^- \longrightarrow H$). So, H_2SO_4 here acts as an oxidizing agent or oxidant.

ii. **Reductant (Reducing agent):** The substance in a redox reaction which cause reduction by losing one or more electron. It shows the increase in oxidation number. In the above given reaction the Zn atom has lost 2 electron i.e. its oxidation number is increased from 0 to 2.

$Zn \longrightarrow Zn^{++} + 2e^-$ Hence, Zn acts as a reducing agent.

The given reaction is

$N_2H_4 + ClO_3^- \longrightarrow NO + Cl^- + H_2O$

Oxidation number method

$\overset{+3}{N_2}H_4 + \overset{+7}{Cl}O_3^- \longrightarrow \overset{+4}{N}O + \overset{+2}{Cl}^- + H_2O$

Change in oxidation number of an element

$C_2H_2O_4 + MnO_4^- + H^+ \longrightarrow CO_2 + Mn^{2+} + H_2O$

(1) (5)

(2) (10)

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If both the change in oxidation number is odd then double them.

Criss-cross the change in oxidation number.

$C_2H_2O_4 + MnO_4^- + H^+ \longrightarrow CO_2 + Mn^{2+} + H_2O$

(2) (10)

$5C_2H_2O_4 + 2MnO_4^- + H^+ \longrightarrow 10CO_2 + 2Mn^{2+} + H_2O$

To balance H and O-atom, H_2O is multiplied by 8 and H^+ is multiplied by 6

$5C_2H_2O_4 + 2MnO_4^- + 6H^+ \longrightarrow 10CO_2 + 2Mn^{2+} + 8H_2O$

Thus, the redox reaction is balanced.

---

49. **2071 (Set C) Q.No. 25 What is meant by redox reaction? Balance the following equation by oxidation number method indicating oxidant and reductant: [1+4]**

$KMnO_4 + Na_2O_2 + H_2SO_4 \longrightarrow K_2SO_4 + MnSO_4 + Na_2SO_4 + O_2 + H_2O$

a. **Redox reaction:** The reaction in which both oxidation and reduction reaction occurs simultaneously is known as redox reaction.

Oxidation number method

$\overset{+7}{KMnO_4} + \overset{-1}{Na_2O_2} + H_2SO_4 \longrightarrow K_2SO_4 + \overset{+2}{MnSO_4} + Na_2SO_4 + \overset{0}{O_2} + H_2O$

Change in oxidation of an element

$KMnO_4 + Na_2O_2 + H_2SO_4 \longrightarrow K_2SO_4 + MnSO_4 + Na_2SO_4 + O_2 + H_2O$

(5) (1)

If both the change in oxidation is odd then double them.

$KMnO_4 + Na_2O_2 + H_2SO_4 \longrightarrow K_2SO_4 + MnSO_4 + Na_2SO_4 + O_2 + H_2O$

(10) (2)

Criss-cross the change in oxidation number

$2KMnO_4 + 5Na_2O_2 + H_2SO_4 \longrightarrow K_2SO_4 + 2MnSO_4 + Na_2SO_4 + 5O_2 + H_2O$

To balance Na- atom, Na_2SO_4 is multiplied by 5

$2KMnO_4 + 5Na_2O_2 + H_2SO_4 \longrightarrow K_2SO_4 + 2MnSO_4 + 5Na_2SO_4 + 5O_2 + H_2O$

To balance the SO_4^{--} radical, H_2SO_4 is multiplied by 8

$2KMnO_4 + 5Na_2O_2 + 8H_2SO_4 \longrightarrow K_2SO_4 + 2MnSO_4 + 5Na_2SO_4 + 5O_2 + H_2O$

To balance H and O atom, H_2O is multiplied by 8

$2KMnO_4 + 5Na_2O_2 + 8H_2SO_4 \longrightarrow K_2SO_4 + 2MnSO_4 + 5Na_2SO_4 + 5O_2 + 8H_2O$

Thus, the redox reaction is balanced. In the above redox reaction

$KMnO_4$ is oxidant and Na_2O_2 is reductant.

---

50. **2071 (Set D) Q.No. 25 Distinguish between oxidant and reductant. Balance the following equation by oxidation number method. [1+4]**

$KMnO_4 + HCl \longrightarrow KCl + MnCl_2 + H_2O + Cl_2$

i. **Oxidant (Oxidizing agent):** The substance in a redox reaction which causes oxidation by accepting one or more electron. Example: It undergoes decrease in oxidation number.

$\overset{0}{Zn} + \overset{+1}{H_2SO_4} \longrightarrow \overset{+2}{ZnSO_4} + \overset{0}{H_2}$

Here, hydrogen atom of sulphuric acid is in +1 state but hydrogen molecule in 0 oxidation state i.e. a hydrogen atom has accepted one electron ($H^+ + e^- \longrightarrow H$). So, H_2SO_4 here acts as an oxidizing agent or oxidant.

ii. **Reductant (Reducing agent):** The substance in a redox reaction which cause reduction by losing one or more electron. It shows the increase in oxidation number. In the above given reaction, the Zn atom has lost 2 electron i.e. its oxidation number is increased from 0 to 2.

$Zn \longrightarrow Zn^{++} + 2e^-$ Hence, Zn acts as a reducing agent.

The given reaction is

$N_2H_4 + ClO_3^- \longrightarrow NO + Cl^- + H_2O$

Balancing redox reaction: Please refer to 2076 Set C Q.No. 23

51. 2070 Supp. Q.No. 24 Define oxidiation number and balance the following equation by oxidation number or ion-electron method indicating oxidant and reductant: [1+4]

$CuSO_4 + HI \longrightarrow Cu_2I_2 + H_2SO_4 + I_2$

Oxidation number: The residual charge appeared on a single atom when other atoms are removed from the molecules, is known as Oxidation Number i.e. O.N. It may be a +ve, -ve or zero. Example- in HCl, the O.N. of Cl is -1 because when hydrogen is removed as an ion from the molecules, the residual charge on Cl^- atom becomes -1.

Oxidation number method:

$\overset{+2}{CuSO_4} + \overset{-1}{HI} \longrightarrow \overset{+1}{Cu_2I_2} + H_2SO_4 + \overset{0}{I_2}$

Change in oxidation number of an element

$CuSO_4 + HI \longrightarrow Cu_2I_2 + H_2SO_4 + I_2$

(1) (1)
(2) (2)

Criss-cross the change in oxidation number

$2CuSO_4 + 2HI \longrightarrow Cu_2I_2 + H_2SO_4 + I_2$

To balance SO_4 radical, H_2SO_4 is balanced by 2

$2CuSO_4 + 2HI \longrightarrow Cu_2I_2 + 2H_2SO_4 + I_2$

To balance I – atom, 2HI is balanced by 2

$2CuSO_4 + 4HI \longrightarrow Cu_2I_2 + 2H_2SO_4 + I_2$

Thus, the redox reaction is balanced. In the above redox reaction $CuSO_4$ is oxidant and HI is reductant.

52. 2070 Set C Q.No. 24 What is oxidation number? Balance the following equation by oxidation number or ion-electron method. [1+4]

$Cu + HNO_3 \longrightarrow Cu(NO_3)_2 + NO + H_2O$.

Oxidation number: The residual charge appeared on a single atom when other atoms are removed from the molecules, is known as Oxidation Number i.e. O.N. It may be a +ve, -ve or zero. Example- in HCl, the O.N. of Cl is -1 because when hydrogen is removed as an ion from the molecules, the residual charge on Cl^- atom becomes -1.

Oxidation number of an element

$\overset{0}{Cu} + \overset{+5}{HNO_3} \longrightarrow \overset{+2}{Cu(NO_3)_2} + \overset{+2}{NO} + H_2O$

Change in oxidation number

$Cu + HNO_3 \longrightarrow Cu(NO_3)_2 + NO + H_2O$

(2) (3)

Criss – cross the change in oxidation number

$3Cu + 2HNO_3 \longrightarrow 3Cu(NO_3)_2 + 2NO + H_2O$

To balance N – atom, $2HNO_3$ is multiplied by 4

$3Cu + 8HNO_3 \longrightarrow 3Cu(NO_3)_2 + 2NO + H_2O$

To balance H and O – atom, H_2O is multiplied by 4

$3Cu + 8HNO_3 \longrightarrow 3Cu(NO_3)_2 + 2NO + 4H_2O$

Thus, the redox reaction is balanced.

53. 2070 Set D Q.No. 24 What is meant by oxidation number? Balance the following equation by oxidation number or ion-electron method indicating oxidant reluctant. [1+4]

$NaOH + S \longrightarrow Na_2S + Na_2S_2O_3 + H_2O$

Oxidation number: The residual charge appeared on a single atom when other atoms are removed from the molecules, is known as Oxidation Number i.e. O.N. It may be a +ve, -ve or

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zero. Example- in HCl, the O.N. of Cl is -1 because when hydrogen is removed as an ion from the molecules, the residual charge on Cl- atom becomes -1.

Oxidation number method:

Oxidation number of an element

$$\overset{0}{NaOH} + \overset{}{S} \longrightarrow \overset{-2}{Na_2S} + \overset{+2}{Na_2S_2O_3} + H_2O$$

Change in oxidation number

$$NaOH + \underset{(2)}{S} + \underset{(2)}{S} \longrightarrow Na_2S + Na_2S_2O_3 + H_2O$$

Criss – cross the change in oxidation number

$$NaOH + 2S + 2S \longrightarrow 2Na_2S + Na_2S_2O_3 + H_2O$$

To balance Na – atom, NaOH is multiplied by 6

$$6NaOH + 2S + 2S \longrightarrow 2Na_2S + Na_2S_2O_3 + H_2O$$

To balance H and O – atom, H_2O is multiplied by 3

$$6NaOH + 2S + 2S \longrightarrow 2Na_2S + Na_2S_2O_3 + 3H_2O$$

$$6NaOH + 4S \longrightarrow 2Na_2S + Na_2S_2O_3 + 3H_2O$$

Thus, the redox reaction is balanced.

The same element sulphur acts as both oxidant and reductant.

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54. **2069 (Set A) Q. No. 23 What is meant by redox reaction? Balance the following equation by oxidation number or ion-electron method: [1+4]**

$KMnO_4 + C_2H_2O_4 + H_2SO_4 \longrightarrow K_2SO_4 + MnSO_4 + CO_2 + H_2O$

Ans The reaction in which both oxidation and reduction reaction occurs simultaneously is known as redox reaction.

Oxidation number method

$$\overset{+7}{KMnO_4} + \overset{+3}{C_2H_2O_4} + H_2SO_4 \longrightarrow K_2SO_4 + \overset{+2}{MnSO_4} + \overset{+4}{CO_2} + H_2O$$

Change in oxidation of an element

$$\underset{(5)}{KMnO_4} + \underset{(1)}{C_2H_2O_4} + H_2SO_4 \longrightarrow K_2SO_4 + MnSO_4 + CO_2 + H_2O$$

If both the change in oxidation is odd then double them.

$$\underset{(10)}{KMnO_4} + \underset{(2)}{C_2H_2O_4} + H_2SO_4 \longrightarrow K_2SO_4 + MnSO_4 + CO_2 + H_2O$$

Criss-cross the change in oxidation number

$$2KMnO_4 + 5C_2H_2O_4 + H_2SO_4 \longrightarrow K_2SO_4 + 2MnSO_4 + 10CO_2 + H_2O$$

To balance the SO_4^{--} radical, H_2SO_4 is multiplied by 3

$$2KMnO_4 + 5C_2H_2O_4 + 3H_2SO_4 \longrightarrow K_2SO_4 + 2MnSO_4 + 10CO_2 + H_2O$$

To balance H and O atom, H_2O is multiplied by 8

$$2KMnO_4 + 5C_2H_2O_4 + 3H_2SO_4 \longrightarrow K_2SO_4 + 2MnSO_4 + 10CO_2 + 8H_2O$$

Thus, the redox reaction is balanced.

---

55. **2069 (Set B) Q. No. 25 What is meant by oxidation number? Balance the following equation by oxidation number or ion-electron method:**

$MnO_4^- + C_2H_2O_4 + H^+ \longrightarrow Mn^{++} + H_2O + CO_2$. [1+4]

Ans **Oxidation number:** The residual charge appeared on a single atom when other atoms are removed from the molecules, is known as Oxidation Number i.e. O.N. It may be a +ve, -ve or zero. Example- in HCl, the O.N. of Cl is -1 because when hydrogen is removed as an ion from the molecules, the residual charge on Cl- atom becomes -1.

$$\overset{+7}{MnO_4^-} + \overset{+3}{C_2H_2O_4} + H^+ \longrightarrow \overset{+2}{Mn^{++}} + H_2O + \overset{+4}{CO_2}$$

Change in O.N. of an element

$MnO_4^- + C_2H_2O_4 + H^+ \longrightarrow Mn^{++} + H_2O + CO_2$

(5) (1)

If both the change in oxidation is odd then double them.

$MnO_4^- + C_2H_2O_4 + H^+ \longrightarrow Mn^{++} + H_2O + CO_2$

(10) (2)

Criss-cross the change in oxidation number

$2MnO_4^- + 5C_2H_2O_4 + H^+ \longrightarrow 2Mn^{++} + H_2O + 10CO_2$

To balance H and O-atom, H_2O is multiplied by 8 and H^+ is multiplied by 6.

$2MnO_4^- + 5C_2H_2O_4 + 6H^+ \longrightarrow 2Mn^{++} + 8H_2O + 10CO_2$

Thus, the given redox reaction is balanced.

---

56. 2067 Q.No. 24 **Balance the following redox reaction by oxidation number of ion-electron method and point out the oxidant and reductant.** [4+1]

$K_2Cr_2O_7 + SnCl_2 + HCl \longrightarrow CrCl_3 + SnCl_4 + KCl + H_2O$

The redox reaction is

$K_2Cr_2O_7 + SnCl_2 + HCl \longrightarrow KCl + CrCl_3 + SnCl_4 + H_2O$

Step- 1

O.N. of an elements are

$\overset{+6}{K_2Cr_2O_7} + \overset{+2}{SnCl_2} + HCl \longrightarrow KCl + \overset{+3}{CrCl_3} + \overset{+4}{SnCl_4} + H_2O$

Step – 2

Change in O.N.

$K_2Cr_2O_7 + SnCl_2 + HCl \longrightarrow KCl + GrCl_3 + SnCl_4 + H_2O$

(3) (2)

Step – 3

Criss-cross the change in O.N.

$K_2Cr_2O_7 + 3SnCl_2 + HCl \longrightarrow KCl + 2CrCl_3 + 3SnCl_4 + H_2O$

Step – 4

To balance K- atom, KCl is multiplied by 2

$K_2Cr_2O_7 + 3SnCl_2 + HCl \longrightarrow 2KCl + 2CrCl_3 + 3SnCl_4 + H_2O$

Step- 5

To balance Cl- atom, HCl is multiplied by 14

$K_2Cr_2O_7 + 3SnCl_2 + 14HCl \longrightarrow 2KCl + 2CrCl_3 + 3SnCl_4 + H_2O$

Step- 6

To balance H- and O-atom, H_2O is multiplied by 7

$K_2Cr_2O_7 + 3SnCl_2 + 14HCl \longrightarrow 2KCl + 2CrCl_3 + 3SnCl_4 + 7H_2O$

Thus the redox reaction is balanced.

Here, $K_2Cr_2O_7$ is oxidant and $SnCl_2$ is reductant.

---

57. 2066 Q.No. 25 **Prove that Oxidation and Reduction is simultaneous process.' Balance the following equation by oxidation number method or ion-electron method.** [2+3]

$MnO_2 + HCl \longrightarrow MnCl_2 + Cl_2 + H_2O$

Both oxidation and reduction involves in the same chemical reaction. The species which loses the electron in the reaction is said to be oxidized and the species which gains the electron is said to be reduced. In a chemical reaction, oxidation process is always followed by reduction and vice-versa. Both process take place side by side i.e. occur simultaneously which is known as oxidation reduction reaction or Redox reaction.

Balancing redox reaction:

$\overset{+4}{MnO_2} + \overset{-1}{HCl} \longrightarrow \overset{+2}{MnCl_2} + \overset{0}{Cl_2} + H_2O$

Oxidation half:

$2Cl^- \longrightarrow 2Cl^\circ + 2e^-$ ... (i)

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Reduction half:

$Mn^{+4} + 2e^- \longrightarrow Mn^{+2}$ ... (ii)

By adding both the equation.

$2Cl^- \longrightarrow 2Cl^o + 2e^-$

$Mn^{+4} + 2e^- \longrightarrow Mn^{+2}$

$Mn^{+4} + 2Cl^- \longrightarrow 2Cl^o + Mn^{+2}$

Thus the above redox reaction becomes

$MnO_2 + 2HCl \longrightarrow MnCl_2 + Cl_2 + H_2O$

To balance Cl- atom 2HCl is multiplied by 2

$MnO_2 + 4HCl \longrightarrow MnCl_2 + Cl_2 + H_2O$

To balance H- and O-atom, H_2O is multiplied by 2

$MnO_2 + 4HCl \longrightarrow MnCl_2 + Cl_2 + 2H_2O$

Thus the redox reaction is balanced.

---

58. **2065 Q. No. 25 What is oxidation number? Balance the following equation by oxidation number or ion-electron method:** **[1+4]**

$KI + H_2SO_4 \longrightarrow K_2SO_4 + I_2 + H_2S + H_2O$

The residual charge appeared on a single atom when other atoms are removed from the molecule is known as Oxidation Number i.e. O.N. It may be a +ve, -ve or zero.

Oxidation number method:

$\overset{-1}{KI} + \overset{+6}{H_2SO_4} \longrightarrow K_2SO_4 + \overset{0}{I_2} + \overset{-2}{H_2S} + H_2O$

Change in oxidation number of an element

$KI + H_2SO_4 \longrightarrow K_2SO_4 + I_2 + H_2S + H_2O$

(1) (8)

Criss-cross the change in oxidation number

$8KI + H_2SO_4 \longrightarrow K_2SO_4 + 4I_2 + H_2S + H_2O$

To balance K – atom, K_2SO_4 is balanced by 4

$8KI + H_2SO_4 \longrightarrow 4K_2SO_4 + 4I_2 + H_2S + H_2O$

To balance S – atom, H_2SO_4 is balanced by 5

$8KI + 5H_2SO_4 \longrightarrow 4K_2SO_4 + 4I_2 + H_2S + H_2O$

To balance H and O – atom, H_2O is multiplied by 4

$8KI + 5H_2SO_4 \longrightarrow 4K_2SO_4 + 4I_2 + H_2S + 4H_2O$

Thus, the redox reaction is balanced.

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59. **2064 Q.No. 24 Define redox reaction. Balance the following equation by Oxidation number or ion-electron method. Also point out the oxidant and reductant:**

$I_2 + HNO_3 \longrightarrow HIO_3 + NO_2 + H_2O$

Redox reaction: The reaction in which both oxidation and reduction reaction occurs simultaneously is known as redox reaction or oxidation and reduction reaction.

Oxidation number method

$I_2 + HNO_3 \longrightarrow HIO_3 + NO_2 + H_2O$

Step- 1:

The oxidation number of an element.

$\overset{0}{I_2} + \overset{+5}{HNO_3} \longrightarrow \overset{+5}{HIO_3} + \overset{+4}{NO_2} + H_2O$

Step- 2:

Change in O.N.

$I_2 + HNO_3 \longrightarrow HIO_3 + NO_2 + H_2O$

(5) (1)

(10) (2) If both the change in O.N. is odd then double them.

Step-3:
Criss- cross the change in O.N.

$I_2 + 10HNO_3 \longrightarrow 2HIO_3 + 10NO_2 + H_2O$

Step-4:
To balance H- and O- atom, H_2O is balance by 4

$I_2 + 10HNO_3 \longrightarrow 2HIO_3 + 10NO_2 + 4H_2O$

Thus the redox reaction is balanced.
Here, I_2 is oxidant and HNO_3 is reductant.

---

60. 2062 Q.No. 25 **Point out the oxidant and reductant in the following redox reaction and balance the reaction by oxidation number or ion electron method.** [1.5+3.5]

$NaOH + Br_2 \longrightarrow NaBrO_3 + NaBr + H_2O$

The redox reaction is

$NaOH + Br_2 \longrightarrow NaBrO_3 + NaBr + H_2O$

Step- 1:
The oxidation of the elements are

$$\overset{0}{NaOH} + \overset{}{Br_2} \longrightarrow \overset{+5}{NaBrO_3} + \overset{-1}{NaBr} + H_2O$$

Here Br_2 acts as both oxidizing and reducing agent.

Step -2:
Change in oxidation number

$$NaOH + \underset{(5)}{Br_2} + \underset{(10)}{Br_2} \longrightarrow NaBrO_3 + \underset{(1)}{NaBr} + \underset{(2)}{H_2O}$$

If both the change in O.N. is odd then double them.

Step- 3:
Criss-cross the change in O.N.

$NaOH + Br_2 + 5Br_2 \longrightarrow 2NaBrO_3 + 10NaBr + H_2O$

Step – 4:
To balance Na- atom, NaOH is multiplied by 12

$12NaOH + Br_2 + 5Br_2 \longrightarrow 2NaBrO_3 + 10NaBr + H_2O$

Step – 5:
To balance H- and O- atom, H_2O is multiplied by 6

$12NaOH + Br_2 + 5Br_2 \longrightarrow 2NaBrO_3 + 10NaBr + 6H_2O$

or, $12NaOH + 6Br_2 \longrightarrow 2NaBrO_3 + 10NaBr + 6H_2O$

Thus the redox reaction is balanced.
Here, Oxidant and reductant both are Br_2.

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61. 2057 Q.No. 24 **Define oxidation and reduction in terms of electronic concept. Balance the following reaction by ion electron or oxidation number method** [2+3]

$Cu + HNO_3 \longrightarrow Cu(NO_3)_2 + NO + H_2O$

Oxidation: It is defined as the chemical process which involves

i. The loss of electron.
ii. The increase in positive charge.
iii. The decrease in negative charge.

Oxidation is also known as de-electronation. Example:

i. Loss of electron

$Na \longrightarrow Na^+ + e^-$

$K \longrightarrow K^+ + e^-$

$Ca \longrightarrow Ca^{++} + 2e^-$

ii. Increase in +ve charge.

$Sn^{2+} \longrightarrow Sn^{4+} + 2e^-$

$Fe^{2+} \longrightarrow Fe^{3+} + e^-$

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iii. Decrease in –ve charge.

$MnO_4^{--} \longrightarrow MnO_4^{-} + e^-$

$2Cl^- \longrightarrow Cl_2 + 2e^-$

$S^{2-} \longrightarrow S + 2e^-$

Reduction: It is defined as the chemical process which involves

i. The gain of electrons.
ii. The decrease in positive charge.
iii. The increase in negative charge.

Reduction is also known as **electronation**. Example:

i. Gain of electron resulting in decrease in +ve charge.

$2H^+ + 2e^- \longrightarrow H_2$

$Fe^{3+} + e^- \longrightarrow Fe^{2+}$

$Zn^{2+} + 2e^- \longrightarrow Zn$

ii. Gain of electron resulting in increase of –ve charge.

$MnO_4^- + e^- \longrightarrow MnO_4^{--}$

$Cl_2 + 2e^- \longrightarrow 2Cl^-$

Oxidation number method: Please refer to 2070 Set C Q.No. 24

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62. 2056 Q.No. 24 **Specifying oxidation half, reduction half, oxidizing agent and reducing agent balance the equation by ion electron or O.N. method:** **[5]**

$Fe^{2+} + H^+ + NO_3^- \longrightarrow Fe^{3+} + NO + H_2O$

Ion electron method:

$\overset{+2}{Fe^{2+}} + H^+ + \overset{+5}{NO_3^-} \longrightarrow \overset{+3}{Fe^{3+}} + \overset{+2}{NO} + H_2O$

Oxidation half

$Fe^{2+} \longrightarrow Fe^{3+} + e^-$ ... (i)

Reduction half

$N^{5+} + 3e^- \longrightarrow N^{2+}$ ... (ii)

To balance charge equation (i) is multiplied by 6 and equation is multiplied by 2 then adding both equation (i) and (ii) then we get

$6\,Fe^{2+} \longrightarrow 6\,Fe^{3+} + 6\,e^-$

$2\,N^{5+} + 6\,e^- \longrightarrow 2\,N^{2+}$

$6Fe^{2+} + 2N^{5+} \longrightarrow 6Fe^{3+} + 2N^{2+}$

Thus, the above redox reaction becomes

$6Fe^{2+} + H^+ + 2NO_3^- \longrightarrow 6Fe^{3+} + 2NO + H_2O$

To balance H - and O - atom, H_2O is multiplied by 4 and H^+ is multiplied by 8.

$6\,Fe^{2+} + 8\,H^+ + 2\,NO_3^{1-} \longrightarrow 6\,Fe^{3+} + 2\,NO + 4\,H_2O$

Thus the redox reaction is balanced.

Fe^{2+} is reducing agent or reductant and NO_3^- is oxidizing agent or oxidant.

LONG ANSWER QUESTIONS [10 MARKS]

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63. 2059 Q.No. 31

a. Define oxidation and reduction in terms of electronic concept. **[2+3+3+2]**

b. You are given the equation $Zn + HNO_3 \longrightarrow Zn(NO_3)_2 + N_2O + H_2O$

i. Explain with electronic concept which substance is oxidized and which is reduced?

ii. Balance the equation by ion electron or oxidation number method.

iii. Indicate the number of HNO_3 molecules acting as an oxidizing agent and as an acidic agent.

a. **Oxidation:** Please refer to 2057 Q.No. 24

Reduction: Please refer to 2057 Q.No. 24

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b. i. The given equation is

$$\overset{0}{Zn} + \overset{+5}{HNO_3} \longrightarrow \overset{+2}{Zn(NO_3)_2} + \overset{+1}{N_2O} + H_2O$$

Half oxidation: $Zn \longrightarrow Zn^{+2} + 2e^-$

Half reduction: $N^{+5} + 4e^- \longrightarrow N^{+1}$

Zinc i.e. Zn is oxidized by losing electron and nitrogen of nitric acid is reduced by gaining electron. So, zinc acts as reducing agent and nitric acid acts as oxidizing agent.

ii. Oxidation number method

$$\overset{0}{Zn} + \overset{+5}{HNO_3} \longrightarrow \overset{+2}{Zn(NO_3)_2} + \overset{+1}{N_2O} + H_2O$$

Change in oxidation number of an element

$$Zn + HNO_3 \longrightarrow Zn(NO_3)_2 + N_2O + H_2O$$

(2) (4)

Criss – cross the change in oxidation number

$$4\,Zn + 2\,HNO_3 \longrightarrow 4\,Zn(NO_3)_2 + N_2O + H_2O$$

To balance N – atom, $2HNO_3$ is multiplied by 5

$$4\,Zn + 10\,HNO_3 \longrightarrow 4\,Zn(NO_3)_2 + N_2O + H_2O$$

To balance H and O – atom H_2O is balanced by 5

$$4\,Zn + 10\,HNO_3 \longrightarrow 4\,Zn(NO_3)_2 + N_2O + 5\,H_2O$$

Thus, the redox reaction is balanced.

iii. Ten molecules of nitric acid are taken part in balancing redox reaction. Only two molecules of nitric acid act as oxidizing agent and eight molecules of nitric acid acts as an acidic agent.

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64. 2055 Q.No. 28

a. Define oxidation and reduction (electronic interpretation). [10]

b. Balance the following equations, identifying in each case the oxidizing and the reducing agent:

i. $H_2S + H_2O_2 \longrightarrow S + H_2O$

ii. $C + HNO_3 \longrightarrow NO_2 + H_2O + CO_2$

iii. $MnO_4^- + S^{2-} + H_2O \longrightarrow MnO_2 + S + OH^-$

a. Oxidation: Please refer to 2057 Q.No. 24

Reduction: Please refer to 2057 Q.No. 24

b. i. $H_2S + H_2O_2 \longrightarrow S + H_2O$

Oxidation number of an element

$$\overset{-2}{H_2}\overset{-1}{S} + \overset{-1}{H_2}\overset{-2}{O_2} \longrightarrow \overset{0}{S} + \overset{-2}{H_2O}$$

Change in oxidation number

$$H_2S + H_2O_2 \longrightarrow S + H_2O$$

(2) (1)

Criss – cross the change in oxidation number

$$H_2S + H_2O_2 \longrightarrow S + 2H_2O$$

Thus, the redox reaction is balanced.

ii. $C + HNO_3 \longrightarrow NO_2 + H_2O + CO_2$

Oxidation number of an element

$$\overset{0}{C} + \overset{+5}{HNO_3} \longrightarrow \overset{+4}{NO_2} + H_2O + \overset{+4}{CO_2}$$

Change in oxidation number

$$C + HNO_3 \longrightarrow NO_2 + H_2O + CO_2$$

(4) (1)

Criss – cross the change in oxidation number

$$C + 4\,HNO_3 \longrightarrow 4\,NO_2 + H_2O + CO_2$$

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To balance H and O – atom, H_2O is balanced by 2

$C + 4\,HNO_3 \longrightarrow 4\,NO_2 + 2H_2O + CO_2$

Thus, the redox reaction is balanced.

iii. $MnO_4^- + S^{2-} + H_2O \longrightarrow MnO_2 + S + OH^-$

Oxidation of an element

$\overset{+7}{MnO_4^-} + \overset{-2}{S^{2-}} + H_2O \longrightarrow \overset{+4}{MnO_2} + \overset{0}{S} + OH^-$

Change in oxidation number

$MnO_4^- + S^{2-} + H_2O \longrightarrow MnO_2 + S + OH^-$

(3) (2)

Criss – cross the change in oxidation number

$2\,MnO_4^- + 3\,S^{2-} + H_2O \longrightarrow 2\,MnO_2 + 3\,S + OH^-$

To balance H and O–atom, H_2O is multiplied by 4 and OH^- is multiplied by 8

$2\,MnO_4^- + 3\,S^{2-} + 4\,H_2O \longrightarrow 2\,MnO_2 + 3\,S + 8\,OH^-$

Thus, the redox reaction is balanced.

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65. 2054 Q.No. 29 **With a suitable example explain the terms:** **[10]**

a. **Oxidizing agent**
b. **Reducing agent**
c. **Oxidation**
d. **Reduction and balance the following reactions by oxidation number method**
   i. $Cr_2O_7^{2-} + Fe^{2+} + H^+ \longrightarrow Cr^{3+} + Fe^{3+} + H_2O$
   ii. $Zn + HNO_3 \longrightarrow Zn(NO_3)_2 + N_2O + H_2O$

Ans

a. **Oxidizing agent:** Please refer to 2072 Set C Q.No. 24

b. **Reducing agent:** Please refer to 2072 Set C Q.No. 24

c. **Oxidation:** Please refer to 2057 Q.No. 24

d. **Reduction:** Please refer to 2057 Q.No. 24

i. Oxidation number method

$\overset{+6}{Cr_2O_7^{2-}} + \overset{+2}{Fe^{2+}} + H^+ \longrightarrow \overset{+3}{Cr^{3+}} + \overset{+3}{Fe^{3+}} + H_2O$

Change in oxidation number

$Cr_2O_7^{2-} + Fe^{2+} + H^+ \longrightarrow Cr^{3+} + Fe^{3+} + H_2O$

(3) (1)

If both the change in oxidation is odd then double them

$Cr_2O_7^{2-} + Fe^{2+} + H^+ \longrightarrow Cr^{3+} + Fe^{3+} + H_2O$

(6) (2)

Criss – cross the change in oxidation number

$Cr_2O_7^{2-} + 6\,Fe^{2+} + H^+ \longrightarrow 2\,Cr^{3+} + 6\,Fe^{3+} + H_2O$

To balance H and O – atom, H_2O is multiplied by 7 and H^+ is multiplied by 14

$Cr_2O_7^{2-} + 6\,Fe^{2+} + 14\,H^+ \longrightarrow 2\,Cr^{3+} + 6\,Fe^{3+} + 7\,H_2O$

Thus, the redox reaction is balanced.

Here, $Cr_2O_7^{2-}$ is oxidizing agent and Fe^{2+} is reducing agent.

ii. Oxidation number method:

$\overset{0}{Zn} + \overset{+5}{HNO_3} \longrightarrow \overset{+2}{Zn(NO_3)_2} + \overset{+1}{N_2O} + H_2O$

Change in oxidation number of an element

$Zn + HNO_3 \longrightarrow Zn(NO_3)_2 + N_2O + H_2O$

(2) (4)

Criss – cross the change in oxidation number

$4\,Zn + 2\,HNO_3 \longrightarrow 4\,Zn(NO_3)_2 + N_2O + H_2O$

To balance N – atom, $2HNO_3$ is multiplied by 5

$4\ Zn + 10\ HNO_3 \longrightarrow 4\ Zn(NO_3)_2 + N_2O + H_2O$

To balance H and O – atom H_2O is balanced by 5

$4\ Zn + 10\ HNO_3 \longrightarrow 4\ Zn(NO_3)_2 + N_2O + 5\ H_2O$

Thus, the redox reaction is balanced.

Here, Zn acts as reducing agent and HNO_3 acts as oxidizing agent.

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66. 2053 Q.No. 3 Group C

a. What do you mean by redox-reaction?

b. Balance the following redox-reaction by oxidation number method

$KMnO_4 + KCl + H_2SO_4 \longrightarrow MnSO_4 + K_2SO_4 + H_2O + Cl_2$

Ans

a. **Redox reaction:** The reaction in which both oxidation and reduction reaction occu simultaneously is known as redox reaction.

b. **Oxidation number method**

$\overset{+7}{K}\overset{}{M}\overset{}{n}\overset{}{O_4} + \overset{-1}{K}\overset{}{Cl} + \overset{}{H_2}\overset{}{S}\overset{}{O_4} \longrightarrow \overset{+2}{M}\overset{}{n}\overset{}{S}\overset{}{O_4} + \overset{}{K_2}\overset{}{S}\overset{}{O_4} + \overset{}{H_2}\overset{}{O} + \overset{0}{Cl_2}$

Change in oxidation number

$KMnO_4 + KCl + H_2SO_4 \longrightarrow MnSO_4 + K_2SO_4 + H_2O + Cl_2$

(5) (1)

If both the change in oxidation is odd then double them

$KMnO_4 + KCl + H_2SO_4 \longrightarrow MnSO_4 + K_2SO_4 + H_2O + Cl_2$

(10) (2)

Criss – cross the change in oxidation number

$2\ KMnO_4 + 10\ KCl + H_2SO_4 \longrightarrow 2\ MnSO_4 + K_2SO_4 + H_2O + 5\ Cl_2$

To balance K – atom, K_2SO_4 is multiplied by 6

$2\ KMnO_4 + 10\ KCl + H_2SO_4 \longrightarrow 2\ MnSO_4 + 6\ K_2SO_4 + H_2O + 5\ Cl_2$

To balance SO_4^{--} radical, H_2SO_4 is multiplied by 8

$2\ KMnO_4 + 10\ KCl + 8\ H_2SO_4 \longrightarrow 2\ MnSO_4 + 6\ K_2SO_4 + H_2O + 5\ Cl_2$

To balance H and O – atom, H_2O is multiplied by 8

$2\ KMnO_4 + 10\ KCl + 8\ H_2SO_4 \longrightarrow 2\ MnSO_4 + 6\ K_2SO_4 + 8\ H_2O + 5\ Cl_2$

Thus, the redox reaction is balanced.

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67. 2052 Q.No. 2 Group C **Define oxidation reduction in terms of loss and gain of electrons. Illustrate your answe with balanced symbol equation.** [10]

$S + HNO_3 \longrightarrow SO_2 + NO_2 + H_2O$

In the above reactants which one is oxidized and which one is reduced?

a. **Oxidation:** Please refer to 2057 Q.No. 24

Oxidation number method

$\overset{0}{S} + \overset{+5}{H}\overset{}{N}\overset{}{O_3} \longrightarrow \overset{+4}{S}\overset{}{O_2} + \overset{+4}{N}\overset{}{O_2} + \overset{}{H_2}\overset{}{O}$

Change in oxidation number

$S + HNO_3 \longrightarrow SO_2 + NO_2 + H_2O$

(4) (1)

Criss – cross the change in oxidation number

$S + 4\ HNO_3 \longrightarrow SO_2 + 4\ NO_2 + H_2O$

To balance H and O – atom, H_2O is multiplied by 2

$S + 4\ HNO_3 \longrightarrow SO_2 + 4\ NO_2 + 2\ H_2O$

Thus, the redox reaction is balanced.

Here, sulphur is oxidized i.e. oxidation number is increased from 0 to + 4 and nitrogen of nitr acid is reduced i.e. oxidation number is decreased from + 5 to + 4.

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87. 2051 Q.No. 2 Group C

a. Define oxidation and reduction. [10]

b. Balance the following oxidation-reduction equations (You may use either ion-electron method or oxidation number method)

(i) $HNO_3 + H_2S \longrightarrow NO + S + H_2O$

(ii) $KMnO_4 + KCl + H_2SO_4 \longrightarrow MnSO_4 + K_2SO_4 + H_2O + Cl_2$

a. **Oxidation:** Please refer to 2057 Q.No. 24

Reduction: Please refer to 2057 Q.No. 24

b.

i. $HNO_3 + H_2S \longrightarrow NO + S + H_2O$

Oxidation number method

$$\overset{+5}{HNO_3} + \overset{-2}{H_2S} \longrightarrow \overset{+2}{NO} + \overset{0}{S} + H_2O$$

Change in oxidation number of an element

$$HNO_3 + H_2S \longrightarrow NO + S + H_2O$$

(3) (2)

Cross – cross the change in oxidation number

$$2\,HNO_3 + 3\,H_2S \longrightarrow 2\,NO + 3\,S + H_2O$$

To balance H and O – atom, H_2O is multiplied by 4

$$2\,HNO_3 + 3\,H_2S \longrightarrow 2\,NO + 3\,S + 4\,H_2O$$

Thus, the redox reaction is balanced.

ii. $KMnO_4 + KCl + H_2SO_4 \longrightarrow MnSO_4 + K_2SO_4 + H_2O + Cl_2$

Oxidation number method

$$\overset{+7}{KMnO_4} + \overset{-1}{KCl} + H_2SO_4 \longrightarrow \overset{+2}{MnSO_4} + K_2SO_4 + H_2O + \overset{0}{Cl_2}$$

Change in oxidation number

$$KMnO_4 + KCl + H_2SO_4 \longrightarrow MnSO_4 + K_2SO_4 + H_2O + Cl_2$$

(5) (1)

If both the change in oxidation number are odd then double them.

$$KMnO_4 + KCl + H_2SO_4 \longrightarrow MnSO_4 + K_2SO_4 + H_2O + Cl_2$$

(10) (2)

Criss – cross the change in oxidation number

$$2\,KMnO_4 + 10\,KCl + H_2SO_4 \longrightarrow 2\,MnSO_4 + K_2SO_4 + H_2O + 5\,Cl_2$$

To balance K – atom, K_2SO_4 is multiplied by 6

$$2\,KMnO_4 + 10\,KCl + H_2SO_4 \longrightarrow 2\,MnSO_4 + 6\,K_2SO_4 + H_2O + 5\,Cl_2$$

To balance SO_4^{--} radical, H_2SO_4 is multiplied by 8

$$2\,KMnO_4 + 10\,KCl + 8\,H_2SO_4 \longrightarrow 2\,MnSO_4 + 6\,K_2SO_4 + H_2O + 5\,Cl_2$$

To balance H and O – atom, H_2O is multiplied by 8

$$2\,KMnO_4 + 10\,KCl + 8\,H_2SO_4 \longrightarrow 2\,MnSO_4 + 6\,K_2SO_4 + 8\,H_2O + 5\,Cl_2$$

Thus, the redox reaction is balanced.

WRITE SHORT NOTES ON [5 MARKS]

88. 2071 Supp Q. No. 33d **Electronic interpretation of oxidation and reduction.** [5]

a. The concept which deals with oxidation and reduction in terms of electron transfer between the reactant is called electronic concept .This is modern concept.

Oxidation: According to this concept, Oxidation is defined as the chemical process which involves

i. The loss of electron.

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ii. The increase in positive charge.
iii. The decrease in negative charge.

Oxidation is also known as de-electronation. Example:

i. Loss of electron

$Na \longrightarrow Na^+ + e^-$

$K \longrightarrow K^+ + e^-$

$Ca \longrightarrow Ca^{++} + 2e^-$

ii. Increase in +ve charge.

$Sn^{2+} \longrightarrow Sn^{4+} + 2e^-$

$Fe^{2+} \longrightarrow Fe^{3+} + e^-$

iii. Decrease in –ve charge.

$MnO_4^{--} \longrightarrow MnO_4^- + e^-$

$2Cl^- \longrightarrow Cl_2 + 2e^-$

$S^{2-} \longrightarrow S + 2e^-$

Reduction: According to this concept, Reduction is defined as the chemical process whi involves

i. The gain of electrons.
ii. The decrease in positive charge.
iii. The increase in negative charge.

Reduction is also known as electronation. Example:

i. Gain of electron resulting in decrease in +ve charge.

$2H^+ + 2e^- \longrightarrow H_2$

$Fe^{3+} + e^- \longrightarrow Fe^{2+}$

$Zn^{2+} + 2e^- \longrightarrow Zn$

ii. Gain of electron resulting in increase of –ve charge.

$MnO_4^- + e^- \longrightarrow MnO_4^{--}$

$Cl_2 + 2e^- \longrightarrow 2Cl^-$

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78. 2068 Q.No. 33 d Oxidation and reduction in term of electronic concept.

Please refer to 2071 Supp Q. No. 33d

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Unit 9

Equilibria

VERY SHORT ANSWER QUESTIONS [2 MARKS]

1. 2076 Set B Q.No. 12 State law of mass action. [2]

Ans "The rate at which a substance reacts is directly proportional to its active mass and the rate of a chemical reaction is directly proportional to the products of active masses of the reactants".

2. 2076 Set C Q.No. 12 2072 Set C Q.No. 12 Define equilibrium constant. What information would you expect when equilibrium constant Kc > 1? [1+1]

Ans Equilibrium constant (K_C): The ratio of velocity constant of forward reaction and backward reaction is called equilibrium constant. It is denoted by Kc.

$$K_C = \frac{K_f}{K_b}$$

If the value of $K_C > 1$ the equilibrium will shift in forward direction. This is due to the higher concentration of product in equilibrium. Higher the concentration of product, higher the value of K_C, lower the concentration product, lower the value of K_C.

3. 2075 GIE Q.No. 12 Define equilibrium constant (Kc). Give the relationship Kp between Kc for the following reaction. [1+1]

$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$

Ans Equilibrium constant (K_C): The ratio of velocity constant of forward reaction and backward reaction is called equilibrium constant. It is denoted by Kc.

$$K_C = \frac{K_f}{K_b}$$

Relationship:

$PCl_5(g) \longrightarrow PCl_3(g) + Cl_2(g)$

Total mole of reactant = 1 mole

Total mole of product = 2 mole

$\Delta n = (2 - 1) = 1$

$K_p = K_C RT^{\Delta n}$

$K_p = K_C RT$

4. 2075 Set A Q.No. 12 Define equilibrium constant. Write equilibrium constant Kc for the reaction. [2]

$CaCO_3(s) \overset{\Delta}{\rightleftharpoons} CaO(s) + CO_2(g)$

Ans Equilibrium constant: It is the ratio of two rate constant i.e. the rate constant for forward reaction (K_f) and rate constant for backward reaction (K_b). It is denoted by K or K_{eq}.

$$K = \frac{K_f}{K_b}$$

The equilibrium constant for a reaction

$CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$

$K = \frac{[CaO][CO_2]}{[CaCO_3]}$ [The concentration of solid or liquid species is always unity]

So, $K = [CO_2]$ The equilibrium constant only depends upon the concentration of carbon-dioxide molecule.

5. 2075 Set B Q.No. 12 What is meant by equilibrium constant (K_c)? Write down the expression of equilibrium constant for the following reaction. [1½]

$3Fe(s) + 4H_2O(g) \rightleftharpoons Fe_2O_3(s) + 4H_2(g)$

The ratio of product of concentration of the products to that of reactants, each concentration term raises to the power respective of stoichiometric coefficient in a balanced chemical equation is called equilibrium constant(K_C).

$K_c = \frac{[H_2]^3}{[H_2O]^3}$ [If the reactants or products are in solid or liquid state, their concentrations are said to be constant and taken as unity]

6. 2074 Supp Q.No. 12 What is the effect of increase of pressure and decrease of temperature in the following chemical equilibrium? [1½]

$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) + heat$

In the given reaction

$2SO_2(g) + O_2(g) \longrightarrow 2SO_3(g) + heat$

2 volume 1 volume 2 volume

Effect of pressure: The total volume of reactant is greater than the total volume of product, so increasing the pressure in this reaction equilibrium shift is forward direction i.e. more SO_3 gas is formed.

Effect of temperature: This reaction is exothermic reaction because heat energy is evolved in the reaction, so decreasing temperature equilibrium shift in forward direction.

7. 2074 Set A Q.No. 12 2074 Set B Q.No. 12 Write the relationship between Kp and Kc for the reaction. [1½]

$PCl_5(g) \longrightarrow PCl_3(g) + Cl_2(g)$

$N_2(g) + 3H_2(g) \longrightarrow 2NH_3(g)$

i. $PCl_5(g) \longrightarrow PCl_3(g) + Cl_2(g)$

Total mole of reactant = 1 mole

Total mole of product = 2 mole

$\Delta n = (2 - 1) = 1$

$K_P = K_C RT^{\Delta n}$

$K_P = K_C RT$

ii. $N_2(g) + 3H_2(g) \longrightarrow 2NH_3(g)$

Total mole of reactant = 4 mole

Total mole of product = 2 mole

$\Delta n = (2 - 4) = -2$

$K_P = K_C RT^{\Delta n}$

$K_P = K_C(RT)^{-2}$

$K_P = \frac{K_c}{(RT)^2}$

8. 2073 Supp Q.No. 12 Write the expression for equilibrium constant (Kc) for the following reactions: [1½]

i. $2Cu(NO_3)_2(s) \rightleftharpoons 2CuO(s) + 4NO_2(g) + O_2(g)$

ii. $Fe(s) + CO(g) \rightleftharpoons Fe(s) + CO_2(g)$

The equilibrium constant (Kc) for the reaction:

i. $2Cu(NO_3)_2(s) \rightleftharpoons 2CuO(s) + 4NO_2(g) + O_2(g)$

$K_c = [NO_2]^4[O_2]$

ii. $Fe(s) + CO(g) \rightleftharpoons Fe(s) + CO_2(g)$

$K_c = \frac{[CO_2]}{[CO]}$

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9. 2073 Set C Q. No. 12 2073 Set D Q. No. 12 **Write the expression for equilibrium constant (Kc) for;**
$4\,NO\,(g) + 6\,H_2O\,(g) \rightleftharpoons 4\,NH_3\,(g) + 5\,O_2\,(g)$
What is the relationship between Kc and Kp for the above reaction? [1+1]

The given equilibrium reaction is

$$4\,NO\,(g) + 6\,H_2O\,(g) \rightleftharpoons 4\,NH_3\,(g) + 5\,O_2\,(g)$$

$$K_c = \frac{[NH_3]^4[O_2]^5}{[NO]^4[H_2O]^6}$$

We know that,

$K_p = K_c\,(RT)^{\Delta n}$

Where, Δn = No. of mole of product – No. of mole of reactant

For above reaction $\Delta n = [(4+5) - (4+6)] = [9 - 10] = -1$

Hence, $K_p = K_c\,(RT)^{(-1)}$

10. 2072 Supp Q. No. 12 **What is the relationship between Kp and Kc for the following gaseous reaction:**
i. $N_2 + 3H_2 \rightleftharpoons 2NH_3$
ii. $N_2 + O_2 \rightleftharpoons 2NO$ [1+1]

i. $N_2 + 3H_2 \rightleftharpoons 2NH_3$

$\Delta n = (2 - 4) = -2$

$K_p = K_c\,RT^{\Delta n}$

$K_p = K_c\,(RT)^{-2}$

$$K_p = \frac{K_c}{(RT)^2}$$

ii. $N_2 + O_2 \rightleftharpoons 2NO$

$\Delta n = (2 - 2) = 0$

$K_p = K_c\,RT^{\Delta n}$

$K_p = K_c\,(RT)^{0}$

$K_p = K_c$

11. 2072 Set D Q.No. 12 **Define equilibrium constant (K_c). Why is backward reaction favoured when $K_c < 1$?** [1+1]

Equilibrium constant (K_C): The ratio of velocity constant of forward reaction and backward reaction is called equilibrium constant. It is denoted by Kc.

$$K_C = \frac{K_f}{K_b}$$

The amounts of reactants are greater than amount of product. Due to this equilibrium will shift in backward direction.

12. 2072 Set E Q.No. 12 **Define equilibrium constant (K_c) and write the relationship between K_P and K_C for the following reaction:** [1+1]
$H_2\,(g) + I_2\,(g) \rightleftharpoons 2\,HI\,(g)$.

Equilibrium constant (K_C): The ratio of velocity constant of forward reaction and backward reaction is called equilibrium constant. It is denoted by Kc.

$$K_C = \frac{K_f}{K_b}$$

In the reaction

$$H_2\,(g) + I_2\,(g) \rightleftharpoons 2HI\,(g)$$

The relation between K_P and K_C

$K_P = K_C$

13. 2071 Supp Q. No. 12 **State Le-Chaterlier principle. What is the effect of temperature on the equilibrium of the following reaction:**
$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ $(\Delta H = -93.6\,kJ)$ [2]

Le- Chaterlier principle: "If a system in equilibrium is subjected to a change in concentration, pressure or temperature then the equilibrium shifts in such a way so as to nullify the effect of the change".

The given reaction is

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ $\Delta H = -93.6\,kJ$

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Effect of temperature: The value of ΔH is negative i.e. -93.6 kJ. So, the given reaction is exothermic. If temperature is increased on exothermic reaction, the equilibrium will shift in backward direction and vice-versa.

14. **2071 (Set C) Q.No. 12** **Predict the favourable conditions for forward reaction in the following case:** [2]

$$4\,NH_3\,(g) + 5\,O_2\,(g) \rightleftharpoons 4\,NO\,(g) + 6\,H_2O\,(g) + Heat$$

The reversible reaction is gives as

$4NH_3\,(g) + 5\,O_2\,(g) \rightleftharpoons 4\,NO\,(g) + 6\,H_2O + Heat$

Heat energy is released in the above reaction. So, it is exothermic reaction. Total number of moles of product (4 + 6 = 10) is grater than total moles of reaction (4 + 5 = 9). The favourable condition for forward reaction is.

a. High concentration of NH_3 and O_2.
b. Lowering of pressure
c. Lowering of temperature.

15. **2071 (Set D) Q.No. 12** **Define equilibrium constant (Kc). What would be the expression for Kc in the following reaction?** [1+1]

Equilibrium constant (K_C): The ratio of velocity constant of forward reaction and backward reaction is called equilibrium constant. It is denoted by Kc.

$$K_C = \frac{K_f}{K_b}$$

K_c for a reaction

$C(s) + CO_2(g) \rightleftharpoons 2\,CO\,(g)$

$$K_c = \frac{[CO]^2}{[C][CO_2]}$$

$$K_c = \frac{[CO]^2}{[CO_2]}$$

16. **2070 Supp. Q.No. 12** **State law of mass action and write Kc for the following equilibrium reaction.** [1+1]

$$CaCO_3(s) \underset{\Delta}{\rightleftharpoons} CaO(s) + CO_2(g)$$

Law of mass action: "The rate at which a substance reacts is directly proportional to its active mass and the rate of a chemical reaction is directly proportional to the products of active masses of the reactants".

K_c for equilibrium reaction

$$K_c = \frac{[CaO]\,[CO_2]}{[CaCO_3]}$$ [The concentration of solid or liquid species is always unity]

So, $K_c = [CO_2]$, The equilibrium constant only depends upon the concentration of carbondioxide molecule.

17. **2070 Set C Q.No. 7** **Mention proper conditions for maximum yield of SO_3 in the following equilibrium reaction?**

$$2\,SO_2 + O_2 \rightleftharpoons SO_3 + heat$$

Formation of sulphur trioxide (SO_3) from sulphur dioxide (SO_2) and oxygen(O_2): SO_2 and O_2 react to form SO_3.

The reaction is exothermic in nature (ΔH = -ve)

$2SO_2 + O_2 \rightleftharpoons 2SO_3 + 42\,Kcal.$

2vol. 1vol. 2vol.

i. **Effect of temperature:** Since the reaction is exothermic, on increasing the temperature the equilibrium shifts to the backward direction i.e. SO_3 decomposes to give SO_2 and O_2

ii. **Effect of pressure:** Here, total volume of the product is less than that of the reactant. So, on increasing pressure the equilibrium shifts to the direction where volume is decreased i.e. in forward direction.

iii. **Effect of concentration:** On increasing the concentration of the reactant i.e. SO_2 and O_2 then the equilibrium will shift in forward direction. Thus, the favorable condition for formation of SO_3 is

Low temperature # High pressure # High concentration of SO_2 and O_2

18. **2070 Set D Q.No. 12 What is meant by equilibrium constant (Kc)? Write a chemical equilibrium in which Kc become equal to Kp.** **[1+1]**

Equilibrium constant(K_c): It is the ratio of two rate constant i.e. the rate constant for forward reaction(K_f) and rate constant for backward reaction(K_b). It is denoted by Kc or K_{eq}.

$$Kc = \frac{K_f}{K_b}$$

Chemical equilibrium in which Kc = Kp

$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$

19. **2069 (Set A) Q. No. 12 What is the effect of increasing pressure and decreasing temperature on the following equilibrium:** **[2]**

$N_2+3H_2 \rightleftharpoons 2NH_3+heat$

The given equilibrium reaction

$N_2 + 3H_2 \longrightarrow 2NH_3 + heat$

1 volume 3 volume 2 volume

1 mole 3 mole 2 mole

Reactant = 1 + 3 = 4 volume = 4 mole

Product = 2 volume = 2 mole

Volume or mole of reactant > Volume or mole of product

In the above equilibrium reaction, the total volume of product is less than total volume of product. We know that increasing pressure in equilibrium reaction, equilibrium shift in a direction where volume is decreased. Thus, equilibrium will shift in forward direction by increasing pressure.

Effect of temperature: Above reaction is exothermic reaction due to the evolution of heat energy. By decreasing the temperature in exothermic reaction, equilibrium will shift in forward direction.

20. **2069 (Set B) Q. No. 12 Define law of mass action. What is the relation between Kp and Kc for the following reaction?**

$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$ **[1+1]**

Law of mass action: The quantitative relation between rate of reaction and the concentration of reactant species is known as law of mass action. The given reaction is

$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$

$\Delta n = (2 - 1) = 1$

$K_p = K_c RT^{\Delta n}$

$K_p = K_c RT$

21. **2068 Q.No. 12 What happens when the pressure is increased in the following equilibrium reaction:**

i. **$N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$**

ii. **$N_2(g) + H_2(g) \rightleftharpoons NH_3(g)$** **[1+1]**

i. $N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$

1 volume 1 volume 2 volume

1 mole 1 mole 2 mole

Total volume or mole of reactant i.e.(1 + 1) = 2 volume or mole = total volume or mole of product i.e. 2 volume or mole

There is no effect pressure on the equilibrium reaction.

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ii. $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3$

1 volume 3 volume 2 volume

1 mole 3 mole 2 mole

Total volume or mole of reactant i.e. (1 + 3) = 4 volume or mole

Total volume or mole of products = 2 volume or mole

Total volume or mole of product is less than total volume or mole of reactant. By increasing the pressure on equilibrium reaction, equilibrium will shift in forward direction.

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22. 2067 Q.No. 12 What is meant by the term active mass? Express the active mass of the reactants in the following reaction 2P + Q ⟶ products. [1+1]

Active mass: The term 'active mass' of any species is equivalents to the molar concentration of that species. It is expressed in square brackets [ ] which is raised to a power equal to its stoichiometric coefficient in balanced chemical equation. For example, the active mass of the substance 'A' is expressed by [A] or C_A.

The term 'molar concentration i.e. molarity of a substance means the no. of gram moles of the substance dissolved per unit volume of its solution.

$$\text{Molar Concentration} = \frac{\text{No. of gram moles of solute}}{\text{Volume of solution in litre}}$$

$$= \frac{\text{Weigth of solute in gram}}{\text{Molar mass of solute} \times \text{volume of solution in litre}}$$

The given reaction is

$2P + Q \longrightarrow$ Products

Rate $\alpha [P]^2[Q]^1$

Rate $= K[P]^2[Q]^1$

The active mass of reactant P is $[P]^2$

The active mass of reactant Q is $[Q]^1$

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23. 2066 Q.No. 12 What happens when pressure is increased in the following equilibrium reactions? [1+1]

$N_2O_4(g) \rightleftharpoons 2NO_2(g)$

$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$

In $N_2O_4(g) \rightleftharpoons 2NO_2(g)$

1 volume 2 volume

The volume of product is more than volume of reactant. So, increasing pressure in this reaction equilibrium will shift in backward direction. According to Le-Chatelier principle when pressure is increased in equilibrium reaction then equilibrium will shift in such a direction where volume is decreased.

In $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$

1 volume 1 volume 2 volume

Here, total volume of reactant is equal to the total volume of product. So, increasing pressure in this reaction there is no effect of pressure in the equilibrium reaction.

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24. 2065 Q. No. 12 Define equilibrium constant. Write the expression of equilibrium constant (Kc) for the following reaction:

$CaCO_3(S) \rightleftharpoons CaO(s) + CO_2(g)$ [2]

Please refer to 2075 Set A Q.No. 12

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25. 2064 Q.No. 10 Why is the formation of SO_3 favoured by increasing pressure and decreasing temperature of the following system?

$2SO_2(g) + O_2(g) \rightleftharpoons 3SO_3(s) + \text{heat}$ [2]

Please refer to 2074 Supp Q.No. 12

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26. **2063 Q.No. 6** **How do increase in termperature and pressure affect the equilibrium of the following reaction.** **[2]**
$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) + heat$

The given equilibrium is

$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) + heat$

2 vol 1 vol 2 vol

2 mole 1 mole 2 mole

Affect of temperature: This reaction is exothermic reaction because heat energy is evolved. So, increasing the temperature on exothermic reaction, equilibrium will shift in backward direction.

Affect of pressure: Total vol. or mole of reactant = 2 + 1 = 3 vol or mole and total vol or mole of product = 2 vol or mole. The total volume or mole of product is less than total volume or mole of reactant. So, increasing pressure on equilibrium reaction, equilibrium will shift in forward direction.

27. **2062 Q.No. 8** **Why does pressure have no effect on $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$? Write Kc for the reaction.** **[2]**

The given reaction is

$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$

1 vol 1 vol 2 vol

1 mole 1 mole 2 mole

Total vol or mole of reactant = 1 + 1 = 2 vol or mole

Total vol or mole of products = 2 vol or mole

In this reaction total vol or mole of reactant = total vol or mole of product. So, there is no effect of pressure on equilibrium reaction.

The equilibrium constant in terms of concentration is

$$K_c = \frac{[HI]^2}{[H_2]\,[I_2]}$$

28. **2060 Q.No. 11** **Write down the relation between Kp and Kc. What is condition for a gaseous reaction to have Kp = Kc?** **[2]**

The relation between Kp and Kc is

$K_p = K_c RT^{\Delta n}$ Where, Δn is difference in no. of mole of product and no. of mole of reactant.

If the value of Δn is Zero then $K_p = K_c$ i.e. no. of moles of product is equal to the no. of moles of reactant.

29. **2059 Q.No. 9** **How does temperature change affect the equilibrium of the given reaction?** **[2]**
$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$, $\Delta H = -22.4$ Kcal / mol

The given equilibrium reaction is

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ $\Delta H = -22.4$ KCal / mol

The value of ΔH is in negative i.e. – 22.4 KCal / mol. So, the reaction is exothermic and increasing the temperature on exothermic reaction, equilibrium will shift in backward direction and vice – versa.

30. **2056 Q.No. 11** **Predict the effect of temperature on the equilibrium of the reaction:** **[2]**
$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$, H = – 93.6 kJ

The given equilibrium reaction is

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ H = – 93.6 kJ

The value of is in negative i.e. – 93.6 kJ. So, the reaction is exothermic and increasing the temperature on exothermic reaction, equilibrium will shift in backward direction and vice-versa.

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SHORT ANSWER QUESTIONS

31. 2058 Q.No. 24 What would be the effect on the position of equilibrium of the relation? [5]
$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$
Of (a) adding Cl_2 (b) adding PCl_3 (c) decreasing the pressure by increasing the volume of the system (d) increasing temperature (the reaction is endothemic in the forward reaction) (e) adding a catalyst.

Ans The given reaction

$$PCl_5(g) + \Delta \rightleftharpoons \underbrace{PCl_3(g) + Cl_2(g)}_{2\text{ Volume}}$$

1 volume → 1 volume + 1 volume

a. **Adding Cl_2:** Here, Cl_2 is product when increasing the concentration of Cl_2 then the equilibrium shift in backward direction i.e. more PCl_5 is formed.

b. **Adding PCl_3:** Here PCl_3 is also product so increasing the concentration of PCl_3 then the equilibrium shift in backward direction.

c. **Decreasing pressure:** Here total volume of product is more than reactant so, decreasing pressure in this reaction equilibrium shift in forward direction.

d. **Increasing temperature:** This reaction is endothermic reaction so increasing the temperature the equilibrium shift in forward direction i.e. more heat energy is absorbed by PCl_5 and breaking of PCl_5 is faster and formation of product i.e. PCl_3 and Cl_2 is also faster.

32. 2057 Q.No. 25 State Le-chatlier's principle. How does the change in temperature and pressure affect the equilibrium of the following reaction? [1+2+2]
$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) + 22.4$ K Cal

Ans Statement: "If a system in equilibrium is subjected to a change in concentration, pressure or temperature then the equilibrium shifts in such a way so as to nullify the effect of the change."

The given equilibrium reaction is

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ $\Delta H = -22.4$ KCal / mole

Affect of temperature: The value of ΔH is in negative i.e. – 22.4 KCal / mole. So, the reaction is exothermic and increasing the temperature on exothermic reaction, equilibrium will shift in backward direction and vice – versa.

Affect of pressure:

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3$

1 volume 3 volume 2 volume

1 mole 3 mole 2 mole

Total volume or mole of reactant i.e. (1 + 3) = 4 volume or mole

Total volume or mole of product = 2 volume or mole

Total volume or mole of product is less than total volume or mole of reactant. By increasing the pressure on equilibrium reaction, equilibrium will shift in forward direction

WRITE SHORT NOTES ON

33. 2076 Set B Q.No. 33iv 2076 Set C Q.No. 33iv 2075 Set A Q.No. 33ii 2074 Supp Q.No. 33(iii) 2072 Supp Q. No. 33b 2072 Set C Q.No. 33b 2072 Set D Q.No. 33b 2071 (Set D) Q.No. 33 (c) 2070 Set C Q.No. 33c 2070 Set D Q.No. 33c 2069 (Set A) Q. No. 33a Relationship between Kp and Kc. [5]

Ans Let us consider a gaseous reaction,

$aA + bB \rightleftharpoons cC + dD$

The equilibrium constant in terms of concentration can be written as

$$K_c = \frac{[C]^c[D]^d}{[A]^a[B]^b} \quad \ldots (i)$$

The equilibrium constant in terms of partial pressure can be written as

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$$K_c = \frac{PC^c PD^d}{PA^a PB^b} \quad \ldots (ii)$$

Where, P_A, P_B, P_C and P_D are the partial of A,B,C and D respectively.

We have, $PV = nRT$

$$P = \frac{n}{V}RT \text{ (where } \frac{n}{V} \text{ = molar concentration)}$$

i.e. $P_A = \frac{n_A}{V}RT = [A]RT$

$$P_B = \frac{n_B}{V}RT = [B]RT$$

$$P_C = \frac{n_C}{V}RT = [C]RT$$

$$P_D = \frac{n_D}{V}RT = [D]RT$$

Therefore, the equation (ii) becomes

$$K_p = \frac{[C]^c (RT)^c [D]^d (RT)^d}{[A]^a (RT)^a [B]^b (RT)^b} = \frac{[C]^c [D]^d}{[A]^a [B]^b} RT^{(c+d)-(a-b)} = K_c(RT)^{\Delta n}$$

Where, $\Delta n = (c + d) - (a + b)$ which represents the change in number of moles in the reaction.

$K_p = K_c(RT)^{\Delta n}$

When $\Delta n = 0$ then $K_p = K_c$

2075 GIE Q.No. 33ii | 2074 Set A Q.No. 33iv | 2074 Set B Q.No. 33ii | 2071 Set C Q.No. 33c **Law of mass action and characteristics of equilibrium constant.** [5]

Norwegian chemist Guldberg and Waage suggested a quantitative relationship between the rate of reaction and concentration of reactant, which is known as law of mass action. It states that "The rate at which a substance reacts is directly proportional to its active mass and the rate of a chemical reaction is directly proportional to the products of active masses of the reactants".

The term 'active mass' of any species is equivalents to the molar concentration of that species. It is expressed in square brackets[ ].For example, the active mass of the substance 'A' is expressed by [A] or C_A.

The term 'molar concentration i.e.molarity' of a substance means the no. of gram moles of the substance dissolved per unit volume of its solution.

$$\text{Molar Concentration} = \frac{\text{No. of gram moles of solute}}{\text{Volume of solution in litre}}$$

$$= \frac{\text{Weigth of solute in gram}}{\text{Molar mass of solute x volume of solution in litre}}$$

Let us consider a reaction: $A \longrightarrow B$

According to law of mass action

Rate of reaction $\propto$ [A]

Let us consider a reversible reaction,

$A + B \rightleftharpoons C + D$

According to law of mass action,

Rate of forward reaction $\propto$ [A][B]

Rate of forward reaction = $k_f[A][B]$

Similarly, rate of backward reaction $\propto$ [C][D]

Rate of backward reaction = $k_b[C][D]$

Where, k_f and k_b are the proportionality constants, called velocity constant for forward and backward reaction respectively.

At equilibrium, rate of forward reaction = rate of backward reaction.

$\therefore K_f[A][B] = K_b[C][D]$

$$\frac{K_f}{K_b} = \frac{[C][D]}{[A][D]}$$

or, $K = \frac{[C][D]}{[A][B]}$ Where, K is a constant called equilibrium constant.

Let us take a reaction, $2A \rightleftharpoons B$

The reaction can also be written as

$A + A \rightleftharpoons B$

The equilibrium constant can be expressed as $K = \frac{[B]}{[A][A]}$

or, $K = \frac{[B]}{[A]^2}$

Here, the concentration of A raises to the power its stoichiometric coefficient i.e. 2.

If we consider a reaction, $aA + bB \rightleftharpoons cC + dD$ Then, equilibrium constant can be expressed as

$$K = \frac{[C]^c[D]^d}{[A]^a[B]^b}$$

Thus, the equilibrium constant (K_C or K) refers to the ratio of product of concentrations of the products to that of the reactants, each concentration term raises to the power respective stoichiometric coefficient in a balanced chemical equation.

Characteristics of Equilibrium Constant (K_C)

Following are the main characteristics:

i. The value of equilibrium constant is independent of the concentrations of the species in the reaction.
ii. The value of equilibrium constant depends upon the temperature.
iii. The equilibrium constant value does not depend upon the use of catalyst.
iv. The equilibrium constant for forward reaction is reciprocal of that for the backward reaction.

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35. 2075 Set B Q.No. 33i 2073 Supp Q.No. 33ii 2069 Set B Q. No. 33d Application of Le-Chatelier's principle in chemical equilibrium. [5]

In 1884, a French chemist Le-Chatelier studied the effect of concentration, pressure and temperature on the state of equilibrium. It states that "If a system in equilibrium is subjected to a change in concentration, pressure or temperature then the equilibrium shifts in such a way so as to nullify the effect of the change." That is in an equilibrium reaction:

1. On increasing the concentration, the equilibrium shift to the direction where the increased concentration is consumed. On doing so, the effect of increased concentration will be minimized.
2. On increasing the pressure, the equilibrium shifts to the direction where volume is decreased. As we know that when the pressure is increased the volume will decreased. So the equilibrium shifts to the side where volume is increased then the effect of increased pressure will be minimized.
3. On increasing the temperature, the equilibrium shifts to the direction where heat is absorbed. As we know that the increased temperature raises the heat. If the equilibrium shifts to the side where heat is absorbed then the effect of increased temperature will be minimized.

Application of Le-Chatelier's principle in Physical Equilibria

Let us see some application in physical equilibrium.

a. **Let us take conversion of ice into water**

Ice + Heat $\rightleftharpoons$ Water (liquid) at 0°C and 1 atm pressure

i. **Effect of change in temperature:** Since, the melting of ice is endothermic process, hence increasing in temperature shifts the equilibrium in forward side to from more liquid water and decrease in temperature shifts the equilibrium backward to form more ice.

ii. **Effect of change in pressure:** At 0°C, ice occupies greater volume than water. On increasing the pressure, the equilibrium will shifts to the water side so that the effect of the increased pressure will be minimized. Hence, the melting point of ice decreases when the pressure is increased.

b. **Let us consider dissolution of a gas in water**

Gas + Water $\rightleftharpoons$ Aqueous solution of the gas + Heat

Since the dissolution of gas is an exothermic process and proceeds by the decrease in the volume, the favorable condition for the dissolution of the gases is low temperature and high pressure. This is the reason that aerated drinks are kept under high pressure and low temperature.

Application of Le-Chatelier's principle in Chemical Equilibria

Let us consider a reaction

Formation of sulphur trioxide (SO_3) from sulphur dioxide (SO_2) and oxygen(O_2)

SO_2 and O_2 react to form SO_3.

The reaction is exothermic in nature (ΔH = -ve)

$$2SO_2 + O_2 \rightleftharpoons 2SO_3 + 42 \text{ Kcal.}$$

2vol. 1vol. 2vol.

i. **Effect of temperature:** Since the reaction is exothermic, on increasing the temperature the equilibrium shifts to the backward direction i.e. SO_3 decomposes to give SO_2 and O_2

ii. **Effect of pressure:** Here, total volume of the product is less than that of the reactant. So, on increasing pressure the equilibrium shifts to the direction where volume is decreased i.e. in forward direction.

iii. **Effect of concentration:** On increasing the concentration of the reactant i.e. SO_2 and O_2 then the equilibrium will shift in forward direction. Thus, the favorable condition for formation of SO_3 is

Low temperature # High pressure # High concentration of SO_2 and O_2

Effect of catalyst: There is no effect of catalyst on equilibrium

Effect of inert gas: When an inert gas is added to an equilibrium system, the volume of the system will be increased. Hence, on adding inert gas the equilibrium shifts to the larger volume side so that the effect of addition is minimized. If volume is maintained constant then there will be no effect of inert gas on equilibrium.

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36. 2073 Set C Q. No. 33ii | 2073 Set D Q. No. 33ii | 2072 Supp Q. No. 33i | 2070 Supp. Q.No. 33c **Le-Chatelier's principle and its application** **[5]**

↘ Please refer to 2075 Set B Q.No. 33i

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37. 2072 Set E Q.No. 33iii **Law of mass action and chemical equilibrium** **[5]**

↘ Please refer to 2075 GIE Q.No. 33ii

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38. 2067 Q.No. 33b | 2064Q.No. 33d | 2061 Q.No. 33d **Le-Chatelier's Principle.** **[5]**

↘ Please refer to 2075 Set B Q.No. 33i

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39. 2066 Q.No. 33 a | 2063 Q.No. 33a | 2059 Q.No. 33a **Law of mass action** **[5]**

↘ Please refer to 2075 GIE Q.No. 33ii

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Unit 10

Non-Metals I

10.1 Hydrogen

VERY SHORT ANSWER QUESTIONS [2 MARKS]

1. 2076 Set B Q.No. 14 **What is meant by para-hydrogen? How is it converted into ortho-hydrogen?** [1+1]

Molecules of hydrogen in which the spins of both the nuclei are in the opposite direction are called para hydrogen.



Para hydrogen
opposite spin

The para form is transformed into ortho form by the following methods.

a. By treatment with catalysts like platinum or iron
b. By passing an electric discharge
c. By heating to 800°C or more.
d. By mixing with paramagnetic molecules like O_2, NO, NO_2.
e. By mixing with nascent hydrogen or atomic hydrogen.

2. 2075 Set A Q.No. 13 **Illustrate with an example to show nascent hydrogen is more powerful reducing agent than dihydrogen.** [2]

The reaction which shows nascent hydrogen is more powerful reducing agent than molecular hydrogen.

Acidified solution of $KMnO_4$ is not reduced by molecular hydrogen but reduced by nascent hydrogen.

$KMnO_4 + H_2SO_4 + H_2 \longrightarrow$ No reaction

$2KMnO_4 + 3H_2SO_4 + 10[H] \xrightarrow{Zn + dil.\ H_2SO_4} K_2SO_4 + 2MnSO_4 + 8H_2O$

Pink → Colourless

3. 2075 Set B Q.No. 14 **Mention an important application of each of the following.** [0.5×4=2]

i. Ozone-layer ii. Heavy water
iii. Dihydrogen iv. Tritium

Important application of:

i. **Ozone layer:** It protects us from UV-rays coming from sun.
ii. **Heavy water:** It is used as coolant in nuclear reactor.

iii. **Dihydrogen:** It is used for the synthesis of ammonia in Haber's process.
iv. **Tritium:** It is used as radioactive substance in cancer therapy.

4. **2074 Supp Q.No. 13 Which one is more stable and why Ortho Hydrogen or Para Hydrogen?** **[1+1]**

Ordinary dihydrogen is an equilibrium mixture of ortho and para hydrogen.

ortho hydrogen $\rightleftharpoons$ para hydrogen

The amount of ortho and para hydrogen varies with temperature as:

- At 0°K, hydrogen contains mainly para hydrogen which is more stable.
- At the temperature of liquefaction of air, the ratio of ortho and para hydrogen is 1 : 1.
- At the room temperature, the ratio of ortho to para hydrogen is 3 : 1.
- Even at very high temperatures, the ratio of ortho to para hydrogen can never be more than 3 : 1.

Thus, it has been possible to get pure para hydrogen by cooling ordinary hydrogen gas to a very low temperature (close to 20 K) but it is never possible to get a sample of hydrogen containing more than 75% of ortho hydrogen.

5. **2074 Set A Q.No. 13 Which one is the least abundant isotope of hydrogen? Mention its two uses.** **[1+1]**

Tritium is the least abundant isotope of hydrogen in the nature.

Two important uses of Tritium:

i. Tritium is widely used in nuclear weapons for boosting a fission bomb or the fission primary of a thermonuclear weapon.
ii. Tritium is an important fuel for controlled nuclear fusion in both magnetic confinement and inertial confinement fusion reactor designs.

6. **2074 Set B Q.No. 13 Mention an important uses of each of the following** **[0.5×4]**

i. Deuterated water **ii. Tritium**
iii. Nascent hydrogen **iv. Ozone layer**

i. **Deuterated water:** It is used as coolant in nuclear reactor.
ii. **Tritium:** It is used as radioactive subsatance in cancer therapy.
iii. **Nanscent hydrogen:** It is used as reducing agent.
iv. **Ozone layer:** It protects us from Ultra Violet rays coming from sun.

7. **2073 Supp Q.No. 13 Which one is more stable? Ortho-hydrogen or para-hydrogen. How is ortho-hydrogen converted into para-hydrogen?** **[1+1]**

At 0oK para hydrogen is more stable than ortho hydrogen. For the conversion of ortho hydrogen into para hydrogen two environmental conditions are necessary: The environment has to be cooled down below 20 K and a paramagnetic catalyst material has to present. The paramagnetic catalyst enables the spin flip of the molecules from ortho hydrogen to para hydrogen.

8. **2073 Set C Q. No. 13 Distinguish between atomic hydrogen and nascent hydrogen.** **[2]**

Following are the difference between atom and nascent hydrogen:

Atomic Hydrogen	Nascent Hydrogen
a. Atomic hydrogen is formed by heating molecular hydrogen. $H_2 \longrightarrow 2H - 104$ Kcal (Molecular, Atomic)	a. Nascent hydrogen is formed during chemical reaction. $Zn + H_2SO_4 \longrightarrow ZnSO_4 + 2H$ (Nascent)
b. It cannot be produced in solution at ordinary temperature.	b. It can be prepared in solution at ordinary temperature.
c. It is more powerful reducing agent than nascent hydrogen.	c. It is less reducing agent than atomic hydrogen.

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9. **2073 Set D Q. No. 13** **What is nascent hydrogen? Mention an example to show nascent hydrogen is more powerful reducing agent than molecular hydrogen.** [1+1]

Nascent hydrogen: The hydrogen which is produced at the moment of its birth due to chemical reaction is known as nascent hydrogen.

Nascent hydrogen is more powerful reducing agent than molecular hydrogen:

The reaction which shows nascent hydrogen is more powerful reducing agent than molecular hydrogen. Acidified solution of $KMnO_4$ is not reduced by molecular hydrogen but reduced by nascent hydrogen.

$$KMnO_4 + H_2SO_4 + H_2 \longrightarrow \text{No reaction}$$

$$2KMnO_4 + 3H_2SO_4 + 10[H] \xrightarrow{Zn + dil.\ H_2SO_4} K_2SO_4 + 2MnSO_4 + 8H_2O$$

Pink → Colourless

10. **2072 Set E Q.No. 13** **Name the isotopes of hydrogen and mention an important use of heavy hydrogen.** [1+1]

Hydrogen has three isotopes: They are (i) protium, (ii) deuterium and (iii) tritium.

Heavy hydrogen is deuterium. it is used in the preparation of hydrogen bomb.

$$_1H^2 + {}_1H^3 \longrightarrow {}_2He^4 + {}_on^1 + \text{Energy}$$

Deuterium

11. **2071 Supp Q. No. 13** **Name the isotopes of hydrogen. In what respect do they differ from one another?** [2]

Hydrogen has three isotopes. They are (i) Protium (ii) Deuterium (iii) Tritium

i. **Protium:** It contains one proton, one electron and no neutron. It is also called ordinary hydrogen atom. Naturally occurring hydrogen contains about 99.9%.

ii. **Deuterium:** It contains one proton, one electron and one neutron. It is also called heavy hydrogen and denoted by D_2. Naturally occurring hydrogen contains about 0.015%.

iii. **Tritium:** It contains one proton, one electron and two neutrons. It is also called radioactive hydrogen. Naturally occurring hydrogen contains about 0.001% and denoted by T_3.

Protium is the isotope which does not contain neutron.

12. **2071 (Set C) Q.No. 14** **Mention one use of each of the following** [0.5 × 4 = 2]

a. Nascent hydrogen **b. Deuterium**
c. Heavy water **d. Ozone**

Use of:

a. **Nascent hydrogen:** It is used as reducing agent.
b. **Deuterium:** It is used to prepare heavy water which is used as moderator in nuclear reaction.
c. **Heavy water:** It is used as coolant in nuclear reactor.
d. **Ozone:** It is used for sterilizing of water.

13. **2069 (Set A) Q. No. 13** **Name the isotopes of hydrogen. Which of the isotope of hydrogen is radioactive?** [1+1]

There are three isotope of hydrogen

i. Protium
ii. Deuterium
iii. Tritium

The isotope tritium is radioactive.

14. **2069 (Set B) Q. No. 14** **Give a reaction to show nascent hydrogen is more powerful reducing agent than molecular hydrogen.** [2]

Please refer to **2075 Set A Q.No. 13**

15. **2068 Q.No. 13** **Mention one important use of each of the followings:** [0.5×4=2]

i. Heavy water **ii. Tritium**
iii. Nascent hydrogen **iv. Deuterium**

Use of:

i. **Heavy water:** It is used as coolant in nuclear reactor.
ii. **Tritium:** It is used as radioactive substance in cancer therapy.
iii. **Nascent hydrogen:** It is used as reducing agent.
iv. **Deuterium:** It is used to prepare heavy water which is used as moderator in nuclear reaction.

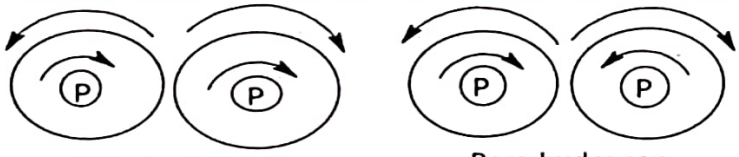
16. 2066 Q.No. 14 **Mention an important use of each of the followings:** [0.5×4=2]
i. Heavy water **ii. Ozone Layer**
iii. Hydrogen gas **iv. Deuterium**

i. **Heavy water:** It is used as coolant in nuclear reactor.
ii. **Ozone layer:** It protects us from Ultra Violet rays coming from sun.
iii. **H_2 gas:** It is used as manufacture of vegetable ghee.
iv. **Deuterium:** It is used to prepare heavy water which is used as moderator in nuclear reaction.

17. 2059 Q.No. 13 **Differentiate between ortho and para hydrogen.** [2]

Following are the difference

Ortho Hydrogen	Para Hydrogen
1. The hydrogen molecules in which the spin of protons are same.	1. The hydrogen molecules in which the spin of protons are opposite.
2. 75% hydrogens are ortho at normal condition.	2. 25% hydrogens are para at normal condition.
3. It is more stable.	3. It is less stable.
4. Its % can be increased by increasing temp.	4. Its % can be increased by decreasing temp.



Otho hydrogen parallel spins

Para hydrogen opposite spins

18. 2054 Q.No. 7 **Give a reaction which shows that water contains hydrogen.** [2]

When water vopour i.e. steam is passed through the red hot iron tube then hydrogen gas is evolved which shows water contains H_2 because iron does not contain hydrogen. The hydrogen gas must come from water molecules.

$$3Fe + 4H_2O \longrightarrow Fe_3O_4 + 4H_2\uparrow$$

19. 2054 Q.No. 8 **When steam is passed through red hot coke, a mixture of two gasses is obtained. Name the gases and write the reaction involved.** [2]

When steam is passed through red hot coke then a mixture of two gas CO and H_2 gases are formed.

$$C + H_2O\ (steam) \longrightarrow CO\uparrow + H_2\uparrow$$

The mixture of mixture of carbonmonoxide (CO) and hydrogen(H_2) are called water gas.

20. 2054 Q.No. 27(c) **What happens when Zinc dust is added to an acidified solution of potassium permanganate.** [2]

When zinc dust is added to the acidified solution of $KMnO_4$, pink colour of $KMnO_4$ is changed into colourless. Due to formation of nascent hydrogen.

$$[Zn + H_2SO_4 \longrightarrow ZnSO_4 + 2H\ (nascent)] \times 5$$

$$2KMnO_4 + 3H_2SO_4 + 10H \longrightarrow K_2SO_4 + 5ZnSO_4 + 2MnSO_4 + 8H_2O$$

$$2KMnO_4 + 8H_2SO_4 + 5Zn \longrightarrow 5ZnSO_4 + K_2SO_4 + 2MnSO_4 + 8H_2O$$

Pink Colourless

21. 2052 Q.No. 21 **Show that nascent hydrogen is powerful reducing agent than molecular hydrogen.** [1.5]

Please refer to 2075 Set A Q.No. 13

22. 2052 Q.No. 23 **List all the possible isotopes of hydrogen. Name the isotope which does not contain neutron.** [1.5]

Please refer to 2071 Supp Q. No. 13

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WRITE SHORT NOTES ON [2 MARKS]

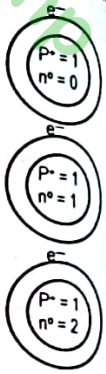
23. 2051 Q.No. 4 Group C Isotopes of Hydrogen

Isotopes of hydrogen: Hydrogen has three isotope. They are (i) Protium (ii) Deuterium (iii)Tritium

i. **Protium:** It contains one proton, one electron and no neutron. It is also called ordinary hydrogen atom. Naturally occurring hydrogen contains about 99.9% . Its mass no. is 1.

ii. **Deuterium:** It contains one proton, one electron and one neutron. It is also called heavy hydrogen and denoted by D_2. Naturally occurring hydrogen contains about 0.015%. Its mass no. is 2.

iii. **Tritium:** It contains one proton, one electron and two neutrons. It is also called radioactive hydrogen. Naturally occurring hydrogen contains about 0.001% and denoted by T_3. Its mass no. is 3.



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10.2 Oxygen

VERY SHORT ANSWER QUESTIONS

1. 2076 Set B Q.No. 13 **Give reason to show** [1+1]
   i. **Al_2O_3 is an amphoteric oxide**
   ii. **BaO_2 is a peroxide.**

Ans

i. It is amphoteric oxide because it reacts both acid as well as base to give salt and water.

$Al_2O_3 + 6HCl \longrightarrow 2AlCl_3 + 3H_2O$

Base Acid Salt Water

$Al_2O_3 + 2NaOH \longrightarrow 2NaAlO_2 + H_2O$

Acid Base Salt Water

ii. The oxidation number of oxygen in BaO_2 is -1 and it reacts with mineral acid to give H_2O_2. Due to this BaO_2 is peroxide.

$BaO_2 + H_2SO_4 \longrightarrow BaSO_4 + H_2O_2$

2. 2075 GIE Q.No. 13 **Give reason** [1+1]
   i. **CO_2 as an acidic oxide.**
   ii. **Al_2O_3 as an amphoteric oxide.**

Ans CO_2: It is acidic oxide because it reacts with base to form salt and water.

$CO_2 + 2NaOH \longrightarrow Na_2CO_3 + H_2O$

Al_2O_3: Please refer to 2076 Set B Q.No. 13

3. 2075 Set B Q.No. 13 **Classify the following oxides.** [0.5×4=2]
   BaO_2, Al_2O_3, Fe_3O_4, N_2O_3

Ans BaO_2 = Peroxide

Al_2O_3 = Amphoteric oxide

Fe_3O_4 = Mixed oxide

N_2O_3 = Acidic oxide

4. 2073 Set C Q. No. 14 **What are oxides? Write an example of** [1+1]
   i. **Amphoteric oxide**
   ii. **Mixed oxide**

Ans Oxides are binary compounds of oxygen with other elements. Example:

i. Amphoteric oxide: Al_2O_3

ii. Mixed oxide: Fe_3O_4 ($FeO + Fe_2O_3$)

5. 2072 Supp Q. No. 13 **Classify the following oxides:**
   N_2O_3, NO, BaO_2, Fe_3O_4 [2]

Ans N_2O_3:Acidic oxide NO: Neutral oxide

BaO_2: Peroxide Fe_3O_4: Mixed oxide

6. 2072 Set C Q.No. 14 **Classify the following oxides giving suitable reason:** [1+1]
   i. **BaO_2** ii. **Al_2O_3**

Ans

i. It is peroxide. It has peroxy linkage (—O—O—) and oxidation number oxygen is -1. It produces hydrogen peroxide with acid.

$BaO_2 + 2HCl \longrightarrow BaCl_2 + H_2O_2$

Barium peroxide Hydrogen peroxide

ii. It shows the properties of both acid and base. It reacts with acid and base. It is amphoteric oxide.

$Al_2O_3 + 6HCl \longrightarrow 2AlCl_3 + 3H_2O$

$Al_2O_3 + 2NaOH \longrightarrow 2NaAlO_2 + H_2O$

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7. 2071 (Set D) Q.No. 14 **Give reason:** [1+1]
   a. CO_2 as an acidic oxide
   b. Al_2O_3 as an amphoteric oxide

Ans CO_2: Please refer to 2075 GIE Q.No. 13
Al_2O_3: Please refer to 2076 Set B Q.No. 13

8. 2070 Set C Q.No. 12 **Mention one example of each of the followings:** [2]
   a. Peroxide b. Neutral oxide

Ans
a. Peroxide: Sodium peroxide (Na_2O_2)
b. Neutral oxide: Carbonmonoxide (CO)

9. 2070 Set D Q.No. 13 **Classify the following oxides.** [4×0.5]
   N_2O_3, NO, BaO_2 and Fe_2O_3.

Ans N_2O_3: It is acidic oxide.
NO: It is neutral oxide.
BaO_2: It is peroxide.
Fe_2O_3: It is basic oxide.

10. 2069 (Set A) Q. No. 14 **Name the allotropes of oxygen. Give an important use of each.** [1+1]

Ans Allotropes of oxygen are: (a) Oxygen (b) Ozone
a. Oxygen (O_2): It is used for supporter for burning.
b. Ozone (O_3): It is used for purifying environmental pollution.

11. 2067 Q.No. 14 **Mention one example of each of the following:** [0.5 × 4]
   i. Allotrope of oxygen
   ii. Most abundant isotope of hydrogen
   iii. Amphetoric oxide
   iv. Neutral oxide

Ans
i. Allotrope of oxygen: Example: $_8O^{16}$
ii. Most abundant isotope of hydrogen: $_1H^1$ (Protium)
iii. Amphoteric oxide: ZnO
iv. Neutral oxide : NO

12. 2065 Q. No. 15 **Classify the following oxides with reason: Al_2O_3, CO_2** [2]

Ans Al_2O_3: Please refer to 2076 Set B Q.No. 13
CO_2: Please refer to 2075 GIE Q.No. 13

13. 2063 Q.No. 12 **What are oxides? Give an example of an amphoteric oxide.**

Ans Oxides are binary compounds of oxygen with another elements. Example: ZnO, Al_2O_3, PbO, SnO etc

14. 2061 Q.No. 26 **What are oxides? Classify the following oxides justifying the classification:** [5]
   a. NO
   b. CO_2
   c. ZnO
   d. CaO

Ans Oxides: Oxides are the binary compound of oxygen with another element i.e. metals or non-metals.

a. NO: It is neutral oxide because it does not react with acid or base.

b. CO_2: It is acidic oxide because it reacts with base to form salt and water.

$$\underset{\text{Acid}}{CO_2} + \underset{\text{Base}}{2NaOH} \longrightarrow \underset{\text{Salt}}{Na_2CO_3} + \underset{\text{Water}}{H_2O}$$

c. ZnO: It is amphoteric oxide because it reacts with acid as well base to give salt and water.

$$\underset{\text{Base}}{ZnO} + \underset{\text{Acid}}{2HCl} \longrightarrow \underset{\text{Salt}}{ZnCl_2} + \underset{\text{Water}}{H_2O}$$

$$\underset{\text{Acid}}{ZnO} + \underset{\text{Base}}{2NaOH} \longrightarrow \underset{\text{Salt}}{Na_2ZnO_2} + \underset{\text{Water}}{H_2O}$$

d. CaO: It is basic oxide because it reacts with acid to form salt and water.

$CaO + 2HCl \longrightarrow CaCl_2 + H_2O$

15. 2058 Q.No. 16 **What are Neutral and Amphoteric Oxides? Give one example of each.** [2]

» Neutral oxide: Those oxides which show neither acidic nor basic in nature. They do not form salt with acid and base. Example: H_2O

Amphoteric oxide: Those metallic oxides which show both acidic and basic properties is called amphoteric oxide and they produce salt with both acid and base. Example: ZnO

16. 2057 Q.No. 13 **Write the names of any two neutral oxides with their formulae.** [2]

» Neutral oxide : Those oxide which shows neither acidic nor basic in nature. They do not form salt with acid and base. Example: H_2O, CO, N_2O, NO etc.

17. 2053 Q.No. 24 Group A **Choose oxide from the following that you would expect to be acidic. Give reaction to justify. Your choice Na_2O, ZnO, MgO, SO_3.** [1.5]

» Na_2O: It is basic oxide because it reacts with acid to give salt and water.

$Na_2O + 2\,HCl \longrightarrow 2\,NaCl + H_2O$

Base Acid Salt Water

ZnO: It is amphoteric oxide because it reacts with acid as well base to give salt and water.

$ZnO + 2HCl \longrightarrow ZnCl_2 + H_2O$

Base Acid Salt Water

$ZnO + 2NaOH \longrightarrow Na_2ZnO_2 + H_2O$

Acid Base Salt Water

MgO: It is basic oxide because it reacts with acid to give salt and water.

$MgO + 2\,HCl \longrightarrow MgCl_2 + H_2O$

Base Acid Salt Water

SO_3: It is an acidic oxide because it reacts with base to give salt and water.

$SO_3 + 2NaOH \longrightarrow Na_2SO_4 + H_2O$

Acid Base Salt Water

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10.3 Ozone

VERY SHORT ANSWER QUESTIONS

1. **2076 Set C Q.No. 13 How does chlorofluoro carbon deplet ozone layer?** [2]

American NASA scientist, in 1858, discovered the depletion of ozone layer over Antartica. They found that ozone layer is depleting at an alarming rate. The main cause of ozone layer depletion is chlorofluoro carbons (CFC). These are called Freon's because they are chlorine and fluorine substituted methane. These compounds are non-toxic and stable, so used in refrigerators, air conditioners etc. The common CFC's are $CFCl_3$ (Freon 11), CCl_2F_2 (Freon 12), $CHClF_2$ (Freon 22) etc. It is estimated that one molecule of CFC's can destroy 100,000 molecules of ozone.

Following reaction occurs

$$CCl_2F_2\,(g) \xrightarrow{\text{UV-light}} CClF_2\,(g) + Cl\,(g)$$

Chlorine atoms decompose the ozone layer.

$$Cl\,(g) + O_3 \longrightarrow ClO + O_2$$

$$ClO \xrightarrow{\text{UV-light}} Cl + O$$

$$O_3 + O \longrightarrow 2O_2$$

2. **2075 GIE Q.No. 14 Why is ozone layer formed at stratosphere? Give an importance of ozone layer.** [1+1]

The stratosphere is the second layer of the atmosphere as we go upward. The stratosphere stretches between 15 and 50 km up from the Earth's surface. Ozone is produced naturally in the stratosphere when highly energetic solar radiation breaks down molecules of oxygen (O_2) and causes the two oxygen atoms to split apart in a process called **photolysis**. If a freed atom collides with another (O_2), it joins up, forming ozone (O_3). Ozone layer is relatively abundant in the stratosphere, this layer absorbs energy from incoming ultraviolet radiation from the Sun.

Step: I

$$O{=}O + \text{Ultraviolet Sunlight} \longrightarrow \underbrace{O}_{\text{Oxygen atom}} + O$$

Step: II

$$O_2 + O \longrightarrow \underbrace{O_3}_{\text{Ozone}}$$

3. **2075 Set A Q.No. 14 Why is ozone layer formed on stratosphere? Name any one substance which is responsible for ozone layer depletion.** [1+1]

Please refer to 2075 GIE Q.No. 14

Chlorofluorocarbon (CFC_S) is one of the substance which is the responsible for ozone layer depletion.

4. **2074 Supp Q.No. 14 How are chlorofluorocarbon responsible for the depletion of ozone layer?** [2]

Please refer to 2076 Set C Q.No. 13

5. **2074 Set A Q.No. 14 2074 Set B Q.No. 14 Suggest your ideas to protect Ozone layer from its depletion.** [2]

The depletion of the ozone layer is a phenomena that was observed during the later part of the 70s and has since then showed a declining rate of 4% per decade and there is a remarkable decrease over the polar regions of the Earth. The main reason for the destruction of the ozone is by man-made halocarbon refrigerants such as CFCs, halons and freons that are released into the atmosphere and are known as 'ozone depleting substances'

There are five ways in which we can contribute to protecting the ozone layer and our precious Earth:

i. Limit private vehicle driving

ii. Use eco-friendly household cleaning products
iii. Avoid using pesticides
iv. Developing stringent regulations for rocket launches
v. Banning the use of dangerous nitrous oxide

6. 2073 Supp Q.No. 14 2073 Set D Q. No. 14 **How does formation of Ozone take place in stratosphere? Give any two uses of Ozone.** [1+1]

Formation of ozone: Ozone is found in maximum concentration in the upper stratosphere i.e. at a height of 50 km and above in the form of a layer called ozone layer.

Oxygen molecule absorbs the harmful uv-rays which changes to atomic oxygen. Atomic oxygen thus produced combines with molecular oxygen to form ozone layer.

$$\underset{\text{molecule}}{O_2\,(g)} \underset{}{\overset{\text{UV - rays}}{\rightleftharpoons}} \underset{\text{atomic oxygen}}{O} + O$$

$$O_2\,(g) + O \longrightarrow \underset{\text{ozone}}{O_3\,(g)}$$

Two uses of ozone:

i. It is used for sterilizing of water.
ii. It is used to prepare aldehyde and ketones.

7. 2072 Set C Q.No. 13i **What happens when Silent electric discharges is passed through pure and dry oxygen.** [1]

When silent electric discharge is passed through pure and dry oxygen, ozone is obtained.

$$3O_2 \underset{\text{Electric discharge}}{\overset{\text{Silent}}{\rightleftharpoons}} 2O_3,\ \Delta H = +284.5\ \text{kJ mol}^{-1}$$

8. 2072 Set C Q.No. 13ii **What happens when Mercury is exposed to ozonised atmosphere.** [1]

When mercury is exposed to ozonised atmosphere, mercurous oxide and oxygen is obtained.

$$2Hg + \underset{\text{Ozone}}{O_3} \longrightarrow \underset{\text{Mercurous oxide}}{Hg_2O} + O_2$$

9. 2072 Set D Q.No. 13 2068 Q.No. 14 **How does CFC deplete Ozone layer?** [2]

Please refer to 2076 Set C Q.No. 13

10. 2072 Set E Q.No. 14 **Write down balanced chemical equation for the formation of ozone from oxygen. What is meant by tailing of mercury?** [1+1]

Preparation of ozone from oxygen

Ozone is prepared by passing silent electric discharge through pure, cold and dry oxygen in a ozoniser.

$$O_2\,(g) \xrightarrow[\text{discharge}]{\text{Electric}} O + O$$

$$O_2(g) + O \longrightarrow O_3(g),\ \Delta H = 142.7\ \text{kJ mol}^{-1}$$

Tailing of mercury: When mercury comes in contact with ozone, mercurous oxide is obtained. The meniscus of mercury is lowered and it leaves a tail when allowed to run through an inclined surface. This property of mercury is called tailing of mercury.

$$O_3(g) \longrightarrow O_2\,(g) + [O]$$

$$2Hg + [O] \longrightarrow \underset{\text{Mercurous oxide}}{Hg_2O}$$

11. 2071 Supp Q. No. 14 **What is meant by ozone hole?** [2]

Ozone hole: The chlorofluoro carbon (CFC) deplete the ozone layer by making hole is called ozone hole.

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Chlorine atom decomposes the ozone layer.

$$CCl_2F_2\ (g) \xrightarrow{\text{UV - light}} CClF_2\ (g) + Cl\ (g)$$
(CFC)

$$Cl\ (g) + O_3 \longrightarrow ClO + O_2$$

$$ClO \xrightarrow{\text{UV - light}} Cl + O$$

$$O_3 + O \longrightarrow 2O_2$$

12. 2071 (Set C) Q.No. 13 **Why is ozone layer formed at stratosphere? Give an importance of ozone layer.** [1+

Please refer to 2073 Supp Q.No. 14

13. 2070 Supp. Q.No. 13 **How is ozone layer formed in the stratosphere? Give its one use.** [1+

Please refer to 2073 Supp Q.No. 14

14. 2070 Set C Q.No. 19 **How is Ozone formed in the stratosphere?**

Please refer to 2073 Supp Q.No. 14

15. 2070 Set D Q.No. 14 2069 (Set B) Q. No. 13 **How is oxygen converted into ozone? Mention major one use ozone.** [1+

Oxygen molecule absorbs the harmful uv-rays which changes to atomic oxygen. Atomic oxyge thus produced combines with molecular oxygen to form ozone layer.

$$\underset{\text{molecule}}{O_2\ (g)} \underset{}{\overset{\text{UV - rays}}{\rightleftharpoons}} \underset{\text{atomic oxygen}}{O + O}$$

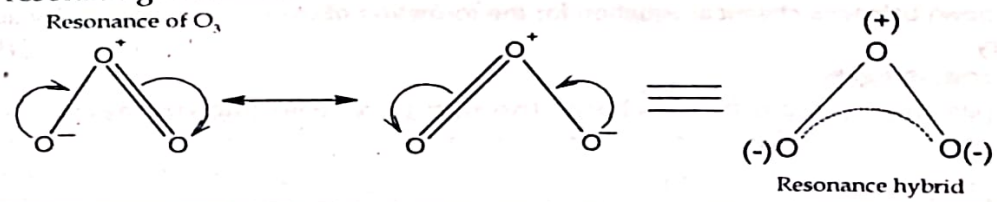
$$O_2\ (g) + O \longrightarrow \underset{\text{ozone}}{O_3\ (g)}$$

Two uses of ozone:

a. It is used for sterilizing of water.
b. It is used to prepare aldehyde and ketones.

16. 2064 Q.No. 14 **Write the resonating structure of ozone.**

Ozone forms two possible resonance structure and the true structure is the hybrid of tw resonating structure.



17. 2062 Q.No. 12 **Write resonance structures of ozone.**

Please refer to 2064 Q.No. 14

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10.4 Water

VERY SHORT ANSWER QUESTIONS

1. **2076 Set C Q.No. 9 Name any two properties of water in which hydrogen bonding is evident.** [1+1]

Ans The two properties of water in which hydrogen bonding is evident:

i. Water has high polarity.

ii. Water has high heat of evaporation

2. **2076 Set C Q.No. 14 What is meant by heavy water? Mention its any two applications.** [1+1]

Ans Deuterium oxide (D_2O) is called heavy water. The two applications of heavy water:

i. It is used as a tracer in the study of reactions occurring in living organism.

ii. It is employed in the preparation of heavy hydrogen.

3. **2072 Supp Q. No. 14 What is meant by heavy water? Write important use of it.** [1+1]

Ans Please refer to 2076 Set C Q.No 14

4. **2072 Set D Q.No. 14 Why is water called universal solvent?** [2]

Ans Water has high dielectric constant value i.e. 82. So, water is a good solvent for ionic as well as covalent substance and hence called as universal solvent. Due to the polar in nature, water dissolves many polar i.e. ionic substance.

5. **2071 (Set D) Q.No. 13 Why is water an excellent solvent for polar substances?** [2]

Ans Please refer to 2072 Set D Q.No 14

6. **2070 Supp. Q.No. 14 Mention an important application of each:** [1+1]
   i. Heavy water ii. Tritium

Ans **Application of:**

i. **Heavy water:** It is used as coolant in nuclear reactor.

ii. **Tritium:** It is used as radioactive substance in cancer therapy.

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10.5 Nitrogen and Its Compounds

VERY SHORT ANSWER QUESTIONS

1. **2063 Q.No. 16 What happens when the precipitate obtained by the addition of $AgNO_3$ solution on sodium chloride is treated with ammonia solution?**

The ppt. obtained by the addition of $AgNO_3$ solution on sodium chloride is treated with NH_4OH solution, a soluble complex of diamine silver (I) chloride is formed.

$$AgNO_3 + NaCl \longrightarrow AgCl\downarrow + NaNO_3$$

Curdy whit ppt.

$$AgCl + 2NH_4OH \longrightarrow [Ag(NH_3)_2]^+Cl^- + 2H_2O$$

Diamine silver (I) chloride

2. **2062 Q.No. 14 What happens when freshly prepared ferrous sulphate is added to the mixture of conc. nitric acid and conc. sulphuric acid?** [2]

When freshly prepared $FeSO_4$ solution is added to the mixture of conc. HNO_3 and conc. H_2SO_4, a dark brown ring of nitrosyl ferrous sulphate is appeared at the junction of two liquids.

$$2HNO_3 \longrightarrow 2NO + H_2O + 3[O]$$

$$[2FeSO_4 + H_2SO_4 + [O] \longrightarrow Fe_2(SO_4)_3 + H_2O] \times 3$$

$$6FeSO_4 + 2HNO_3 + 3H_2SO_4 \longrightarrow 3Fe_2(SO_4)_3 + 4H_2O + 2NO\uparrow$$

$$FeSO_4 + NO \longrightarrow FeSO_4.NO$$ (Nitrosyl ferrous sulphate)

Dark brown ring

3. **2061 Q.No. 15 Explain why ammonia gas cannot be dried by passing through conc. H_2SO_4 acid?** [2]

Ammonia is itself a base so, reacts with acid i.e. conc. H_2SO_4 to give salt. Due to this cannot be dried by conc. H_2SO_4.

$$Conc.H_2SO_4 + 2NH_3 \longrightarrow (NH_4)_2SO_4$$

Ammonium sulphate

4. **2061 Q.No. 17 In the ring test of nitrate what chemical compound is formed?**

In the ring test of nitrate radical, a brown ring is formed between the junctions of two liquid. This is due to the formation of nitrosyl ferrous sulphate.

$$NO_3^- + H_2SO_4 \longrightarrow HSO_4^- + HNO_3$$

$$6FeSO_4 + 2HNO_3 + 3H_2SO_4 \longrightarrow 3Fe_2(SO_4)_3 + 4H_2O + 2NO\uparrow$$

$$FeSO_4 + NO \longrightarrow FeSO_4.NO$$ (Nitrosyl ferrous sulphate)

5. **2060 Q.No.27i 2059 Q.No. 32i 2053 Q.No.7b 2052 Q.No.7c 2052 Q.No.7d 2051 Q.No. 7b What happens when: [1.5**

   a. **Gas obtained by heating slaked lime and ammonium chloride is passed through copper sulphate solution.**
   b. **Dilute nitric acid reacts with magnesium.**
   c. **A mixture of ammonia and oxygen is passed over platinum gauze heated to 800° C.**
   d. **A solution of sodium nitrite and ammonium chloride is heated to boiling.**
   e. **Zinc is added in a hot alkaline solution of potassium nitrate.**
   f. **Mercurous nitrate paper is exposed in ammonia gas.**
   g. **Mercurous nitrate paper is placed over a jar containing ammonia gas.**

a. When slaked lime i.e. $Ca(OH)_2$ is heated with NH_4Cl then ammonia gas is formed.

$$Ca(OH)_2 + 2NH_4Cl \longrightarrow CaCl_2 + 2H_2O + 2NH_3\uparrow$$

Thus the formed ammonia gas is passed through copper sulphate solution then bluish white ppt. is obtained, but passed in excess then deep blue ppt. of tetramine copper sulphate is formed.

$$NH_3 + H_2O \longrightarrow NH_4OH$$

$$CuSO_4 + 2NH_4OH \longrightarrow Cu(OH)_2\downarrow + (NH_4)_2SO_4$$

Bluish white ppt.

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$Cu(OH)_2 + (NH_4)_2SO_4 + 2NH_4OH \longrightarrow [Cu(NH_3)_4]SO_4 \downarrow + H_2O$
Deep blue ppt.
Tetramine copper sulphate

b. Very dilute nitric acid gives hydrogen gas with Mg metal.
$2HNO_3 + Mg \longrightarrow Mg(NO_3)_2 + H_2 \uparrow$

c. When a mixture of ammonia and oxygen is passed over platinum guage heated to 800°C then NO gas is formed.
$4NH_3 + 5O_2 \xrightarrow[800^\circ C]{Pt} 4NO \uparrow + 6H_2O$

d. When a solution of sodium nitrite and ammonium chloride is heated to boiling then N_2 gas is formed.
$NaNO_2 + NH_4Cl \longrightarrow NH_4NO_2 + NaCl$
$NH_4NO_2 \xrightarrow{Boil} N_2 \uparrow + 2H_2O$

e. When zinc is added to hot alkaline solution of potassium nitrate then ammonia gas is formed.
$4Zn + KNO_3 + 7KOH \longrightarrow 4K_2ZnO_2 + NH_3 \uparrow + 2H_2O$
Pot. Zincate ammonia

f. When mercurous nitrate paper is placed over a jar containing ammonia gas then paper changed into black. This is due to the formation of mercuric amino nitrate.
$Hg_2(NO_3)_2 + 2NH_3 \longrightarrow [Hg + Hg(NH_2)NO_3] + NH_4NO_3$
Mercuric amino nitrate(black)

g. Same as above answer of f

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i. **2059 Q.No. 17 Write the action of aquaregia on gold.** **[2]**

Aqua regia is the mixture of 3 volume HCl and 1 volume HNO_3. When aqua regia is treated with gold then aurochloric acid is formed.
$3Conc.\ HCl + Conc.\ HNO_3 \longrightarrow NOCl + 2H_2O + 2Cl$
$Au + 3Cl \longrightarrow AuCl_3$
$AuCl_3 + HCl \longrightarrow HAuCl_4$ (Aurochloric acid)

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i. **2055 Q.No. 15 Write equations for the reactions between:** **[2]**
a. ammonia and copper (II) oxide,
b. ammonia and chlorine

a. **Ammonia and copper(II) oxide:** Ammonia reacts with copper(II) oxide to liberate nitrogen gas with the deposition of copper metal.
$3CuO + 2NH_3 \longrightarrow 3Cu + 3H_2O + N_2 \uparrow$

b. **Ammonia and chlorine:** Ammonia reacts with chlorine to form ammonium chlorine with the evolution of nitrogen gas.
$8NH_3 + 3Cl_2 \longrightarrow 6NH_4Cl + N_2 \uparrow$
Ammonium chloride

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i. **2053 Q.No. 15 Group A How does an ammonia molecule differ from ammonium ion?** **[2]**

Ammonia (NH_3): It is Lewis base, having pyramidal shape and contains one lone pair of electron and three bond pair of electrons.
Ammonium ion (NH_4^+): It is positively charged ion, having tetrahedral shape and is conjugate acid of ammonia.

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i. **2051 Q.No. 9 Write the names of any two metals which can liberate Hydrogen gas from Nitric Acid.** **[2]**

The two metals which liberate hydrogen gas from nitric acid are Mg and Mn.
$Mg + 2HNO_3 \longrightarrow Mg(NO_3)_2 + H_2 \uparrow$
$Mn + 2HNO_3 \longrightarrow Mn(NO_3)_2 + H_2 \uparrow$

SHORT ANSWER QUESTIONS

10. 2075 GIE Q.No. 27 Give balanced chemical equation for the preparation of ammonia from nitrogen and hydrogen. How does ammonia reacts with:

i. Mercurous paper **ii. Nessler's reagent**
iii. Oxygen **iv. Sodium metal** **[1+1+1+1+1]**

Preparation of ammonia from nitrogen and hydrogen: Please refer to 2071 Set D Q.No. 27

Action of ammonia with:

i. Mercurous paper: When mercurous nitrate paper is placed over a jar containing ammonia gas then paper changed into black. This is due to the formation of mercuric amino nitrate.

$$Hg_2(NO_3)_2 + 2NH_3 \longrightarrow \underset{\text{Mercuric amino nitrate(black)}}{[Hg + Hg(NH_2)NO_3]} + NH_4NO_3$$

ii. Nessler's reagent: When ammonia gas is passed through Nessler's reagent, reddish brown ppt of iodide of Million's base is obtained.

$$\underset{\text{Nessler's reagent}}{2\,K_2[HgI_4]} + 4\,NH_3 + H_2O \longrightarrow \underset{\text{Reddish brown ppt}}{HgO.Hg\begin{matrix}I\\ \diagup\\ \diagdown\\ NH_2\end{matrix}} + 4\,KI + 3\,NH_4I$$

iii. Oxygen: Ammonia gas burns with atmospheric oxygen with greenish yellow flame to produce nitrogen gas and water.

$$4\,NH_3 + 3\,O_2 \longrightarrow 6H_2O + 2\,N_2$$

iv. Sodium metal: Sodium metal reacts with liquid ammonia to form hydrogen gas.

$$2Na + 2NH_3 \longrightarrow \underset{\text{Sodamide}}{2NaNH_2} + H_2\uparrow$$

11. 2075 Set A Q.No. 28 How is ammonia manufactured by Haber's process? Write the action of ammonia on copper sulphate solution. **[4+1]**

Manufacture of ammonia by Haber's process: When nitrogen and hydrogen gas is directly combined in the ratio of 1:3 by volume and heated at 450°C–500°C temperature and 200-900 atm pressure in the presence of iron or molybdenum catalyst then ammonia gas is formed. This is reversible and exothermic reaction.

$$N_2(g) + 3H_2(g) \underset{\text{200 – 900 atm, Fe or Mo Catalyst}}{\overset{\text{450°C – 500°C}}{\rightleftharpoons}} 2NH_3(g) + 92.6\ kJ\ mol^{-1}$$

The formation of ammonia is monitored by Le-Chatelier principle.

Favorable condition for the manufacture of ammonia by Haber's process:

i. Low temperature: This is exothermic reaction so, lowering temperature equilibrium shift in forward direction. The optimum temperature is 450 – 500°C.

ii. High pressure: The total volume of product is lower than total volume of reactant so, increasing pressure equilibrium shift in forward direction. Pressure is above 200 – 900 atm.

iii. Presence of catalyst: The catalyst increases the formation of ammonia. Finely divided iron catalyst and Mo promoter is used.

iv. High concentration: By increasing the concentration of reactant, i.e. N_2 and H_2 large amount of ammonia is formed.

v. Purity of gas: Pure H_2 gas and N_2 gas should be supplied

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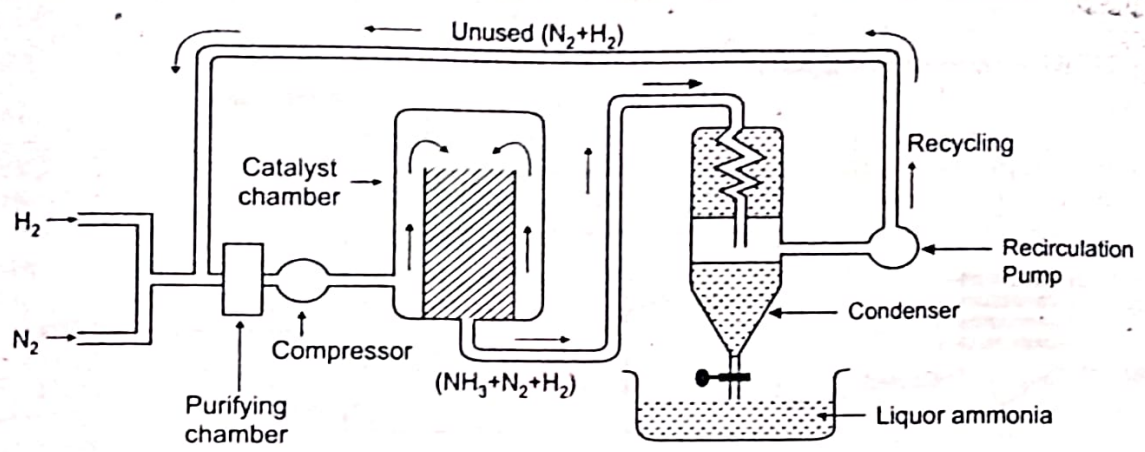


Fig: Manufacture of ammonia by Haber's process

Working plant for the manufacture of Ammonia by Haber's process:

a. **Production of $N_2$and H_2 gas**: N_2 gas is obtained by fractional distillation of air and H_2 gas is obtained by fractional liquefaction of water gas (CO + H_2).

b. **Compressor**: The mixture of N_2 and H_2 gas is passed into the purifying chamber to a pressure of 200-900 atmospheric pressure. The purifying chamber contains soda-lime water which absorbs CO_2 and moisture.

c. **Catalyst chamber**: This chamber is packed with finely divided Fe and little Mo as a promoter. The mixture of gas are passed through catalyst chamber at about 450-500°C.

d. **Condenser**: The gas which is coming out from catalytic chamber contains NH_3 along with N_2 and H_2. The mixture of gas is passed through a condenser where NH_3 gas is condensed to liquid NH_3 which is collected in a receiver.

NH_3 (gas) $\longrightarrow$ NH_3 (liquid)

e. **Recirculation Pump**: The uncondensed N_2 and H_2 gases are re-circulated through to the recirculation pump. This increases the percentage yield of NH_3 gas.

Action of NH_3 with $CuSO_4$:

Ammonia gas is passed through copper sulphate solution then bluish white ppt. is obtained, but passed in excess then deep blue ppt. of tetramine copper sulphate is formed.

$NH_3 + H_2O \longrightarrow NH_4OH$

$CuSO_4 + 2NH_4OH \longrightarrow \underset{\text{Bluish white ppt.}}{Cu(OH)_2\downarrow} + (NH_4)_2SO_4$

$Cu(OH)_2 + (NH_4)_2SO_4 + 2NH_4OH \longrightarrow \underset{\substack{\text{Deep blue ppt.}\\ \text{Tetramine copper sulphate}}}{[Cu(NH_3)_4]SO_4\downarrow} + H_2O$

12. 2075 Set B Q.No. 28 **How is nitric acid prepared from catalytic oxidation of ammonia?** **[5]**

Manufacture of Nitric acid by catalytic oxidation of ammonia or Ostwald's process:

In this process, nitric acid is prepared by the catalytic oxidation of ammonia and can be done by following steps.

i. Ammonia is oxidized to nitric oxide by passing a mixture of ammonia and air at 900°C in the presence of Pt catalyst.

$4NH_3 + 5O_2 \xrightarrow[\text{Pt Catalyst}]{900^\circ C} 6H_2O + 4NO\uparrow + \text{heat}$

ii. Nitric oxide thus formed is cooled to about 50 – 100°C and oxidized to nitrogen dioxide.

$2NO + O_2 \longrightarrow 2NO_2\uparrow$

iii. Nitrogen dioxide is then converted into nitric acid by passing NO_2 gas in water in the presence of air.

$$4NO_2 + 2H_2O + O_2 \longrightarrow 4HNO_3$$

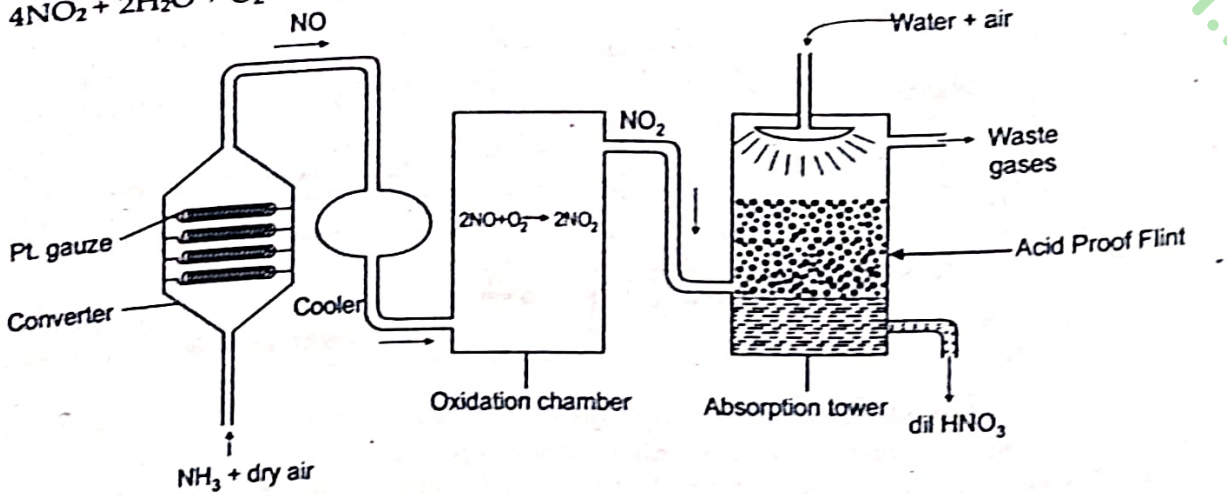


Fig: Manufacture of nitric acid by Ostwald's process

Procedure: Nitric acid is manufactured by Ostwald process. The process is explained in three steps:

Step – I: Oxidation of ammonia into nitric oxide in the catalytic chamber.

A mixture of dry air(free from carbon dioxide and dust particle) and dry ammonia in the ratio of 10:1 by volume, is first compressed and then passed into the catalytic chamber containing platinum gauze as catalyst at about 900°C. This results in the oxidation of ammonia into nitrogen monoxide.

$$4NH_3 + 5O_2 \xrightarrow[900^\circ C]{Pt} 4NO\uparrow + 6H_2O + \text{heat}$$

The reaction is exothermic and the heat evolved maintains the temperature of the catalytic chamber. The hot gases are then passed through a heat exchanger, where they are mixed with air and passed into another cooling chamber called oxidizing chamber.

Step – II: Oxidation of nitric oxide in oxidation chamber.

In this chamber, nitric oxide combines with oxygen to form nitrogen dioxide at about 50°C - 100°C.

$$2NO + O_2 \xrightarrow{50^\circ C - 100^\circ C} 2NO_2\uparrow$$

Step – III: Absorption of nitrogen dioxide in water.

The nitrogen dioxide together with the remaining air is passed through the absorption tower from the top of which warm water trickles. The nitrogen dioxide and oxygen present in the air react with water to form nitric acid.

$$4NO_2 + 2H_2O + O_2 \longrightarrow 4HNO_3$$

The nitric acid obtained at the bottom of the tower is concentrated above 50%. This acid on further distillation gives 68% nitric acid. This acid is concentrated nitric acid which is used in laboratories.

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13. 2074 Supp Q.No. 28 How in ammonia manufactured by Haber's process? What happens when ammonia solution is passed through Nesseler's reagent? [4+1]

Ans Manufacture of ammonia by Haber's process: Please refer to 2075 Set A Q No. 28

What happens when

When ammonia gas is passed through Nessler's reagent, reddish brown ppt of iodide of Million's base is obtained.

$$2\,K_2[HgI_4] + 4\,NH_3 + H_2O \longrightarrow HgO.Hg\begin{matrix}I\\NH_2\end{matrix} + 4\,KI + 3\,NH_4I$$

Nessler's reagent — Reddish brown ppt

14. 2074 Set B Q.No. 28 **How is ammonia manufactured by Haber's process? What happens when ammonia is passed through heated CuO?** **[4+1]**

Manufacture of ammonia by Haber's process: Please refer to 2075 Set A Q.No 28

When ammonia gas is passed through heated CuO, copper oxide is reduced to Cu metal and NH_3 is itself oxidized to N_2.

$$3CuO + 2NH_3 \longrightarrow 3Cu + 3H_2O + N_2$$

15. 2072 Set C Q.No. 28 **Starting from ammonia how would you obtain nitric acid? What is the action of nitric acid on:** **[1.5+1.5+1 + 1]**

i. Fe and ii. KI

Why is conc. nitric acid stored in dark brown bottle?

Manufacture of nitric acid from ammonia:

It involves three different steps:

a **Catalytic oxidation of Ammonia:** Ammonia is oxidized to nitric oxide with air in the presence of Pt catalyst at 800°C.

$$4NH_3 + 5O_2 \xrightarrow[800^\circ C]{\text{Pt-gauze}} 4NO + 6H_2O$$

b. **Oxidation of nitric acid:** Nitric oxide is oxidized by air to form nitrogen dioxide.

$$2NO + O_2 \longrightarrow 2NO_2$$

c **Absorption of nitrogen dioxide:** Nitrogen dioxide is absorbed by water in the presence of air to form nitric acid.

$$4NO_2 + O_2 + 2H_2O \longrightarrow 4HNO_3$$

Action of nitric acid on:

i. **Fe:**

a. Iron reacts with very dil. HNO_3 i.e. about 6% and gets oxidized to ferrous nitrate and ammonium nitrate.

$$Fe + 2\,HNO_3 \longrightarrow Fe(NO_3)_2 + 2\,H] \times 4$$
$$2\,HNO_3 + 8\,H \longrightarrow NH_4NO_3 + 3\,H_2O$$
$$4\,Fe + 10\,HNO_3 \longrightarrow 4\,Fe(NO_3)_2 + NH_4NO_3 + 3\,H_2O$$

b. Iron reacts with cold and dil. HNO_3 i.e. about 20% and gets oxidized to ferrous nitrate and nitrous oxide.

$$Fe + 2\,HNO_3 \longrightarrow Fe(NO_3)_2 + 2\,H] \times 4$$
$$2\,HNO_3 + 8\,H \longrightarrow N_2O + 5\,H_2O$$
$$4\,Fe + 10\,HNO_3 \longrightarrow 4\,Fe(NO_3)_2 + N_2O + 5\,H_2O$$

c. Iron reacts with cold and moderately conc. HNO_3 i.e. about 50% and gets oxidized to ferric nitrate and nitric oxide.

$$Fe + 2\,HNO_3 \longrightarrow Fe(NO_3)_2 + 2\,H] \times 4$$
$$HNO_3 + 3\,H \longrightarrow NO + 2\,H_2O$$
$$Fe + 4\,HNO_3 \longrightarrow Fe(NO_3)_3 + NO + 2\,H_2O$$

d. Iron reacts with cold and conc. HNO_3 i.e. about 70% or more and gets oxidized to ferric nitrate and nitrogen dioxide.

$$Fe + 3\,HNO_3 \longrightarrow Fe(NO_3)_2 + 3\,H$$
$$HNO_3 + H \longrightarrow NO_2 + H_2O\,] \times 3$$
$$Fe + 6\,HNO_3 \longrightarrow Fe(NO_3)_3 + 3\,NO_2 + 3\,H_2O$$

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ii. KI: Nitric acid oxidizes potassium iodide to iodine.

$2HNO_3 \longrightarrow 2NO + H_2O + 3[O]$

$KI + HNO_3 \longrightarrow KNO_3 + HI] \times 6$

$2HI + [O] \longrightarrow H_2O + I_2] \times 3$

$8HNO_3 + 6KI \longrightarrow 2NO + 4H_2O + 6KNO_3 + 3I_2$

When conc. HNO_3 is exposed in open air, it undergoes decomposition to give NO_2 gas which gets dissolved in HNO_3 and turns yellow. Due to this conc. HNO_3 is stored in dark brown bottle.

$4HNO_3 \xrightarrow{h\upsilon} 4NO_2 + O_2 + 2H_2O$

16. **2072 Set D Q.No. 28 How is nitric acid prepared from catalytic oxidation of ammonia?** [5]

➢ Please refer to 2075 Set B Q.No. 28

17. **2072 Set E Q.No. 28 Describe the physical and chemical principle for the manufacture of ammonia by Haber's process. Sketch a neat diagram for it.** [5]

➢ **Manufacture of ammonia by Haber's process:** Please refer to 2075 Set A Q.No. 28

18. **2071 Supp Q. No. 27 Describe Haber's Process for the manufacture of ammonia. What happens when sodium hydroxide is heated with white phosphorous?** [4+1]

➢ **Haber's process for the manufacture of ammonia:** Please refer to 2075 Set A Q.No. 28

Action of NaOH with White Phosphorous:

When sodium hydroxide is heated with white phosphorous, phospine and sodium hypophosphite is obtained

$P_4 + 3NaOH + 3H_2O \xrightarrow[\Delta]{} \underset{\text{phosphine}}{PH_3\uparrow} + \underset{\text{Sod.hypophosphite}}{3NaH_2PO_2}$

19. **2071 (Set C) Q.No. 27 Starting from ammonia, how would you prepare nitric acid. Give balanced chemical reaction for the reaction of conc. nitric acid with (a) copper and (b) magnesium. How would you perform the test of NO_3^- ion in its aqueous solution?** [1+1+1+2]

➢ **Preparation of nitric acid from ammonia:**

The industrial preparation of nitric acid is known as the Ostwald process. The Ostwald process involves the conversion of ammonia into nitric acid in various stages:

Firstly, ammonia is heated with oxygen in the presence of a platinum catalyst to form nitric oxide and water.

$4NH_3(g) + 5O_2(g) \longrightarrow 4NO(g) + 6H_2O(g)$

Secondly, nitric oxide reacts with oxygen to form nitrogen dioxide. This gas is then readily absorbed by the water to produce nitric acid. A portion of nitrogen dioxide is reduced back to nitric oxide.

$2NO(g) + O_2(g) \longrightarrow 2NO_2(g)$

$3NO_2(g) + H_2O(l) \longrightarrow 2HNO_3(aq) + NO(g)$

The NO is recycled, and the acid is concentrated to the required strength by a process called distillation.

Reaction of conc. HNO_3 with:

a. **Copper:** Copper reacts with **cold and conc. HNO_3** evolves nitrogen dioxide and cupric nitrate.

$2HNO_3 \longrightarrow 2NO_2 + H_2O + [O]$

$Cu + [O] \longrightarrow CuO$

$CuO + 2HNO_3 \longrightarrow Cu(NO_3)_2 + H_2O$

$Cu + 4HNO_3 \longrightarrow Cu(NO_3)_2 + 2NO_2 + 2H_2O$

b. **Action of very dilute nitric acid on Mg metal**

Very dilute nitric acid gives hydrogen gas with Mg metal.

$2HNO_3 + Mg \longrightarrow Mg(NO_3)_2 + H_2\uparrow$

Action of dilute nitric acid on Mg metal

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Dilute nitric acid gives NO gas with Mg metal.

$3Mg + 8HNO_3 \longrightarrow 3Mg(NO_3)_2 + 2NO + 4H_2O$

Test of Nitrate ion (NO_3^-): Nitrate salt solution is taken in test tube and equal volume of conc. H_2SO_4 is added to it. Then the solution is cooled under tap water. A freshly prepared saturated $FeSO_4$ solution is added drop wisely to it slightly from the wall of the test tube, by slightly tilting the test tube. A brown ring formed at the junction of two liquid layers indicates the presence of nitrate ion(NO_3^-)

$KNO_3 + H_2SO_4 \longrightarrow KHSO_4 + HNO_3] \times 2$

$2HNO_3 \longrightarrow 2NO + H_2O + 3[O]$

$2FeSO_4 + H_2SO_4 + [O] \longrightarrow Fe_2(SO_4)_3 + H_2O] \times 3$

$2KNO_3 + 5H_2SO_4 + 6FeSO_4 \longrightarrow 2KHSO_4 + 2NO + 4H_2O + 3Fe_3(SO_4)_3$

and $FeSO_4 + NO \longrightarrow FeSO_4.NO$

Nitrosyl ferrous sulphate

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2. **2071 (Set D) Q.No. 27 Give balance chemical equation for the preparation of ammonia from nitrogen and hydrogen. What are the proper physical conditions for better yield of ammonia? Write the action of ammonia on:**
   a. **mercurous nitrate paper.**
   b. **$CuSO_4$ solution**
   c. **CuO** **[1+1+1+1+1]**

The balanced chemical equation for the preparation of ammonia from nitrogen and hydrogen: When nitrogen and hydrogen gas is directly combined in the ratio of 1:3 by volume and heated at 450°C – 500°C temperature and 200-900 atm pressure in the presence of iron or molybdenum catalyst then ammonia gas is formed. This is reversible and exothermic reaction.

$$N_2(g) + 3H_2(g) \underset{200-900\ atm,\ Fe\ or\ Mo\ Catalyst}{\overset{450°C-500°C}{\rightleftharpoons}} 2NH_3(g) + 92.6\ kJ\ mol^{-1}$$

Physical condition for the better yield of ammonia:

Low temperature: This is exothermic reaction so, lowering temperature. equilibrium shift in forward direction. The optimum temperature is 450 – 500°C.

i. **High pressure:** The total volume of product is lower than total volume of reactant so, increasing pressure equilibrium shift in forward direction. Pressure is above 200 – 900 atm.

ii. **Presence of catalyst:** The catalyst increases the formation of ammonia. Finely divided iron catalyst and Mo promoter is used.

iii. **High concentration:** By increasing the concentration of reactant i.e. N_2 and H_2 gas large amount of ammonia is formed.

Action of ammonia with:

a. **Mercurous nitrate solution:** When mercurous nitrate paper is placed over a jar containing ammonia gas then paper changed into black. This is due to the formation of mercuric amino nitrate.

$Hg_2(NO_3)_2 + 2NH_3 \longrightarrow [Hg + Hg(NH_2)NO_3] + NH_4NO_3$

Mercuric amino nitrate(black)

b. **$CuSO_4$ solution:** Ammonia gas is passed through copper sulphate solution then bluish white ppt. is obtained, but passed in excess then deep blue ppt. of tetramine copper sulphate is formed.

$NH_3 + H_2O \longrightarrow NH_4OH$

$CuSO_4 + 2NH_4OH \longrightarrow Cu(OH)_2 \downarrow + (NH_4)_2SO_4$

Bluish white ppt.

$Cu(OH)_2 + (NH_4)_2SO_4 + 2NH_4OH \longrightarrow [Cu(NH_3)_4]SO_4 \downarrow + H_2O$

Deep blue ppt.
Tetramine copper sulphate

c. **CuO:** When ammonia gas is passed through heated CuO, copper oxide is reduced to Cu meta and NH_3 is itself oxidized to N_2.

$$3\,CuO + 2NH_3 \longrightarrow 3Cu + 3H_2O + N_2\uparrow$$

21. 2070 Supp. Q.No. 27 **Give the balanced chemical equations for the preparation of nitric acid from ammonia How does nitric acid react with:** [1+2+2

i. Zinc ii. Iron

Preparation of nitric acid from ammonia: Please refer to 2071 (Set C) Q.No. 27

Reaction of Zinc with HNO_3:

a. Zinc reacts with **very dil. HNO_3** i.e. about 6% and gets oxidized to zinc nitrate and ammonium nitrate.

$$Zn + 2\,HNO_3 \longrightarrow Zn(NO_3)_2 + 2\,H] \times 4$$
$$2\,HNO_3 + 8\,H \longrightarrow NH_4NO_3 + 3\,H_2O$$
$$4\,Zn + 10\,HNO_3 \longrightarrow 4\,Zn(NO_3)_2 + NH_4NO_3 + 3\,H_2O$$

b. Zinc reacts with **cold and dil. HNO_3** i.e. about 20% and gets oxidized to zinc nitrate and nitrou oxide.

$$Zn + 2\,HNO_3 \longrightarrow Zn(NO_3)_2 + 2\,H] \times 4$$
$$2\,HNO_3 + 8\,H \longrightarrow N_2O + 5\,H_2O$$
$$4\,Zn + 10\,HNO_3 \longrightarrow 4\,Zn(NO_3)_2 + N_2O + 5\,H_2O$$

c. Zinc reacts with **cold and moderately conc. HNO_3** i.e. about 50% and gets oxidized to zin nitrate and nitric oxide.

$$Zn + 2\,HNO_3 \longrightarrow Zn(NO_3)_2 + 2\,H] \times 3$$
$$HNO_3 + 3\,H \longrightarrow NO + 5\,H_2O\,] \times 2$$
$$3\,Zn + 8\,HNO_3 \longrightarrow 3\,Zn(NO_3)_2 + 2\,NO + 4\,H_2O$$

d. Zinc reacts with **cold and conc. HNO_3** i.e. about 70% or more and gets oxidized to zinc nitra and nitrogen dioxide.

$$Zn + 2\,HNO_3 \longrightarrow Zn(NO_3)_2 + 2\,H$$
$$HNO_3 + H \longrightarrow NO_2 + H_2O] \times 2$$
$$Zn + 4\,HNO_3 \longrightarrow Zn(NO_3)_2 + NO_2 + 2\,H_2O$$

Reaction of Iron with HNO_3:

a. Iron reacts with **very dil. HNO_3** i.e. about 6% and gets oxidized to ferrous nitrate an ammonium nitrate.

$$Fe + 2\,HNO_3 \longrightarrow Fe(NO_3)_2 + 2\,H] \times 4$$
$$2\,HNO_3 + 8\,H \longrightarrow NH_4NO_3 + 3\,H_2O$$
$$4\,Fe + 10\,HNO_3 \longrightarrow 4\,Fe(NO_3)_2 + NH_4NO_3 + 3\,H_2O$$

b. Iron reacts with **cold and dil. HNO_3** i.e. about 20% and gets oxidized to ferrous nitrate an nitrous oxide.

$$Fe + 2\,HNO_3 \longrightarrow Fe(NO_3)_2 + 2\,H] \times 4$$
$$2\,HNO_3 + 8\,H \longrightarrow N_2O + 5\,H_2O$$
$$4\,Fe + 10\,HNO_3 \longrightarrow 4\,Fe(NO_3)_2 + N_2O + 5\,H_2O$$

c. Iron reacts with **cold and moderately conc. HNO_3** i.e. about 50% and gets oxidized to fer nitrate and nitric oxide.

$$Fe + 2\,HNO_3 \longrightarrow Fe(NO_3)_2 + 2\,H] \times 4$$
$$HNO_3 + 3\,H \longrightarrow NO + 2\,H_2O$$
$$Fe + 4\,HNO_3 \longrightarrow Fe(NO_3)_3 + NO + 2\,H_2O$$

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d. Iron reacts with cold and conc. HNO_3 i.e. about 70% or more and gets oxidized to ferric nitrate and nitrogen dioxide.

$Fe + 3\,HNO_3 \longrightarrow Fe(NO_3)_2 + 3\,H$

$HNO_3 + H \longrightarrow NO_2 + H_2O\ ] \times 3$

$Fe + 6\,HNO_3 \longrightarrow Fe(NO_3)_3 + 3\,NO_2 + 3\,H_2O$

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22. 2070 Set D Q.No. 27 **Write balanced chemical reaction for the preparation of ammonia by Haber's process. How does ammonia react with**
a. Sodium b. chlorine c. $CuSO_4$ solution **[2+3]**

a. When nitrogen and hydrogen gas is directly combined in the ratio of 1:3 by volume and heated at 500°C temperature and 200-700 atm. Pressure in the presence of iron or molybdenum catalyst then ammonia gas is formed. This is reversible and exothermic reaction.

$$N_2 + 3H_2 \underset{\text{200 - 700 atm. Fe or Mo Catalyst}}{\overset{500\ °C}{\rightleftharpoons}} 2NH_3 + 92.6\ KJ\ mol^{-1}$$

Ammonia react with:

a. **Sodium:** Sodium metal reacts with liquid ammonia to form hydrogen gas.

$2Na + 2NH_3 \longrightarrow \underset{\text{Sodamide}}{2NaNH_2} + H_2\uparrow$

b. **Cl_2 gas in excess:** Ammonia reacts with excess of chlorine to give nitrogen trichloride along with ammonium chloride.

$4NH_3 + 3Cl_2 \longrightarrow NCl_3 + 3NH_4Cl$

c. **$CuSO_4$ solution:** Ammonia gas is passed through copper sulphate solution then bluish white ppt. is obtained, but passed in excess then deep blue ppt. of tetramine copper sulphate is formed.

$NH_3 + H_2O \longrightarrow NH_4OH$

$CuSO_4 + 2NH_4OH \longrightarrow \underset{\text{Bluish white ppt.}}{Cu(OH)_2\downarrow} + (NH_4)_2SO_4$

$Cu(OH)_2 + (NH_4)_2SO_4 + 2NH_4OH \longrightarrow \underset{\substack{\text{Deep blue ppt.}\\ \text{Tetramine copper sulphate}}}{[Cu(NH_3)_4]SO_4\downarrow} + H_2O$

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23. 2069 (Set B) Q. No. 29 **Sketch a well-labelled digram for the manufacture of ammonia by Haber's process. Write physical and chemical principles involved in it. Why can't NH_3 be dried by passing over conc. H_2HO_4?[4+1]**

a. **Manufacture of ammonia by Haber's process:** Please refer to 2075 Set A Q.No. 28

Because ammonia reacts with conc. H_2SO_4 to give salt. So, it is not used for drying.

$2NH_3 + H_2SO_4 \longrightarrow \underset{\text{Ammonium sulphate}}{(NH_4)_2SO_4}$

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24. 2067 Q.No. 27 **What are the necessary physical conditions and chemical principle involved in the manufacture of ammonia gas by Haber's process? Why is ammonia highly soluble in water?** **[4 + 1]**

a. **Manufacture of ammonia by Haber's process:** Please refer to 2075 Set A Q.No. 28

Ammonia reacts with water to form soluble ammonium hydroxide. So, ammonia is highly soluble in water

$NH_3 + H_2O \longrightarrow NH_4OH$

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25. 2063 Q.No. 27(ii) **What happens when: The gas obtained by heating ammonium chloride with quick lime is passed through copper sulphate solution?**

a. When slaked lime i.e. $Ca(OH)_2$ is heated with NH_4Cl then ammonia gas is formed.

$Ca(OH)_2 + 2NH_4Cl \longrightarrow CaCl_2 + 2H_2O + 2NH_3\uparrow$

Thus the formed ammonia gas is passed through copper sulphate solution then bluish white ppt. is obtained, but passed in excess then deep blue ppt. of tetramine copper sulphate is formed.

$NH_3 + H_2O \longrightarrow NH_4OH$

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$$CuSO_4 + 2NH_4OH \longrightarrow Cu(OH)_2 \downarrow + (NH_4)_2SO_4$$

Bluish white ppt.

$$Cu(OH)_2 + (NH_4)_2SO_4 + 2NH_4OH \longrightarrow [Cu(NH_3)_4]SO_4 \downarrow + H_2O$$

Deep blue ppt.

Tetramine copper sulphate

26. 2062 Q.No. 27 **Describe the principle involved in the manufacture of ammonia by Haber's process. What happens when ammonia gas is passed through heated CuO?** [4+1]

Manufacture of ammonia by Haber's process: Please refer to 2075 Set A Q No. 28

When ammonia gas is passed through heated CuO, copper oxide is reduced to Cu metal and NH_3 is itself oxidized to N_2.

$$3\,CuO + 2NH_3 \longrightarrow 3Cu + 3H_2O + N_2 \uparrow$$

27. 2060 Q.No. 26 **Discuss the principle and draw a self explanatory sketch for the manufacture of ammonia by Haber's synthesis.** [3+2]

Manufacture of ammonia by Haber's process: Please refer to 2075 Set A Q No. 28

28. 2057 Q.No. 26 **Write down the manufacture of HNO_3 by catalytic oxidation of ammonia.** [5]

Manufacture of Nitric acid by catalytic oxidation of ammonia or Ostwald's process:

Please refer to 2075 Set B Q No. 28

29. 2054 Q.No. 26 **Describe the principle involved in the manufacture of ammonia gas by Haber's process.** [5]

Manufacture of ammonia by Haber's process: Please refer to 2075 Set A Q No. 28

LONG ANSWERS QUESTIONS

30. 2076 Set B Q.No. 30

a. Write down the principle and procedure with self-explanatory diagram for the manufacture of nitric acid by catalytic oxidation of ammonia. How does Conc. HNO_3 react with: [3+3]

i. KI

ii. Zn

b. Explain, why? [2+2]

i. **Conc. HNO_3 is stored in dark bottle.**

ii. **Iron becomes passive when treated with Conc. HNO_3**

a. Manufacture of Nitric acid by catalytic oxidation of ammonia or Ostwald's process:

Please refer to 2075 Set B Q No. 28

Reaction of Conc. HNO_3 react with:

i. KI: Nitric acid oxidizes potassium iodide to iodine.

$$2HNO_3 \longrightarrow 2NO + H_2O + 3\,[O]$$

$$KI + HNO_3 \longrightarrow KNO_3 + HI] \times 6$$

$$2HI + [O] \longrightarrow H_2O + I_2\,] \times 3$$

$$8HNO_3 + 6KI \longrightarrow 2NO + 4H_2O + 6KNO_3 + 3I_2$$

When conc. HNO_3 is exposed in open air, it undergoes decomposition to give NO_2 gas which gets dissolved in HNO_3 and turns yellow. Due to this conc. HNO_3 is stored in dark brown bottle.

$$4HNO_3 \xrightarrow{h\upsilon} 4NO_2 + O_2 + 2H_2O$$

ii. Zn: Zinc reacts with cold and conc. HNO_3 i.e. about 70% or more, it gets oxidized to zinc nitrate and nitrogen dioxide gas.

$$Zn + 4\,HNO_3 \longrightarrow Zn(NO_3)_2 + NO_2 + 2\,H_2O$$

b.

i. In the presence of sunlight, pure nitric acid (HNO_3) decomposes slowly into nitrogen dioxide (NO_2), water (H_2O) and gaseous oxygen (O_2). Due to this, acid turns into yellow or brown (depending on how much is present). To reduce the rate of that decomposition when in storage, it's stored in dark bottles.

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$4HNO_3 \longrightarrow 4NO_2 + 2H_2O + O_2$

ii. When the iron dipped in concentrated HNO_3 (cold or normal temperature), a layer of inert thin oxide film (Fe_3O_4, and some other oxides) is easily formed on the iron surface and prevents HNO_3 from contacting with iron surface. This is called passivation of iron. Such iron is called passive iron.

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31. 2076 Set C Q.No. 30

a. Write down the principle and procedure with self-explanatory diagram for the manufacture of nitric acid by catalytic oxidation of ammonia. How does Conc. HNO_3 react with **[3+3]**

i. P_4

ii. Zn

b. Explain, why? **[2+2]**

i. Conc.nitric acid is stored in dark bottle.

ii. Iron becomes passive when treated with Conc.nitric acid.

a.

Manufacture of Nitric acid by catalytic oxidation of ammonia or Ostwald's process:

Please refer to 2075 Set B Q.No. 28

Reaction of Conc. HNO_3 with:

i. P_4: Phosphorous reacts with conc. HNO_3 to give phosphoric acid.

$P_4 + 20\ HNO_3 \longrightarrow 20\ NO_2 + 4\ H_2O + 4\ H_3PO_4$

ii. Zn: Zinc reacts with cold and conc. HNO_3 i.e. about 70% or more, it gets oxidized to zinc nitrate and nitrogen dioxide gas.

$Zn + 4\ HNO_3 \longrightarrow Zn(NO_3)_2 + NO_2 + 2\ H_2O$

b.

i. In the presence of sunlight, pure nitric acid (HNO_3) decomposes slowly into nitrogen dioxide (NO_2), water (H_2O) and gaseous oxygen (O_2). Due to this, acid turns into yellow or brown (depending on how much is present). To reduce the rate of that decomposition when in storage, it's stored in dark bottles.

$4HNO_3 \longrightarrow 4NO_2 + 2H_2O + O_2$

ii. When the iron dipped in concentrated HNO_3 (cold or normal temperature), a layer of inert thin oxide film (Fe_3O_4, and some other oxides) is easily formed on the iron surface and prevents HNO_3 from contacting with iron surface. This is called passivation of iron. Such iron is called passive iron.

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32. 2074 Set A Q.No. 30 **How is ammonia manufactured by Haber's process? What happens when ammonia is passed through**

i. Copper sulphate solution

ii. Heated copper oxide

Give reactions for the conversion of ammonia to nitric acid. **[6+2+2]**

Manufacture of ammonia by Haber's process: Please refer to 2075 Set A Q.No. 28

What happens when:

i. Ammonia gas is passed through copper sulphate solution then bluish white ppt. is obtained, but passed in excess then deep blue ppt. of tetramine copper sulphate is formed.

$NH_3 + H_2O \longrightarrow NH_4OH$

$CuSO_4 + 2NH_4OH \longrightarrow Cu(OH)_2 \downarrow + (NH_4)_2SO_4$

Bluish white ppt.

$Cu(OH)_2 + (NH_4)_2SO_4 + 2NH_4OH \longrightarrow [Cu(NH_3)_4]SO_4 \downarrow + H_2O$

Deep blue ppt.

Tetramine copper.sulphate

ii. When ammonia gas is passed through heated CuO, copper oxide is reduced to Cu metal and NH_3 is itself oxidized to N_2.

$3\,CuO + 2NH_3 \longrightarrow 3Cu + 3H_2O + N_2 \uparrow$

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Conversion ammonia (NH_3) to nitric acid (HNO_3):

$$4\,NH_3 + 5\,O_2 \xrightarrow[800\,^\circ C]{Pt} 4\,NO + 6\,H_2O + Heat$$

$$4\,NO + O_2 \longrightarrow 2\,NO_2$$

$$2\,NO_2 + 2\,H_2O + O_2 \longrightarrow 4\,HNO_3$$

Nitric acid

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33. 2073 Supp Q.No. 32 Write the principle and process along with self-explanatory diagram for the manufacture of ammonia by Haber's Synthesis. How does ammonia react with:

i. excess chlorine
ii. Nessler's reagent
iii. $FeCl_3$ solution

Why does ammonia turn mercurous nitrate paper black? **[6+3+1]**

Manufacture of NH_3 by Haber's Synthesis: Please refer to 2075 Set A Q.No. 28

Reaction of NH_3 with:

i. **Excess of Chlorine:** Ammonia reacts with excess of chlorine to give nitrogen trichloride along with ammonium chloride.

$$4NH_3 + 3Cl_2 \longrightarrow \underset{\text{Nitrogen trichloride}}{NCl_3} + 3NH_4Cl$$

ii. **Nessler's reagent:** When ammonia gas is passed through Nessler's reagent, reddish brown ppt of iodide of Million's base is obtained.

$$\underset{\text{Nessler's reagent}}{2\,K_2[HgI_4]} + 4\,NH_3 + H_2O \longrightarrow \underset{\text{Reddish brown ppt}}{HgO.Hg\begin{matrix}I\\NH_2\end{matrix}} + 4\,KI + 3\,NH_4I$$

iii. **$FeCl_3$ solution:** When ammonia gas is passed through $FeCl_3$ solution, reddish brown ppt of ferric hydroxide is obtained.

$$FeCl_3 + 3\,NH_4OH \longrightarrow \underset{\text{Reddish brown ppt}}{Fe(OH)_3} + 3\,NH_4Cl$$

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34. 2073 Set C Q. No. 32 2073 Set D Q. No. 32 Write the principle and process involved along with self-explanatory diagram of the manufacture of nitric acid by catalytic oxidation of ammonia. How does concentrated nitric acid react with: **[6+1.5+1.5+1]**

i. Iron
ii. Iodine

Why is conc. HNO_3 stored in dark bottle?

Manufacture of Nitric acid by catalytic oxidation of ammonia or Ostwald's process:

Please refer to 2075 Set B Q.No. 28

Reaction of nitric acid with:

i. **Iron:** Iron is treated with highly conc HNO_3, it becomes passive due to the formation of a layer of ferric nitrate.

$$Fe + 6HNO_3 \longrightarrow \underset{\text{ferric nitrate}}{Fe(NO_3)_3} + 3NO_2\uparrow + 3H_2O$$

ii. **Iodine:** When nitric acid is treated with iodine, iodic acid is obtained with the evolution of NO_2 gas.

$$2HNO_3 \longrightarrow 2NO_2 + H_2O + [O] \times 5$$

$$H_2O + I_2 + 5\,[O] \longrightarrow 2HIO_3$$

$$10\,HNO_3 + I_3 \longrightarrow 2\,HIO_3 + 10\,NO_2 + 4H_2O$$

Nitric acid is stored in dark bottle:

Nitric acid oxidizes potassium iodide to iodine.

$2HNO_3 \longrightarrow 2NO + H_2O + 3[O]$

$KI + HNO_3 \longrightarrow KNO_3 + HI] \times 6$

$2HI + [O] \longrightarrow H_2O + I_2] \times 3$

$8HNO_3 + 6KI \longrightarrow 2NO + 4H_2O + 6KNO_3 + 3I_2$

When conc. HNO_3 is exposed in open air, it undergoes decomposition to give NO_2 gas which gets dissolved in HNO_3 and turns yellow. Due to this conc. HNO_3 is stored in dark brown bottle.

$4HNO_3 \xrightarrow{h\upsilon} 4NO_2 + O_2 + 2H_2O$

2072 Supp Q. No. 31 **Write balanced chemical equation for the preparation of nitric acid from ammonia. Sketch a labeled diagram. How does conc. Nitric acid react with (i) Copper (ii) Phosphorous. Give the composition of aqua-regia. What is the laboratory test of nitrate ion?** **[5+1+1+1+2]**

Preparation of nitric acid from ammonia: Please refer to **2071 (Set C) Q.No. 27**

Reaction of nitric acid with:

Copper: Copper reacts with **cold and conc. HNO_3** evolves nitrogen dioxide and cupric nitrate.

$2HNO_3 \longrightarrow 2NO_2 + H_2O + [O]$

$Cu + [O] \longrightarrow CuO$

$CuO + 2HNO_3 \longrightarrow Cu(NO_3)_2 + H_2O$

$Cu + 4HNO_3 \longrightarrow Cu(NO_3)_2 + 2NO_2 + 2H_2O$

Phosphorous: Phosphorous reacts with nitric acid, phosphoric acid is obtained.

$2HNO_3 \longrightarrow 2NO_2 + H_2O + O] \times 10$

$P_4 + 10[O] \longrightarrow 2P_2O_5$

$P_2O_5 + 3H_2O \longrightarrow 2H_3PO_4] \times 2$

$20HNO_3 + P_4 \longrightarrow 20NO_2 + 4H_2O + 4H_3PO_4$

Composition of aqua-regia: Aqua regia is the mixture of 3 volume HCl and 1 volume HNO_3.

Laboratory test of nitrate (NO_3^-) ion:

Nitrate salt solution is taken in test tube and equal volume of conc. H_2SO_4 is added to it. Then the solution is cooled under tap water. A freshly prepared saturated $FeSO_4$ solution is added drop wisely to it slightly from the wall of the test tube, by slightly tilting the test tube. A brown ring formed at the junction of two liquid layers indicates the presence of nitrate ion(NO_3^-)

$KNO_3 + H_2SO_4 \longrightarrow KHSO_4 + HNO_3] \times 2$

$2HNO_3 \longrightarrow 2NO + H_2O + 3[O]$

$2FeSO_4 + H_2SO_4 + [O] \longrightarrow Fe_2(SO_4)_3 + H_2O] \times 3$

$2KNO_3 + 5H_2SO_4 + 6FeSO_4 \longrightarrow 2KHSO_4 + 2NO + 4H_2O + 3Fe_3(SO_4)_3$

and $FeSO_4 + NO \longrightarrow FeSO_4.NO$

Nitrosyl ferrous sulphate

2070 Set C Q.No. 30 **Describe the principle and draw a self explanatory sketch for the manufacture of ammonia by Haber's synthesis. How does ammonia reacts with:** **[6+4]**

a. **CO_2 gas**
b. **$CuSO_4$ solution**
c. **Na-metal**
d. **Chlorine in excess**

Manufacture of ammonia by Haber's process: Please refer to **2075 Set A Q.No. 28**

Action of ammonia with:

CO_2: Ammonia reacts with CO_2 at high pressure and at 130 to 150°C then urea is formed.

$$CO_2 + 2NH_3 \xrightarrow[\text{Pressure}]{130\text{–}150^\circ C} \underset{\text{Urea}}{H_2N-CO-NH_2} + H_2O$$

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b. **$CuSO_4$ solution:** Ammonia gas is passed through copper sulphate solution then bluish white ppt. is obtained, but passed in excess then deep blue ppt. of tetramine copper sulphate is formed.

$NH_3 + H_2O \longrightarrow NH_4OH$

$CuSO_4 + 2NH_4OH \longrightarrow Cu(OH)_2 \downarrow + (NH_4)_2SO_4$

Bluish white ppt.

$Cu(OH)_2 + (NH_4)_2SO_4 + 2NH_4OH \longrightarrow [Cu(NH_3)_4]SO_4 \downarrow + H_2O$

Deep blue ppt.

Tetramine copper sulphate

c. **Sodium metal:** Sodium metal reacts with liquid ammonia to form hydrogen gas.

$2Na + 2NH_3 \longrightarrow 2NaNH_2 + H_2 \uparrow$

Sodamide

d. **Cl_2 gas in excess:** Ammonia reacts with excess of chlorine to give nitrogen trichloride along with ammonium chloride.

$4NH_3 + 3Cl_2 \longrightarrow NCl_3 + 3NH_4Cl$

Nitrogen trichloride

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37. **2069 (Set A) Q. No. 31 Describe Haber's process for the manufacture of ammonia. Why is NH_3 not dried over conc. H_2SO_4 and anhydrous $CaCl_2$? What is the action when ammonia is passed to mercurous nitrate paper and $FeSO_4$ solution?** [6+2+2]

Manufacture of ammonia by Haber's process: Please refer to 2075 Set A Q.No. 28

Conc. H_2SO_4 and anhydrous $CaCl_2$ are not used to dry to ammonia gas because ammonia reacts with them to form salt.

$2NH_3 + H_2SO_4 \longrightarrow (NH_4)_2SO_4$

$8\ NH_3 + CaCl_2 \longrightarrow CaCl_2.8NH_3$

Action of NH_3 with $Hg_2(NO_3)_2$:

When mercurous nitrate paper is placed over a jar containing ammonia gas then paper changed into black. This is due to the formation of mercuric amino nitrate.

$Hg_2(NO_3)_2 + 2NH_3 \longrightarrow [Hg + Hg(NH_2)NO_3] + NH_4NO_3$

Mercuric amino nitrate (black)

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38. **2068 Q.No. 31 How is nitric acid manufactured by catalytic oxidation of ammonia? Sketch a well-labelled diagram for it. What are the actions of:**
   i. Conc. nitric acid upon iron.
   ii. Dilute nitric acid upon Magnesium.
   iii. A mixture of HNO_3 conc. HCl upon gold.
   Why is conc. nitric acid stored in dark brown bottle? [6+1+1+1+1=10]

Manufacture of Nitric acid by catalytic oxidation of ammonia or Ostwald's process:

Please refer to 2075 Set B Q.No. 28

i. Iron is treated with highly conc HNO_3, it becomes passive due to the formation of a layer of ferric nitrate.

$Fe + 6HNO_3 \longrightarrow Fe(NO_3)_3 + 3NO_2 \uparrow + 3H_2O$

ferric nitrate

ii. When magnesium is treated with dilute nitric acid then nitric oxide gas is formed.

$3Mg + dil.8HNO_3 \longrightarrow 3Mg(NO_3)_2 + 4H_2O + 2NO \uparrow$

iii. When a mixture of conc. Nitric acid and conc. HCl is treated with Au then aurochloric acid is formed.

$3Conc.\ HCl + Conc.\ HNO_3 \longrightarrow NOCl + 2H_2O + 2Cl$

$Au + 3Cl \longrightarrow AuCl_3$

$AuCl_3 + HCl \longrightarrow HAuCl_4$ (Aurochloric acid)

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To prevent from oxidation, nitric acid is stored in dark, brown bottle. If not conc. Nitric acid oxidized to form yellow gas nitrogen dioxygen and finally nitric acid becomes yellow.

$2HNO_3 \xrightarrow[\Delta]{} H_2O + 2NO_2 + [O]$

39. 2066 Q.No. 31 **Write down the principle and sketch a labelled diagram for the manufacture of nitric acid by the oxidation of ammonia. What happens when:** **[6+1+1+2]**
   i. **Conc. nitric acid is exposed to light for long time.**
   ii. **Iron is treated with highly conc. nitric acid.**
   iii. **Freshly prepared $FeSO_4$ solution is added to equal-volume mixture of conc.H_2SO_4 and conc.HNO_3.**

Manufacture of Nitric acid by catalytic oxidation of ammonia or Ostwald's process:

Please refer to 2075 Set B Q No. 28

i. When conc. Nitric acid is exposed to light for a long time then it easily decomposes to give nascent oxygen.

$2HNO_3 \xrightarrow[\Delta]{} H_2O + 2NO_2 + [O]$

or, $2HNO_3 \xrightarrow[\Delta]{} H_2O + 2NO + 3[O]$

ii. Iron is treated with highly conc. HNO_3 then nitrogen dioxide is formed.

$Fe + 6HNO_3 \longrightarrow Fe(NO_3)_3 + 3NO_2 \uparrow + 3H_2O$

iii. When freshly prepared $FeSO_4$ solution is added to the equal volume of conc. H_2SO_4 and conc.HNO_3 then a brown ring is formed between the junction of two liquid layer. This is due to the formation of nitrosyl ferrous sulphate.

$6FeSO_4 + 2HNO_3 + 3H_2SO_4 \longrightarrow 3Fe_2(SO_4)_3 + 4H_2O + 2NO \uparrow$

$FeSO_4 + NO \longrightarrow FeSO_4.NO$ (Nitrosyl ferrous sulphate)

40. 2065 Q. No. 31 **Describe the principle and draw a self explanatory sketch for the manufacture of ammonia by Haber's synthesis. How does ammonia reacts with:** **[6+4]**
   a. **Carbon dioxide**
   b. **Copper Sulphate solution**
   c. **Sodium metal**
   d. **Chlorine gas in excess**

Manufacture of ammonia by Haber's process: Please refer to 2075 Set A Q.No. 28

Second Part: Please refer to 2070 Set C Q.No. 30

41. 2064 Q.No. 31 **Describe the manufacture of nitric acid by catalytic oxidation of ammonia. Write a chemical reaction to show nitric acid contains nitrogen.** **[8+2]**

Manufacture of Nitric acid by catalytic oxidation of ammonia or Ostwald's process:

Please refer to 2075 Set B Q.No. 28

Chemical reaction to show nitric acid contains nitrogen: When copper metal is reacted with nitric acid at high temp. then N_2 gas is formed which show the nitric acid contains N_2 because copper metal does not have nitrogen.

$5Cu + 2NH_3 \longrightarrow 5CuO + H_2O + N_2 \uparrow$

The gas is collected by the downward displacement of water and it's properties are studied. When burning magnesium ribbon is inserted into the gas jar containing nitrogen gas then magnesium nitride is obtained which indicates the presence of nitrogen gas.

$6Mg + 2N_2 \longrightarrow 2Mg_3N_2$

42. 2061 Q.No. 30 **Describe the manufacture of nitric acid by oxidation of ammonia. Give the action of very dilute and dillute nitric acid on the magnesium metal.** **[7+3]**

Manufacture of Nitric acid by catalytic oxidation of ammonia or Ostwald's process:

Please refer to 2075 Set B Q No. 28

Action of very dilute nitric acid on Mg metal

Very dilute nitric acid gives hydrogen gas with Mg metal.

$2HNO_3 + Mg \longrightarrow Mg(NO_3)_2 + H_2 \uparrow$

Action of dilute nitric acid on Mg metal

Dilute nitric acid gives NO gas with Mg metal.

$3Mg + 8HNO_3 \longrightarrow 3Mg(NO_3)_2 + 2NO + 4H_2O$

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43. 2056 Q.No. 30 Describe the manufacture of nitric acid by Ostwald's process giving a neat and labelled diagram. How is nitric acid detected in the laboratory? [8+2]

Manufacture of Nitric acid by catalytic oxidation of ammonia or Ostwald's process:

Please refer to 2075 Set B Q.No. 28

Detection of nitric acid in laboratory: Ring test is best test for the detection of nitric acid in the laboratory. In this test, about 1 mL of HNO_3 is taken in test tube and few ml of conc. H_2SO_4 is added to it. The test tube is cooled in tap water and few mL of freshly prepared $FeSO_4$ solution is added to it dorpwise carefully along the side of the test tube. A dark brown ring is appeared at the junction of two liquids. The chemical reaction takes place as

$HNO_3 \longrightarrow 2\,NO + H_2O + 3\,[O]$

$[2\,FeSO_4 + H_2SO_4 + [O] \longrightarrow Fe_2(SO_4)_3 + H_2O] \times 3$

$6\,FeSO_4 + 2\,HNO_3 + 3\,H_2SO_4 \longrightarrow 3\,Fe_3(SO_4)_3 + 4\,H_2O + 2\,NO$

$FeSO_4 + NO \longrightarrow FeSO_4.NO$ (Nitrosyl ferrous sulphate)

Dark brown ring

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Unit 11

Non-Metals II

11.1 Halogens: (Chlorine, Bromine and Iodine)

VERY SHORT ANSWER QUESTIONS [2 MARKS]

2069 (Set A) Q. No. 15 Why can't HBr and HI be prepared by treating conc. H_2SO_4 with bromide and iodide? [2]

HBr can't be prepared by treating NaBr with conc. H_2SO_4 because HBr formed is further oxidized with H_2SO_4 to form bromine.

$2NaBr + H_2SO_4 \longrightarrow 2HBr + Na_2SO_4$

$2HBr + H_2SO_4 \longrightarrow H_2O + SO_2 + Br_2$

Similarly, HI can't be prepared by treating NaI with conc. H_2SO_4, HI is formed which further oxidized with H_2SO_4 to form iodine.

$2NaI + H_2SO_4 \longrightarrow 2HI + Na_2SO_4$

$H_2SO_4 \longrightarrow H_2O + SO_2 + [O]$

$2HI + [O] \longrightarrow H_2O + I_2$

$2NaI + 2H_2SO_4 \longrightarrow Na_2SO_4 + 2H_2O + SO_2 + I_2$

2063 Q.No. 18 Give the action of (i) KI on copper sulphate solution (ii) Heat on lime stone. [2]

(i) KI is oxidized by $CuSO_4$ to iodine with a dark brown colour precipitate.

$CuSO_4 + 2KI \longrightarrow CuI_2 + K_2SO_4$

$2CuI_2 \longrightarrow Cu_2I_2 + I_2$

Brown ppt

(ii) When limestone is heated at 1000°C, calcium oxide and carbon dioxide is obtained.

$CaCO_3 \xrightarrow[\Delta]{1000°C} CaO + CO_2$

2062 Q.No. 13 Why can't HI be prepared by the action of conc. H_2SO_4 on NaI? [2]

Because HI is formed by the action of NaI and conc. H_2SO_4 is further oxidized by strong oxidizing agent conc. H_2SO_4 into I_2.

$2NaI + H_2SO_4 \longrightarrow 2HI + Na_2SO_4$

$H_2SO_4 \longrightarrow H_2O + SO_2 + [O]$

$2HI + [O] \longrightarrow H_2O + I_2$

$2NaI + 2H_2SO_4 \longrightarrow Na_2SO_4 + 2H_2O + SO_2 + I_2$

2061 Q.No. 19 What happens when KBr is heated with conc. H_2SO_4 acid? [2]

When KBr is heated with conc. H_2SO_4, HBr is obtained which is oxidized to form Br_2 gas.

$2KBr + H_2SO_4 \longrightarrow 2HBr + K_2SO_4$

$H_2SO_4 \longrightarrow H_2O + SO_2 + [O]$

$2HBr + [O] \longrightarrow H_2O + Br_2$

$2KBr + 2H_2SO_4 \longrightarrow K_2SO_4 + 2H_2O + SO_2 + Br_2$

5. **2058 Q.No. 15 How would you obtain bromine from HBr?** [2]

Bromine is obtained from HBr by passing Cl_2 gas in it.

$$2HBr + Cl_2 \longrightarrow 2HCl + Br_2$$

6. **2057 Q.No. 15 Give a chemical reaction to show oxidising action of chlorine.** [2]

Chlorine acts as oxidizing agent in the presence of moisture because it liberates nascent oxygen and oxidizes other substance.

$$Cl_2 + H_2O \longrightarrow HCl + HOCl$$
$$HOCl \longrightarrow HCl + [O]$$
$$H_2S + [O] \longrightarrow H_2O + S$$
$$Cl_2 + H_2S \longrightarrow 2HCl + S$$

7. **2056 Q.No. 15 Give any one chemical reaction to prepare chlorine gas from hydrochloric acid.** [2]

When hydrochloric acid is treated with MnO_2, chlorine gas is formed.

$$4 \text{ Conc. } HCl + MnO_2 \longrightarrow MnCl_2 + 2H_2O + Cl_2 \uparrow$$

8. **2054 Q.No. 16 A test tube contains a solution of one of the following salts: NaCl, NaBr, and NaI. Describe a single test that can distinguish among these salts.** [4]

These given salts can be distinguished by $AgNO_3$ solution test. In this test, these salts are taken separately in three clean and dry test tube and about 2-3 drops of $AgNO_3$ solution is added to them. The different colour of ppt are appeared on the three test tube which indicates the presence of different salts. Curdy white ppt indicates the presence of NaCl, pale yellow ppt indicates the presence of NaBr, yellow ppt indicates the presence of NaI. Following reaction take place

$$NaCl + AgNO_3 \longrightarrow AgCl \downarrow + NaNO_3$$
Curdy white ppt
$$NaBr + AgNO_3 \longrightarrow AgBr \downarrow + NaNO_3$$
Pale yellow ppt
$$NaI + AgNO_3 \longrightarrow AgI \downarrow + NaNO_3$$
Yellow ppt

9. **2051 Q.No. 15 Why are the halogens never found in the free state in nature?** [2]

The elements which are present in group VII A of periodic table is known as halogens i.e. F, Cl, Br, I. They are not found in free state i.e. found in combined state because they have high electron affinity, high electronegativity and low dissociation energy. They can easily react with other elements to form different compound. That is why they are never found in Free State in nature.

SHORT ANSWER QUESTIONS [5 MARKS]

10. **2076 Set B Q.No. 26 Why can't HBr and HI be prepared by heating Conc. H_2SO_4 with bromide and iodide respectively? Write down correct reactions to prepare them. How would you test the presence of Br^- ions in its aqueous solution?** [2+2+1]

HBr can't be prepared by treating NaBr with conc. H_2SO_4 because HBr formed is further oxidized with H_2SO_4 to form bromine.

$$2 NaBr + H_2SO_4 \longrightarrow 2HBr + Na_2SO_4$$
$$2HBr + H_2SO_4 \longrightarrow H_2O + SO_2 + Br_2$$

Similarly, HI can't be prepared by treating NaI with conc. H_2SO_4, HI is formed which further oxidized with H_2SO_4 to form iodine.

$$2NaI + H_2SO_4 \longrightarrow 2HI + Na_2SO_4$$
$$H_2SO_4 \longrightarrow H_2O + SO_2 + [O]$$
$$2HI + [O] \longrightarrow H_2O + I_2$$
$$2NaI + 2H_2SO_4 \longrightarrow Na_2SO_4 + 2H_2O + SO_2 + I_2$$

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Preparation of HBr: HBr is prepared by treating Br_2 with red P and water.

$2P + 3Br_2 \longrightarrow 2PBr_3$

$PBr_3 + 2H_2O \longrightarrow H_3PO_3 + 3HBr$

Preparation of HI: HI is prepared by treating I_2 with red P and water.

$2P + 3I_2 \longrightarrow 2PI_3$

$PI_3 + 2H_2O \longrightarrow H_3PO_3 + 3HI$

Test of Bromide ion (Br^-):

In order to test the presence of Br^- ion in a given solution, about 1 mL of solution is taken in clean and dry test tube and is acidified with 1-2 drops of conc. HNO_3. Then the acidified solution is heated and cooled under tap water. 1-2 drops of $AgNO_3$ solution is added to it. A pale yellow ppt. will seen which indicates the presence of Br^- ion in the given solution.

Br^- (aq.) + $AgNO_3$ (aq.) $\longrightarrow$ $AgBr\downarrow + NO_3^-$ (aq.)

For further confirmation, the yellow ppt. is dissolved in NH_4OH solution and again reappears by adding few drops of dil. HNO_3 solution.

$AgBr + 2NH_4OH \longrightarrow [Ag(NH_3)_2]^+ + 2H_2O + Br^-$

$[Ag(NH_3)_2]^+ + Br^- + 2HNO_3 \longrightarrow AgBr\downarrow + 2NH_4^+ + 2NO_3^-$

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11. **2076 Set C Q.No. 26 Write down chemical reaction for the preparation of iodine from Sea weeds. How does iodine react with** **[2+2+1]**
   i. **Hot and Conc. NaOH**
   ii. **NH_3**
   What is meant by tincture of iodine?

Chemical reaction for the preparation of iodine from Sea weeds: The mother liquor containing KI or NaI is mixed with MnO_2 and conc. H_2SO_4 and heated in a iron retort. Iodine formed sublimes off and collected in a series of earthenware condensers called aludels.

$KI + H_2SO_4 \longrightarrow KHSO_4 + HI] \times 2$

$MnO_2 + H_2SO_4 \longrightarrow MnSO_4 + H_2O + [O]$

$2HI + [O] \longrightarrow I_2 + H_2O$

$2KI + 3H_2SO_4 + MnO_2 \longrightarrow 2KHSO_4 + MnSO_4 + I_2 + 2H_2O$

Reaction of iodine with:

i. **Hot and Conc. NaOH:** Iodine reacts with hot and conc. NaOH to give Sodium iodate.

$6NaOH + 3I_2 \longrightarrow 5NaI + \underset{\text{Sod. Iodate}}{NaIO_3} + 3H_2O$

ii. **NH_3:** Iodine reacts with ammonia to give a brown ppt of ammoniated nitrogen tri-iodide, which is an explosive substance and gives noise simply on rubbing.

$2NH_3 + 3I_2 \longrightarrow 3NH_4I + NI_3.NH_3$

$8NI_3.NH_3 \longrightarrow 6NH_4I + 9I_2 + 5N_2$

Tincture of iodine is usually 2-7% elemental iodine, along with potassium iodide (KI) or sodium iodide (NaI), dissolved in a mixture of ethanol and water. It is used as antiseptic.

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12. **2075 GIE Q.No. 28 Explain, How bromine is manufactured from Carnallite? What happens when Br_2 reacts with hot and conc. NaOH solution?** **[4+1]**

Manufacture of bromine from Carnallite:

Principle: Carnallite contains 0.2% bromine in the form of bromides. Its formula is $KCl.MgCl_2.(MgBr_2).6H_2O$. Carnallite is dissolved in water and the resulting solution is crystallized when crystals of KCl and $MgCl_2$ separate out. The mother liquor containing mainly $MgBr_2$ is treated with Cl_2 and steam when bromine vapours are liberated.

$MgBr_2 + Cl_2 \xrightarrow{\text{Steam}} MgCl_2 + Br_2$

The vapours are condensed by condenser and liquid bromine is collected. The uncondensed Br_2 vapours are absorbed by iron filings.

$3Fe + 4Br_2 \longrightarrow Fe_3Br_8 (FeBr_2.2FeBr_3)$

Description: The mother liquor containing $MgBr_2$ is heated to 60°C and the hot mother liquor dropped from the top of a tower which is packed with quartz. Cl_2 and steam are introduced the tower through two pipes. Br_2 vapours are liberated in the tower which escape through th outlet and are condensed by the condenser and the liquid bromine is collected in the receive The uncondensed vapours of Br_2 are absorbed in iron fillings in the absorption tower. The spe mother liquor collects in the tank. Any unreacted $MgBr_2$ presence in it, is oxidized by Cl_2 to B which enters into the tower and collects as liquid bromine in the receiver.

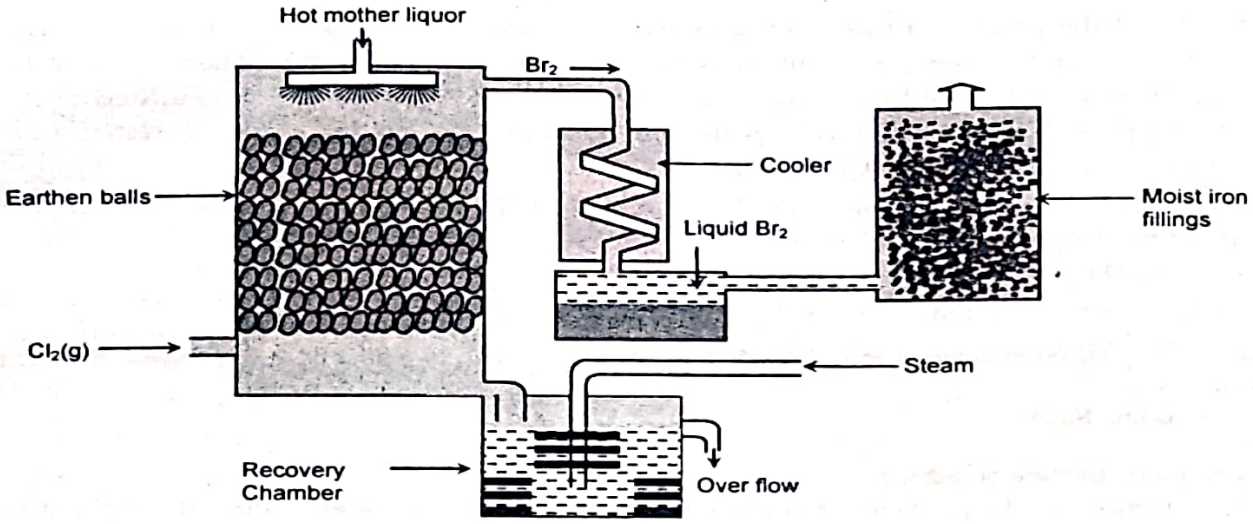


Fig: Manufacture of bromine from Carnallite

Impurities present in Bromine: Bromine manufactured from carnallite contains the followin impurities: (1) Chlorine (2) Iodine

Purification of crude Bromine: The impure Bromine is purified by

a. Distilling with KBr which removes chlorine.

$2KBr + Cl_2 \longrightarrow 2KCl + Br_2$

b. Distillation with ZnO which removes I_2

$2ZnO + 2I_2 \longrightarrow 2\,ZnI_2 + O_2$

The distillate can be dried by placing it in a desiccators containing conc. H_2SO_4 or anhydrou $CaCl_2$.

Bromine reacts with hot and conc. NaOH:

When Bromine is treated with hot and conc. NaOH solution, NaBr and $NaBrO_3$ is obtained.

$Br_2 + H_2O \longrightarrow HBr + HBrO$] x 3

$HBr + NaOH \longrightarrow NaBr + H_2O$] x 3

$HBrO + NaOH \longrightarrow NaBrO + H_2O$] x 3

$3NaBrO \longrightarrow NaBrO_3 + 2NaBr$

$3Br_2 + 6NaOH \longrightarrow 5NaBr + NaBrO_3 + 3H_2O$

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13. 2075 Set A Q.No. 27 **Give balanced chemical reaction for the preparation of chlorine in the laboratory. Compa the bleaching action of Cl_2 and SO_2.** [1

Preparation of chlorine in the laboratory:

Chlorine gas is prepared in the laboratory by heating conc. HCl with MnO_2.

$MnO_2 + 4HCl(conc.) \longrightarrow MnCl_2 + 2H_2O + Cl_2$

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Bleaching action of Cl_2 and SO_2:

Chlorine (Cl_2)	Sulphur dioxide (SO_2)
The bleaching action of chlorine is permanent.	The bleaching action of chlorine is temporary.
It is strong bleaching agent.	It is mild bleaching agent.
The bleaching action of chlorine is due to oxidation process.	The bleaching action of SO_2 is due to oxidation or reduction product formation.
No regain of original colour when exposed to air.	The reduced product regains its original colour when exposed to air.
It is used to bleach paper, wool, textiles etc.	It is used to bleach wool, silk, cane sugar etc.
Action with moisture takes place as $Cl_2 + H_2O \longrightarrow 2HCl + [O]$ This nascent oxygen oxidizes colouring matter into colourless.	Action with moisture takes place as $SO_2 + 2H_2O \longrightarrow H_2SO_4 + 2[H]$ This nascent hydrogen oxidizes colouring matter into colourless.

14. **2075 Set B Q.No. 27 Write down a balanced chemical reaction for the preparation of Cl_2 at laboratory. What is the action of Cl_2 on (i) NH_3 (ii) Conc. NaOH (iii) H_2S. How would you test the presence of Cl^- in its aqueous solution? [1+3+1]**

Chlorine gas is prepared in the laboratory by heating conc. HCl with MnO_2.

$MnO_2 + 4HCl(conc.) \longrightarrow MnCl_2 + 2H_2O + Cl_2$

Action of chlorine (Cl_2) on:

i. **NH_3 :** Chlorine reacts with excess of ammonia to give ammonium chloride and nitrogen.

$8NH_3(excess) + 3Cl_2 \longrightarrow 6NH_4Cl + N_2$

ii. **Conc.NaOH:** When chlorine gas is passed through hot and conc. NaOH, sodium chlorate is obtained.

$6NaOH(conc.) + 3Cl_2 \longrightarrow NaClO_3 + 5NaCl + 3H_2O$

iii. **H_2S:** Chlorine oxidized hydrogen sulphide to sulphur.

$H_2S + Cl_2 \longrightarrow 2HCl + S$

Test of Cl^- ions in its aqueous solution:

In order to test the presence of Cl^- ion in a given solution, about 1 mL of solution is taken in clean and dry test tube and is acidified with 1-2 drops of conc. HNO_3. Then the acidified solution is heated and cooled under tap water. 1-2 drops of $AgNO_3$ solution is added to it. A white ppt. will seen which indicates the presence of Cl^- ion in the given solution.

$Cl^-(aq.) + AgNO_3(aq.) \longrightarrow AgCl\downarrow + NO_3^-(aq.)$

For further confirmation, the white ppt. is dissolved in NH_4OH solution and again reappears by adding few drops of dil. HNO_3 solution.

$AgCl + 2NH_4OH \longrightarrow [Ag(NH_3)_2]^+ + 2H_2O + Cl^-$

$[Ag(NH_3)_2]^+ + Cl^- + 2HNO_3 \longrightarrow AgCl\downarrow + 2NH_4^+ + 2NO_3^-$

If ppt is dissolved soon and also reappears soon it confirms the presence of Cl^-.

15. **2074 Supp Q.No. 26 Why can't HI be prepared by using NaI and Conc. H_2SO_4? Give the balanced chemical reaction for the preparation of HCl. How would you test the presence of Cl^- or Br^- in its aqueous solution? [2+1+2]**

HI can't be prepared by using NaI and conc. H_2SO_4 because HI formed is further oxidised with conc. H_2SO_4 to form iodine (I_2)

$2\,NaI + Conc.\ H_2SO_4 \longrightarrow 2\,HI + Na_2SO_4$

$2\,HI + Conc.\ H_2SO_4 \longrightarrow H_2O + SO_2 + I_2$

Chemical reaction for the preparation of HCl:

HCl is prepared by the reaction between NaCl and conc. H_2SO_4.

$NaCl + H_2SO_4 \longrightarrow NaH_2SO_4 + HCl$

Test of Cl^- ion its aqueous solution: Please refer to 2075 Set B Q.No. 27

Test of Br^- ions in its aqueous solution: Please refer to 2076 Set B Q.No. 26

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16. 2074 Set A Q.No. 27 Why can't HBr prepared by using NaBr and conc. H_2SO_4? Give a balanced chemical reaction for the preparation of HCl. How would you test presence of the Cl^- or Br^- ions in its aqueous solution? [2+1+2]

HBr can't be prepared by treating NaBr with conc. H_2SO_4 because HBr formed is further oxidized with conc. H_2SO_4 to form bromine.

$2\,NaBr + conc.\ H_2SO_4 \longrightarrow 2HBr + Na_2SO_4$

$2HBr + conc.\ H_2SO_4 \longrightarrow H_2O + SO_2 + Br_2$

Chemical reaction for the preparation of HCl:

HCl is prepared by the reaction between NaCl and conc. H_2SO_4.

$NaCl + H_2SO_4 \longrightarrow NaH_2SO_4 + HCl$

Test of Cl^- ion its aqueous solution: Please refer to 2075 Set B Q.No. 27

Test of Br^- ions in its aqueous solution: Please refer to 2076 Set B Q.No. 26

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17. 2074 Set B Q.No. 27 Give balanced chemical reactions for the preparation of HCl and HBr in the laboratory. How would you test the presence of Cl^-, Br^- and I^- ion in its aqueous solution? [2+3]

Preparation of HCl:

HCl gas is prepared in the laboratory by heating NaCl with Conc. H_2SO_4.

$$NaCl + conc.\ H_2SO_4 \xrightarrow[\Delta]{} HCl + NaHSO_4$$

Preparation of HBr: HBr is prepared in the laboratory by treating Br_2 with red P and water.

$2P + 3Br_2 \longrightarrow 2PBr_3$

$PBr_3 + 2H_2O \longrightarrow H_3PO_3 + 3HBr$

Preparation of HI: HI is prepared in the laboratory by treating I_2 with red P and water.

$2P + 3I_2 \longrightarrow 2PI_3$

$PI_3 + 2H_2O \longrightarrow H_3PO_3 + 3HI$

Test of Cl^-, Br^-, I^- ion in aqueous solution:

Test of Cl^- ion in its aqueous solution:

In order to test the presence of Cl^- ion in a given solution, about 1 mL of solution is taken in clean and dry test tube and is acidified with 1-2 drops of conc. HNO_3. Then the acidified solution is heated and cooled under tap water. 1-2 drops of $AgNO_3$ solution is added to it. A white ppt. will seen which indicates the presence of Cl^- ion in the given solution.

$Cl^-\ (aq.) + AgNO_3\ (aq.) \longrightarrow AgCl\downarrow + NO_3^-\ (aq.)$

For further confirmation, the white ppt. is dissolved in NH_4OH solution and again reappears by adding few drops of dil. HNO_3 solution.

$AgCl + 2NH_4OH \longrightarrow [Ag(NH_3)_2]^+ + 2H_2O + Cl^-$

$[Ag(NH_3)_2]^+ + Cl^- + 2HNO_3 \longrightarrow AgCl\downarrow + 2NH_4^+ + 2NO_3^-$

If ppt is dissolved soon and also reappears soon it confirms the presence of Cl^-.

Test of Bromide ion (Br^-): In order to test the presence of Br^- ion in a given solution, about 1 mL of solution is taken in clean and dry test tube and is acidified with 1-2 drops of conc. HNO_3. Then the acidified solution is heated and cooled under tap water. 1-2 drops of $AgNO_3$ solution is added to it. A pale yellow ppt. will seen which indicates the presence of Br^- ion in the given solution.

$Br^-\ (aq.) + AgNO_3\ (aq.) \longrightarrow AgBr\downarrow + NO_3^-\ (aq.)$

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For further confirmation, the yellow ppt. is dissolved in NH_4OH solution and again reappears by adding few drops of dil. HNO_3 solution.

$AgBr + 2NH_4OH \longrightarrow [Ag(NH_3)_2]^+ + 2H_2O + Br^-$

$[Ag(NH_3)_2]^+ + Br^- + 2HNO_3 \longrightarrow AgBr\downarrow + 2NH_4^+ + 2NO_3^-$

Test of I − ion:

In order to test the presence of I − ion in a given solution, about 1 mL of solution is taken in clean and dry test tube and is acidified with 1-2 drops of conc. HNO_3. Then the acidified solution is heated and cooled under tap water. 1-2 drops of $AgNO_3$ solution is added to it. A deep yellow ppt. will seen which indicates the presence of I − ion in the given solution.

I^- (aq.) + $AgNO_3$ (aq.) $\longrightarrow$ $AgI\downarrow + NO_3^-$ (aq.)

Deep yellow ppt

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1. 2073 Supp Q.No. 28 2073 Set C Q. No. 28 2073 Set D Q. No. 28 **Describe the preparation of bromine from Carnallite. What happens when bromine is passed through hot and conc. NaOH ?** [4+1]

Manufacture of bromine from Carnallite: Please refer to 2075 GIE Q.No 28

Bromine reacts with hot and conc. NaOH: Please refer to 2075 GIE Q.No 28

What happens when:

Bromine reacts with hot and conc. NaOH, sodium bromate and sodium bromide is obtained.

$6NaOH + 3Br_2 \longrightarrow NaBrO_3 + 5NaBr + 3H_2O$

Sod.bromate Sod.bromide

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2. 2072 Supp Q. No. 26 **How is bromine manufactured from Carnallite? Give a chemical reaction for the test of bromide ion in the aqueous solution.** [5]

Manufacture of Bromine from Carnallite: Please refer to 2075 GIE Q.No 28

Test of Bromide (Br^-): The given solution of about 1 mL is taken in clean and dry test tube and acidified with 1-2 drops of conc. HNO_3. The acidified solution is heated and cooled under tap water. 1-2 drops of $AgNO_3$ solution is added to it. A light yellow ppt will seen which indicates the presence of Br^- in the given solution.

Br^- (aq.) + $AgNO_3$ (aq.) $\longrightarrow$ AgBr (s) $\downarrow$ + NO_3^-(aq.)

Light yellow ppt

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3. 2072 Set C Q.No. 27 2072 Set D Q.No. 27 **Give a balanced chemical reaction for the preparation of chlorine in the laboratory. How does Cl_2 react with conc. NaOH? Mention uses of chlorine.** [1.5+1.5+2]

Laboratory preparation of chlorine:

Chlorine gas is prepared in the laboratory by heating conc. HCl with MnO_2.

$MnO_2 + 4HCl(conc.) \longrightarrow MnCl_2 + 2H_2O + Cl_2$

Reaction of Cl_2 with conc. NaOH:

When chlorine gas is passed through conc. NaOH, sodium hypochlorite and sodium chloride is obtained.

$2NaOH + Cl_2 \longrightarrow NaCl + NaOCl + H_2O$

Sod. Hypochlorite

Uses of chlorine:

i. It is used in sterilization of drinking water.
ii. It is used for bleaching paper, pulp and textiles.
iii. It is used in the manufacture of insecticides like DDT, germicides, dyes and drugs.
iv. It is used for the manufacture of organic solvent like $CHCl_3$, CCl_4, etc.

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4. 2072 Set E Q.No. 27 **Write down the balanced chemical reaction for the preparation of**

i. HCl ii. HBr

How are chloride, bromide and iodide ions tested in the laboratory? [2+3]

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i. Preparation of HCl

Hydrogen chloride gas is prepared by heating common salt with conc. H_2SO_4.

$$2NaCl + H_2SO_4 \xrightarrow{\text{High temperature}} Na_2SO_4 + 2HCl$$

ii. Preparation of HBr

Hydrogen bromide gas is prepared by the action of bromine on moist red-phosphorous.

$P_4 + 6Br_2 \longrightarrow 4PBr_3$

$PBr_3 + 3H_2O \longrightarrow 3HBr + H_3PO_4] \times 4$

$P_4 + 6Br_2 + 12H_2O \longrightarrow 4H_3PO_3 + 12HBr$

Test of Chloride (Cl^-) ion: In order to test the presence of Cl^- ion in a given solution, about 1 mL of solution is taken in clean and dry test tube and is acidified with 1-2 drops of conc. HNO_3. Then the acidified solution is heated and cooled under tap water. 1-2 drops of $AgNO_3$ solution is added to it. A white ppt will seen which indicates the presence of Cl^- ion in the given solution.

$Cl^-(aq.) + AgNO_3(aq.) \longrightarrow AgCl\downarrow + NO_3^-(aq.)$

White ppt

For further confirmation, the white ppt is dissolved in NH_4OH solution and again reappears by adding few drops of dil. HNO_3 solution.

$AgCl + 2NH_4OH \longrightarrow [Ag(NH_3)_2]^+ + 2H_2O + Cl^-$

$[Ag(NH_3)_2]^+ + Cl^- + 2HNO_3 \longrightarrow AgCl\downarrow + 2NH_4^+ + 2NO_3^-$

If ppt is dissolved soon and also reappears soon it confirms the presence of Cl^-.

Test of bromide ion (Br^-): Please refer to 2072 Supp Q. No. 26

Test of Iodine (I^-): The given solution of about 1 mL is taken in clean and dry test tube and acidified with 1-2 drops of conc. HNO_3. The acidified solution is heated and cooled under tap water. 1-2 drops of $AgNO_3$ solution is added to it. A deep yellow ppt will seen which indicates the presence of I^- in the given solution

$I^-(aq.) + AgNO_3(aq.) \longrightarrow AgI(s)\downarrow + NO_3^-(aq.)$

Deep yellow ppt

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22. 2071 Supp Q. No. 26 What is carnallite? How is bromine manufactured from Carnallite? Give the action of Br_2 on hot NaOH. [1+3+1]

Carnallite: The molecular formula of Carnallite is $KCl.MgCl_2(MgBr_2).6H_2O$. It contains about 0.2% bromine in the form of bromide.

Manufacture of bromine from Carnallite: Please refer to 2075 GIE Q.No. 28

Action of Br_2 on hot NaOH:

Bromine reacts with hot and conc. NaOH, sodium bromate and sodium bromide is obtained.

$6NaOH + 3Br_2 \longrightarrow NaBrO_3 + 5NaBr + 3H_2O$

Sod.bromate Sod.bromide

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23. 2071 (Set C) Q.No. 29 How is bromine manufactured from Carnallite? What happens when Br_2 reacts with Hot and conc. NaOH solution? [4+1]

Manufacture of Bromine from Carnallite: Please refer to 2075 GIE Q.No. 28

Bromine reacts with hot and conc. NaOH:

Bromine reacts with hot and conc. NaOH, sodium bromate and sodium bromide is obtained.

$6NaOH + 3Br_2 \longrightarrow NaBrO_3 + 5NaBr + 3H_2O$

Sod.bromate Sod.bromide

24. 2071 (Set D) Q.No. 29 **Explain, how bromine is manufactured from Carnallite? Why are halides found in sea water?** [4+1]

Manufacture of Bromine from Carnallite: Please refer to 2075 GIE Q.No. 28

Halides are highly reactive and found in nature only in combined state. Halides are found in sea water as salts.

25. 2070 Supp. Q.No. 28 **How is bromine manufacture from Carnallite? Mention the test of bromide ions present in its aqueous solution.** [4+1]

Manufacture of Bromine from Carnallite: Please refer to 2075 GIE Q.No. 28

Test of Bromide ion (Br^-): In order to test the presence of Br^-ion in a given solution, about 1 mL of solution is taken in clean and dry test tube and is acidified with 1-2 drops of conc. HNO_3. Then the acidified solution is heated and cooled under tap water. 1-2 drops of $AgNO_3$ solution is added to it. A pale yellow ppt will seen which indicates the presence of Br^-ion in the given solution.

$$Br^-(aq.) + AgNO_3(aq.) \longrightarrow \underset{\text{Yellow ppt}}{AgBr\downarrow} + NO_3^-(aq.)$$

For further confirmation, the yellow ppt is dissolved in NH_4OH solution and again reappears by adding few drops of dil. HNO_3 solution.

$$AgBr + 2NH_4OH \longrightarrow [Ag(NH_3)_2]^+ + 2H_2O + Br^-$$

$$[Ag(NH_3)_2]^+ + Br^- + 2HNO_3 \longrightarrow AgBr\downarrow + 2NH_4^+ + 2NO_3^-$$

26. 2070 Set C Q.No. 25 **Write an account for the manufacture of bromine from Carnallite. How does bromine reacts with hot and conc. NaOH?** [4+1]

Manufacture of Bromine from Carnallite: Please refer to 2075 GIE Q.No. 28

Bromine reacts with hot and conc. NaOH:

Bromine reacts with hot and conc. NaOH, sodium bromate and sodium bromide is obtained.

$$6NaOH + 3Br_2 \longrightarrow \underset{\text{Sod.bromate}}{NaBrO_3} + \underset{\text{Sod.bromide}}{5NaBr} + 3H_2O$$

27. 2070 Set D Q.No. 28 **How is bromine manufactured from Carnallite. Write any one use of bromine.** [4+1]

Manufacture of Bromine from Carnallite: Please refer to 2075 GIE Q.No. 28

Use of Bromine: It is used for the production of AgBr for light sensitive eye glasses and photographic plates.

28. 2069 (Set A) Q. No. 26 **Compare and contrast the properties of HCl, HBr and HI** [5]

Physical properties

HCl	HBr	HI
1. Colourless gas with pungent smell.	1. Colourless gas with pungent smell.	1. Colourless gas with pungent smell.
2. Highly soluble in water.	2. Highly soluble in water.	2. Highly soluble in water.
3. b.p. = -83°C, m.p. = -114°C	3. b.p. = -72°C, m.p. = -87°C	3. b.p. =-35.5°C, m.p.=-50.9°C
4. Heat of formation= -22 KCal/mol	4. Heat of formation= -13.5 KCal/mol	4. Heat of formation= +0.8 KCal/mol
5. Bond energy = 413 kJ/mol	5. Bond energy = 368 kJ/mol	5. Bond energy = 297 kJ/mol
6. Neither combustible nor a supporter of combustion.	6. Neither combustible nor a supporter of combustion.	6. Neither combustible nor a supporter of combustion.
7. With water, it gives constant boiling mixture which contains 22.2% acid.	7. With water, it gives constant boiling mixture which contains 48% acid.	7. With water, it gives constant boiling mixture which contains 75% acid.

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Chemical properties:

1. **Acid character:** All the hydrogen halides are covalent molecules in the dry state. Their aqueous solutions are called acids. The acid ionizes in water giving hydronium ions.
   $HX(g) + H_2O(l) \longrightarrow H_3O^+(aq.) + X^-(aq.)$
2. **Precipitation reaction:** HCl,HBr,HI give a ppt with silver nitrate.
   HCl gives curdy white ppt. which is soluble in NH_4OH and reappears on adding HNO_3.
   $HCl + AgNO_3 \longrightarrow AgCl\downarrow + HNO_3$
   Curdy white ppt
   $AgCl + 2NH_4OH \longrightarrow Ag(NH_3)_2Cl + 2H_2O$
   Diamine silver chloride
   $[Ag(NH_3)_2]Cl + 2HNO_3 \longrightarrow AgCl\downarrow + 2NH_4NO_3$
   White ppt
   HBr gives pale yellow ppt with $AgNO_3$ less soluble in NH_4OH and insoluble in nitric acid
   $HBr + AgNO_3 \longrightarrow AgBr\downarrow + HNO_3$
   Pale yellow ppt
   $AgBr + 2NH_4OH \longrightarrow Ag(NH_3)_2Br + 2H_2O$
   HI gives yellow ppt with $AgNO_3$ and insoluble in both NH_4OH and HNO_3
   $HI + AgNO_3 \longrightarrow AgI\downarrow + HNO_3$
   Yellow ppt
3. **Reducing property:** The reducing property of halogen acids are in order HCl < HBr < HI.
   $MnO_2 + 4HCl \longrightarrow MnCl_2 + 2H_2O + Cl_2$
   $2HBr + H_2SO_4 \longrightarrow 2H_2O + SO_2 + Br_2$
   $2HI + 2HNO_3 \longrightarrow 2H_2O + 2NO_2 + I_2$

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29. **2069 (Set B) Q. No. 28 Why can't HBr and HI be prepared by the action of conc. H_2SO_4 on bromide and iodide respectively? Suggest alternative methods for the preparation of HBr and HI. How would you test chloride ion in the aqueous solution? [2+2+1]**

HBr can't be prepared by treating NaBr with conc. H_2SO_4 because HBr formed is further oxidized with H_2SO_4 to form bromine.

$2\,NaBr + H_2SO_4 \longrightarrow 2HBr + Na_2SO_4$

$2HBr + H_2SO_4 \longrightarrow H_2O + SO_2 + Br_2$

Similarly, HI can't be prepared by treating NaI with conc. H_2SO_4, HI is formed which further oxidized with H_2SO_4 to form iodine.

$2NaI + H_2SO_4 \longrightarrow 2HI + Na_2SO_4$

$H_2SO_4 \longrightarrow H_2O + SO_2 + [O]$

$2HI + [O] \longrightarrow H_2O + I_2$

$2NaI + 2H_2SO_4 \longrightarrow Na_2SO_4 + 2H_2O + SO_2 + I_2$

Preparation of HBr: HBr is prepared in the laboratory by treating Br_2 with red P and water.

$2P + 3Br_2 \longrightarrow 2PBr_3$

$PBr_3 + 2H_2O \longrightarrow H_3PO_3 + 3HBr$

Preparation of HI: HI is prepared in the laboratory by treating I_2 with red P and water.

$2P + 3I_2 \longrightarrow 2PI_3$

$PI_3 + 2H_2O \longrightarrow H_3PO_3 + 3HI$

Test of Chloride (Cl^-) ion: In order to test the presence of Cl^- ion in a given solution, about 1 mL of solution is taken in clean and dry test tube and is acidified with 1-2 drops of conc. HNO_3. Then the acidified solution is heated and cooled under tap water. 1-2 drops of $AgNO_3$ solution is added to it. A white ppt will seen which indicates the presence of Cl^- ion in the given solution.

$Cl^-(aq.) + AgNO_3(aq.) \longrightarrow AgCl\downarrow + NO_3^-(aq.)$

White ppt

For further confirmation, the white ppt is dissolved in NH_4OH solution and again reappears by adding few drops of dil. HNO_3 solution.

$AgCl + 2NH_4OH \longrightarrow [Ag(NH_3)_2]^+ + 2H_2O + Cl^-$

$[Ag(NH_3)_2]^+ + Cl^- + 2HNO_3 \longrightarrow AgCl\downarrow + 2NH_4^+ + 2NO_3^-$

If ppt is dissolved soon and also reappears soon it confirms the presence of Cl^-.

30. 2068 Q.No. 28 **Give an account of the manufacture of bromine from Carnallite. How does bromine react with hot and conc. NaOH?** **[4+1=5]**

Ans Please refer to 2075 GIE Q No 28

31. 2067 Q.No. 26 **Give suitable balanced chemical reaction for each:**

i. **Laboratory preparation of HCl.**

ii. **Laboratory preparation of HI.** **[1.5 + 1.5 + 2]**

How would you test the presence of Cl^- ion in the aqueous solution?

Ans

i. **Laboratory preparation of HCl:**

HCl gas is prepared in the laboratory by the reaction between NaCl and conc. H_2SO_4.

$NaCl + H_2SO_4 \xrightarrow{\Delta} NaHSO_4 + HCl$

ii. **Laboratory preparation of HI:**

HI gas is prepared in a laboratory by heating a mixture of red phosphorous, iodine and water. The following reactions occur and HI gas is liberated.

$2P + 3I_2 \longrightarrow 2PI_3$

$2P + 5I_2 \longrightarrow 2PI_5$

$PI_3 + 3H_2O \longrightarrow H_3PO_3 + 3HI$

$PI_5 + 4H_2O \longrightarrow H_3PO_4 + 5HI$

Test of Chloride (Cl^-) ion: In order to test the presence of Cl^- ion in a given solution, about 1 mL of solution is taken in clean and dry test tube and is acidified with 1-2 drops of conc. HNO_3. Then the acidified solution is heated and cooled under tap water. 1-2 drops of $AgNO_3$ solution is added to it. A white ppt will seen which indicates the presence of Cl^- ion in the given solution.

$Cl^-(aq.) + AgNO_3(aq.) \longrightarrow \underset{\text{White ppt}}{AgCl\downarrow} + NO_3^-(aq.)$

For further confirmation, the white ppt is dissolved in NH_4OH solution and again reappears by adding few drops of dil. HNO_3 solution.

$AgCl + 2NH_4OH \longrightarrow [Ag(NH_3)_2]^+ + 2H_2O + Cl^-$

$[Ag(NH_3)_2]^+ + Cl^- + 2HNO_3 \longrightarrow AgCl\downarrow + 2NH_4^+ + 2NO_3^-$

If ppt is dissolved soon and also reappears soon it confirms the presence of Cl^-.

32. 2066 Q.No. 26

a. **What happens when gas obtained by heating NaCl and Conc. H_2SO_4 is passed through hot and conc. Solution of NaOH?**

b. **Why can't HI be prepared by heating NaI with conc.H_2SO_4?** **[3+2]**

Ans

a. When NaCl is heated with conc. H_2SO_4, HCl gas is formed. The HCl gas is passed through hot and conc. Solution of NaOH, NaCl salt is formed.

$NaCl + H_2SO_4 \longrightarrow NaHSO_4 + HCl$

$HCl + NaOH \longrightarrow NaCl + H_2O$

b. When NaI is heated with conc. H_2SO_4, HI is formed which undergoes oxidation with strong oxidizing agent H_2SO_4 to form I_2. So, HI can't be prepared by heating NaI with conc. H_2SO_4.

$2NaI + H_2SO_4 \longrightarrow Na_2SO_4 + 2HI$

$2HI + H_2SO_4 \longrightarrow 2H_2O + I_2 + SO_2$

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33. 2065 Q. No. 26 Write down the principle for the preparation of hydroiodic acid (HI) in laboratory. How does HI react with:

a. MnO_2 **b. $CuSO_4$ solution** [3+2]

Preparation of HI gas:

Principle: HI gas is prepared in a laboratory by heating a mixture of red phosphorous, iodine and water. The following reactions occur and HI gas is liberated.

$2P + 3I_2 \longrightarrow 2PI_3$

$2P + 5I_2 \longrightarrow 2PI_5$

$PI_3 + 3H_2O \longrightarrow H_3PO_3 + 3HI$

$PI_5 + 4H_2O \longrightarrow H_3PO_4 + 5HI$

Description: The apparatus used for the preparation of HI gas is shown below.

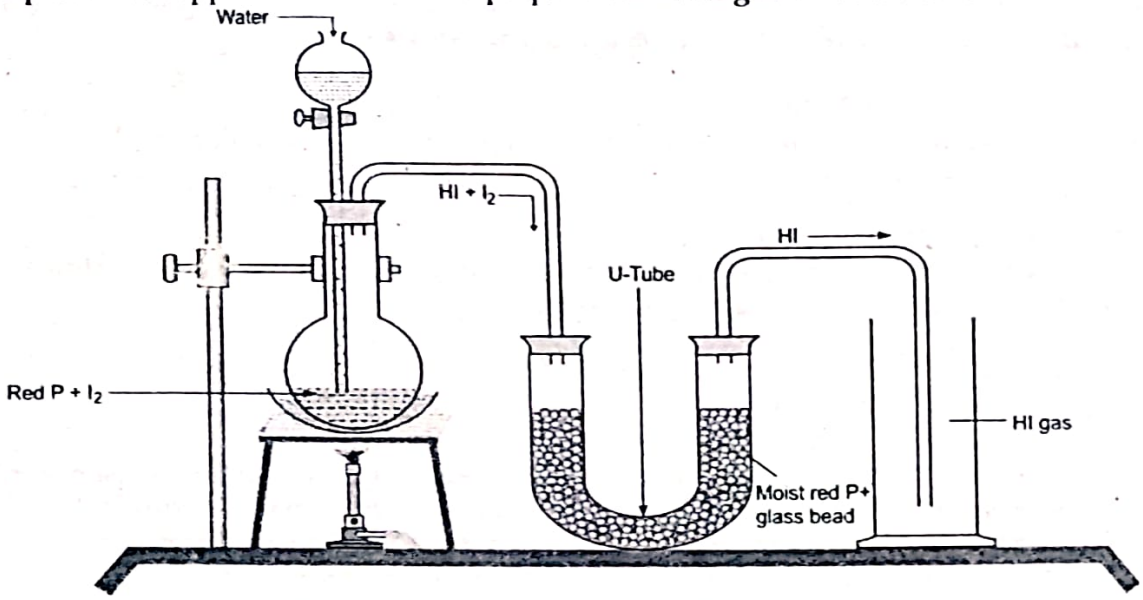


Fig: Laboratory preparation of hydrogen iodide

Red P and iodine are taken in the flask and water is dropped over them through the dropping funnel. On heating the mixture of red phosphorous, iodine and water, HI gas is liberated. This gas becomes mixed with some iodine-vapours. Hence, the mixture of HI and I_2 vapours is passed through an U-tube packed with glass beads and red phosphorous. The vapours of iodine are absorbed by red phosphorous and the pure colourless HI gas is collected in a gas jar by the upward displacement of air.

HCl is prepared by the reaction between NaCl and conc. H_2SO_4.

$$NaCl + H_2SO_4 \xrightarrow[\Delta]{} NaH_2SO_4 + HCl$$

Because HI is formed by the action of NaI and conc. H_2SO_4 is further oxidized by strong oxidizing agent conc. H_2SO_4 into I_2.

$2NaI + H_2SO_4 \longrightarrow 2HI + Na_2SO_4$

$H_2SO_4 \longrightarrow H_2O + SO_2 + [O]$

$2HI + [O] \longrightarrow H_2O + I_2$

$2NaI + 2H_2SO_4 \longrightarrow Na_2SO_4 + 2H_2O + SO_2 + I_2$

Preparation of hydroiodic (HI) acid: The delivery tube is connected to the stem of the funnel by means of a rubber tube and the funnel is placed just over the surface of water in a breaker. The HI gas is passed into water so that there will not be any sucking back of water. The HI gas is absorbed by water saturation to get a concentrated (HI) acid.

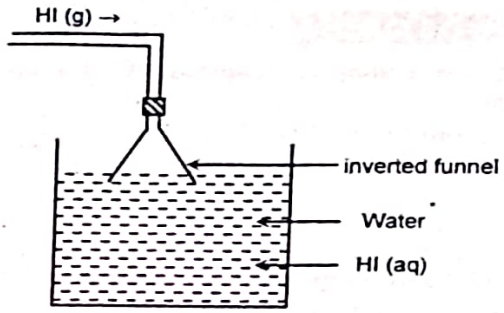


Fig: Dissolution of HI gas

Action of HI with:

a. **With MnO_2:** When HI is reacted with MnO_2, I_2 is liberated.

$$MnO_2 + 2HI \longrightarrow MnI_2 + 2H_2O + I_2$$

b. **With $CuSO_4$ solution:** When HI is treated with $CuSO_4$ solution, the CuI_2 is formed which is very unstable and decomposes to form CuI and I_2.

$$2HI + CuSO_4 \longrightarrow H_2SO_4 + CuI_2$$

$$2CuI_2 \longrightarrow 2CuI + I_2$$

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24. **2064 Q.No. 26 Describe the manufacture of bromine from Carnallite.** **[5]**

Please refer to 2075 GIE Q.No. 28

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25. **2063 Q.No. 26 How is bromine manufactured from Carnallite?**

Please refer to 2075 GIE Q No. 28

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26. **2061 Q.No. 25 Describe how HI is prepared? Why it cannot be prepared in the same way as HCl?** **[3+2]**

Preparation of HI gas: Please refer to 2065 Q. No. 26

HCl is prepared by the reaction between NaCl and conc. H_2SO_4.

$$NaCl + H_2SO_4 \xrightarrow{\Delta} NaH_2SO_4 + HCl$$

Because HI is formed by the action of NaI and conc. H_2SO_4 is further oxidized by strong oxidizing agent conc. H_2SO_4 into I_2.

$$2NaI + H_2SO_4 \longrightarrow 2HI + Na_2SO_4$$

$$H_2SO_4 \longrightarrow H_2O + SO_2 + [O]$$

$$2HI + [O] \longrightarrow H_2O + I_2$$

$$2NaI + 2H_2SO_4 \longrightarrow Na_2SO_4 + 2H_2O + SO_2 + I_2$$

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27. **2059 Q.No. 32 (d) What happens when Chlorine gas is passed into a dilute solution of caustic soda.**

When Cl_2 gas is passed into a dilute solution of NaOH, sodium hypochlorite is obtained.

$$Cl_2 + 2NaOH \longrightarrow \underset{\text{Sod. hypochlorite}}{NaOCl} + NaCl + H_2O$$

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28. **2054 Q.No.27(a) What happens when Concentrated HCl is added to $KMnO_4$?** **[1]**

When conc. HCl is added to $KMnO_4$ solution, pink colour of $KMnO_4$ is discharged into colourless. The acidic solution of $KMnO_4$ acts as oxidizing agent and HCl acts as reducing agent.

$$6HCl + 2KMnO_4 \longrightarrow 2KCl + 2MnCl_2 + 3H_2O + 5[O]$$

$$[2HCl + [O] \longrightarrow H_2O + Cl_2] \times 5$$

$$\underset{\text{Pink}}{2KMnO_4} + 16\,HCl \longrightarrow \underset{\text{colourless}}{2KCl + 2MnCl_2} + 8H_2O + 5Cl_2$$

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LONG QUESTION ANSWERS [10 MARKS]

39. 2061 Q.No. 32 2058 Q.No. 31 **How is bromine manufactured? How does it react with (a) KI solution (b) hot NaOH solution (c) SO_2 solution?** [5+1+2+2]

Manufacture of Bromine from Carnallite: Please refer to 2075 GIE Q.No. 28

Reaction of Bromine with:

a. **With KI solution:** When Bromine is treated with KI solution, KBr and I_2 is obtained.

$$Br_2 + 2KI \longrightarrow 2KBr + I_2$$

b. **With hot and conc. NaOH solution:** When Bromine is treated with hot and conc. NaOH solution, NaBr and $NaBrO_3$ is obtained.

$$Br_2 + H_2O \longrightarrow HBr + HBrO \] \times 3$$
$$HBr + NaOH \longrightarrow NaBr + H_2O \] \times 3$$
$$HBrO + NaOH \longrightarrow NaBrO + H_2O \] \times 3$$
$$3NaBrO \longrightarrow NaBrO_3 + 2NaBr$$
$$3Br_2 + 6NaOH \longrightarrow 5NaBr + NaBrO_3 + 3H_2O$$

c. **With SO_2 solution:** When Bromine is treated with SO_2 solution, HBr and H_2SO_4 is obtained.

$$Br_2 + H_2O \longrightarrow HBr + HBrO$$
$$HBrO \longrightarrow HBr + [O]$$
$$SO_2 + [O] + H_2O \longrightarrow H_2SO_4$$
$$SO_2 + Br_2 + 2H_2O \longrightarrow 2HBr + H_2SO_4$$

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11.2 Carbon

VERY SHORT ANSWER QUESTIONS

1. **2076 Set B Q.No. 15 What products would you expect when CO is** **[1+1]**
   i. **heated with H_2 in presence of ZnO + Cu**
   ii. **passed over heated caustic soda under pressure**

Ans The balanced chemical equations are:

i. When CO gas is heated with H_2 in the presence of ZnO + Cu at 420 – 670K and 300 atmospheric pressure, methanol is obtained.

$$\underset{\text{Water gas}}{CO + 2H_2} \xrightarrow[420-670K,\ 300\ atm]{ZnO + Cu} \underset{\text{Methanol}}{CH_3 - OH}$$

ii. When carbon monoxide is passed over heated caustic soda at 150°C and 7 atmospheric pressure, sodium methanoate is obtained.

$$NaOH + CO \xrightarrow[7\ atm]{150°C} \underset{\text{Sod. methanoate}}{H - \overset{\overset{O}{\|}}{C} - ONa}$$

2. **2076 Set C Q.No. 15 What happens when the gas obtained by heating methanoic (oxalic) acid and conc. sulphuric acid is passed through heated caustic soda under pressure?** **[1+1]**

Ans When conc. H_2SO_4 is heated with oxalic acid then a mixture of CO_2 and CO gas is formed.

$$\underset{\text{Oxalic acid}}{\begin{matrix} O \\ \| \\ C-OH \\ | \\ C-OH \\ \| \\ O \end{matrix}} + H_2SO_4\ (conc.) \xrightarrow{\Delta} CO\uparrow + CO_2 + H_2SO_4 \cdot H_2O$$

The mixture of CO_2 and CO gas is passed through heated caustic soda then different products are formed.

$$CO + NaOH \xrightarrow{\Delta} \underset{\text{Sodium formate}}{H - \overset{\overset{O}{\|}}{C} - O^-Na^+}$$

$$CO_2 + 2NaOH \longrightarrow \underset{\text{Sodium carbonate}}{Na_2CO_3} + H_2O$$

When carbon monoxide is passed over heated finely divided nickel at 80°C, nickel tetracarbonyl is formed.

$$Ni + 4CO \longrightarrow \underset{\text{Nickel tetracarbonyl}}{Ni(CO)_4}$$

1. **2075 GIE Q.No. 15 What happens when** **[1+1]**
   i. **Carbon monoxide is passed over heated caustic soda?**
   ii. **Phosphine is passed into $CuSO_4$ solution?**

Ans

i. When CO gas is passed through heated caustic soda then different products are formed.

$$CO + NaOH \xrightarrow{\Delta} \underset{\text{Sodium formate}}{H - \overset{\overset{O}{\|}}{C} - O^-Na^+}$$

ii. When phosphine (PH_3) gas is passed through copper sulphate ($CuSO_4$) solution, black ppt of cupric phosphide is obtained.

$$3PH_3 + 3CuSO_4 \longrightarrow \underset{\text{(Black ppt)}}{\underset{\text{Cupric phosphide}}{Cu_3P_2}} + 3H_2SO_4$$

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4. 2075 Set A Q.No. 15 **What is meant by allotropy? Name the latest discovered allotropic form of carbon and give its one use.** [1+1]

The two or more forms of the same element having same chemical properties but different physical properties are called allotropes and phenomenon is known as allotropy. The latest discovered form of carbon is Buckminister fullerene. Fullerenes may be used for drug delivery systems in the body, in lubricants and as catalysts.

5. 2075 Set B Q.No. 15 **Give balanced chemical equation for the preparation of CO from oxalic acid. What happens when CO is passed through heated Nickel Powder?** [1+1]

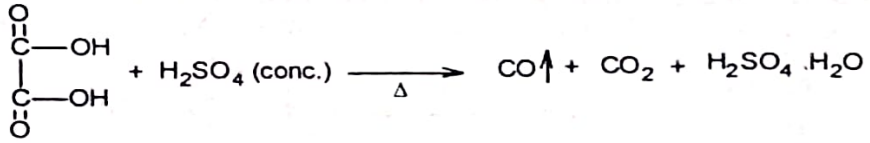
Please refer to 2076 Set C Q.No. 15

6. 2074 Supp Q.No. 15 2074 Set B Q.No. 15 **What is meant by allotropy? Name the hardest allotrope of carbon and its use.** [1+1]

Allotropy: The two or more forms of the same element having same chemical properties but different physical properties are called allotropes and phenomenon is known as allotropy. Diamond is the hardest allotrope of carbon. Diamond is used for making ornaments.

7. 2074 Set A Q.No. 15 2072 Set D Q.No. 15 **Give a balanced chemical reaction for the preparation of CO in the laboratory. Why is CO harmful gas?** [1+1]

The balanced chemical equation for the preparation of carbon monoxide: Carbon monoxide is prepared in the laboratory by the action of conc. H_2SO_4 on formic acid or oxalic acid.

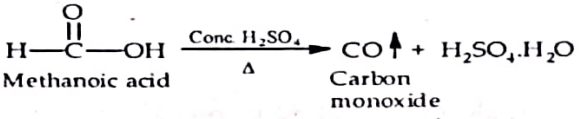


Oxalic acid

CO is harmful gas: Carbon monoxide gas is harmful gas because it combines with chlorine gas to form poisonous phosgene gas. Its one part in 1000 parts of air causes headache.

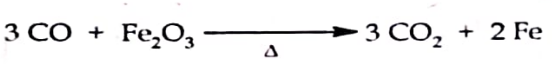
8. 2073 Supp Q.No. 15 **What happens when the gas obtained by heating methanoic acid and conc. H_2SO_4 is passed through heated ferric oxide.** [2]

When methanoic acid is heated with conc. H_2SO_4, carbon monoxide (CO) gas is obtained.



Methanoic acid — Carbon monoxide

When carbon monoxide (CO) gas is heated with ferric oxide (Fe_2O_3), ferric oxide is reduced to iron.



9. 2073 Set C Q. No. 15 **Suggest a reason as to why CO is poisonous?**

When CO is inhaled, it comes to contact with blood and combines with haemoglobin. This decrease the oxygen carrying capacity of blood and the patient die off suffocation. So, carbon monoxide is extremely poisonous.

CO + Haemoglobin ⟶ carboxyhaemoglobin (poisonous)

10. 2073 Set D Q. No. 15 **What happens when the gas obtained by heating methanoic acid and conc. Sulphuric acid is heated with Fe_2O_3?** [2]

Please refer to 2073 Supp Q.No. 15

11. 2072 Supp Q. No. 16 2070 Supp. Q.No. 16 **What happens when carbon monoxide is:**

i. **Heated with hydrogen in presence of ZnO + Cu.** [1]

ii. **Treated with Cl_2 in presence of sunlight.** [1]

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i. When carbon monoxide gas is heated with hydrogen in presence of ZnO and Cu at 300°C then methanol is formed.

$$CO + 2\,H_2 \xrightarrow[ZnO/Cu]{300°C} H_3C-OH$$

Methanol

ii. Carbon monoxide is treated with chlorine in the presence of sunlight, carbonyl chloride or phosgene gas is obtained which is extremely poisonous gas.

$$CO + Cl_2 \xrightarrow{hv} COCl_2$$

Phosgene gas

12. **2072 Set C Q.No. 15 Write down balanced chemical equations giving proper products for the following statements: [1+1]**
   i. Water gas is heated over ZnO + Cu
   ii. Carbon monoxide is passed over heated caustic soda.

i. When water gas ($CO + H_2$) is heated over ZnO + Cu at 420 – 670K and 300 atmospheric pressure, methanol is obtained.

$$\underset{\text{Water gas}}{CO + 2H_2} \xrightarrow[420-670K,\ 300\ atm]{ZnO + Cu} \underset{\text{Methanol}}{CH_3 - OH}$$

ii. Please refer to 2076 Set B Q.No. 15

13. **2072 Set E Q.No. 15 Predict the proper products and write balanced equation for the following:**

i. $CO + H_2 \xrightarrow[\Delta]{ZnO + Cu}$ ii. $HCOOH \xrightarrow[\Delta]{Conc.\ H_2SO_4}$

The major products are

i. $$CO + 2H_2 \xrightarrow[\Delta]{ZnO + Cu} \underset{\text{Methanol}}{CH_3 - OH}$$

ii. $$\underset{\text{Formic acid}}{H-\overset{\overset{O}{\|}}{C}-O-H} \xrightarrow[\Delta]{Conc.H_2SO_4} CO\uparrow + H_2SO_4.H_2O$$

Carbonmonoxide

14. **2071 Supp Q. No. 16 What is allotropy? Write the name of recently discovered allotropies of carbon. [1+1]**

The two or more forms of the same element having same chemical properties but different physical properties are called allotropes and phenomenon is known as allotropy. The latest discovered allotropic form of carbon is Buckminister fullerence or Fullerence. It is also called bucky ball.

15. **2071 (Set C) Q.No. 16 What is meant by fullerene? Mention its use. [2]**

A **fullerene** is any molecule composed entirely of carbon, in the form of a hollow sphere, ellipsoid, tube, and many other shapes. Spherical fullerenes are also called **buckyballs**, and they resemble the balls used in football (soccer). Example: Buckyballs may be used to **store hydrogen**, possibly as a fuel tank for fuel cell powered cars.

16. **2071 (Set D) Q.No. 16 (b) Give balanced chemical equation for the preparation of carbon-monoxide [1]**

Please refer to 2074 Set A Q.No. 15

17. **2068 Q.No. 15 i What happens when: Carbon monoxide is heated with hydrogen in pressence of ZnO and Cu.[1]**

When carbon monoxide gas is heated with hydrogen in presence of ZnO and Cu at 300°C then methanol is formed.

$$CO + 2\,H_2 \xrightarrow[ZnO/Cu]{300°C} H_3C-OH$$

Methanol

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18. 2067 Q.No. 15 What is allotropy? Name the latest discovered allotropic form of carbon. [1+1]

Please refer to 2071 Supp Q. No. 16

19. 2065 Q. No. 14 How would you convert CO into CO_2 and vice versa? [2]

CO can be converted into CO_2 by heating in the presence of excess of air.

$$2CO + O_2 \xrightarrow[\Delta]{} 2CO_2\uparrow$$

CO_2 can be converted into CO by passing through red hot coke.

$$CO_2 + C \xrightarrow[\Delta]{900°C} 2CO\uparrow$$

20. 2064 Q.No. 13 Write a chemical reaction to show the reducing action of CO. [2]

The chemical reaction which shows reducing property as

$$CO + CuO \longrightarrow Cu + CO_2\uparrow$$

21. 2063 Q.No. 13 What is meant by allotropy? Give examples of crystalline allotrope of Carbon. [2]

Allotropy: The two or more forms of the same element having same chemical properties but different physical properties are called allotropes and phenomenon is known as allotropy. The crystalline allotrope of carbon is graphite which is transparent and occurs as octahedral crystal.

22. 2061 Q.No. 14 What is dry ice? Why it is called so? [2]

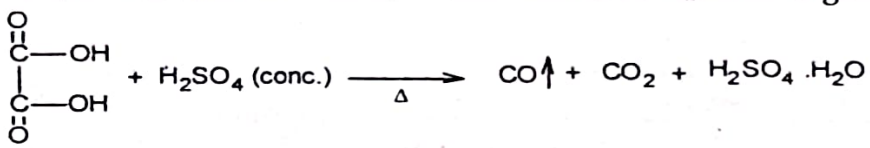
Solid CO_2 is called dry ice because its structure is similar to that of ice. When it is kept for some time then it gets evaporated without wetting the place where it is kept.

23. 2061 Q.No. 18 Why is that carbon monoxide is extremely poisonous? [2]

Please refer to 2073 Set C Q. No. 15

24. 2060 Q.No. 14 What happens when oxalic acid crystals are heated with concentrated sulphuric acid? [2]

When conc. H_2SO_4 is heated with oxalic acid then a mixture of CO_2 and CO gas is formed.



Oxalic acid

25. 2060 Q.No. 17 Why is carbon used as the most common reducing agent in thermal metallurgy? [2]

Carbon is used as common reducing agent in thermal metallurgy due to following reasons:

a. It increases the rate of reaction because it is used in powder form.
b. It is oxidized to carbon monoxide i.e. CO which also acts as reducing agent.
c. The conversion of carbon to carbon monoxide is exothermic process. So, heat energy produced help in thermal metallurgy.
d. Carbon itself is powder but compound formed is gas, it can easily be removed.

26. 2059 Q.No. 15 What happens when a piece of burning magnesium is dropped into a jar full of carbondioxide? [2]

When a piece of burning Mg is passed into a jar containing CO_2 gas, a black mass is seen at the bottom of the jar.

$$CO_2 + 2Mg \longrightarrow 2MgO + C \text{ (black mass)}$$

27. 2058 Q.No. 18 What happens when carbon monoxide is passed over heated finely divided nickel? [2]

When carbon monoxide is passed over heated finely divided nickel at 80°c, nickel tetracarbonyl is formed.

$$Ni + 4CO \xrightarrow{80°C} Ni(CO)_4$$

Nickel tetracarbonyl

28. 2056 Q.No. 12 **Define the terms 'allotropes' with examples.** [2]

The two or more forms of the same element having same chemical properties but different physical properties are called allotropes and phenomenon is known as allotropy.

Example: Graphite, Diamond, Buckminister fullerence or bucky ball (the latest discovered allotrope)

29. 2052 Q.No. 24 Group A **Carbon monoxide is used as a reducing agent in metallurgy but not carbon dioxide. Why?** [1.5]

CO reduces other substance and itself oxidized to form CO_2 but CO_2 already in oxidized form and cannot be further reduce other species. So, CO is used as reducing agent in metallurgy but not CO_2. Following are the reaction which shows the reducing property.

$CuO + CO \longrightarrow Cu + CO_2 \uparrow$

$ZnO + CO \longrightarrow Zn + CO_2 \uparrow$

SHORT ANSWER QUESTIONS

30. 2061Q.N.28c 2056 Q.No. 27a 2056 Q.No. 27b 2051 Q.No.7d **What happens when:**

a. **Carbon monoxide is passed over finelly divided nickel at 80°C.**
b. **a gas obtained from a mixture of marble and dilute hydrocholoric acid is passed into lime water till excess.**
c. **a gas obtained from a mixture of copper tumings and hot conc. Sulphuric acid is passed into chlorine water.**
d. **Carbon monoxide is passed over finely divided nickel.** [5]

a. Please refer to 2076 Set C Q.No. 15

b. When HCl is treated with marble i.e. $CaCO_3$ then CO_2 gas is formed.

$2HCl + CaCO_3 \longrightarrow CaCl_2 + H_2O + CO_2$

When CO_2 gas is passed through the lime water then lime water turns into milky colour due to the formation of $CaCO_3$

$CO_2 + Ca(OH)_2 \longrightarrow CaCO_3 \downarrow + H_2O$

If excess CO_2 gas is passed through the limewater solution then milky colour is disappeared due to the formation of calcium bicarbonate which is soluble in water.

$CO_2 + CaCO_3 + H_2O \longrightarrow Ca(HCO_3)_2$

c. When copper turning is heated with conc. H_2SO_4 then SO_2 gas is formed.

$Cu + 2H_2SO_4 \longrightarrow CuSO_4 + SO_2 + 2H_2O$

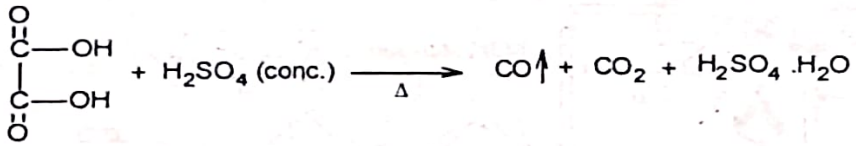
Thus, the SO_2 gas formed is passed through chlorine water then HCl is formed.

$SO_2 + Cl_2 + 2H_2O \longrightarrow 2HCl + H_2SO_4$

d. Please refer to 2076 Set C Q.No. 15

31. 2059 Q.No. 26 **How is carbon monoxide prepared from oxalic acid in the laboratory? Give its action with heated nickel.** [4+1]

Principle: Carbon monoxide is prepared in the laboratory by the action of conc. H_2SO_4 on formic acid or oxalic acid.



Oxalic acid

Procedure: Small amount of oxalic acid is taken in R.B. flask and the flask is fitted with thistle funnel with the help of cork. One delivery tube is fitted with R.B. flask and woulf bottle containing NaOH and another delivery tube is fitted with woulf bottle and beaker containing

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gas jar. The conc. H_2SO_4 is poured in the R.B. flask through thistle funnel and the reaction mixture is heated over sand bath. The mixture of CO and CO_2 gas is formed. The mixture of gas is passed through NaOH solution, the CO_2 gas is dissolved and free CO gas is collected in the gas jar by downward displacement of water.

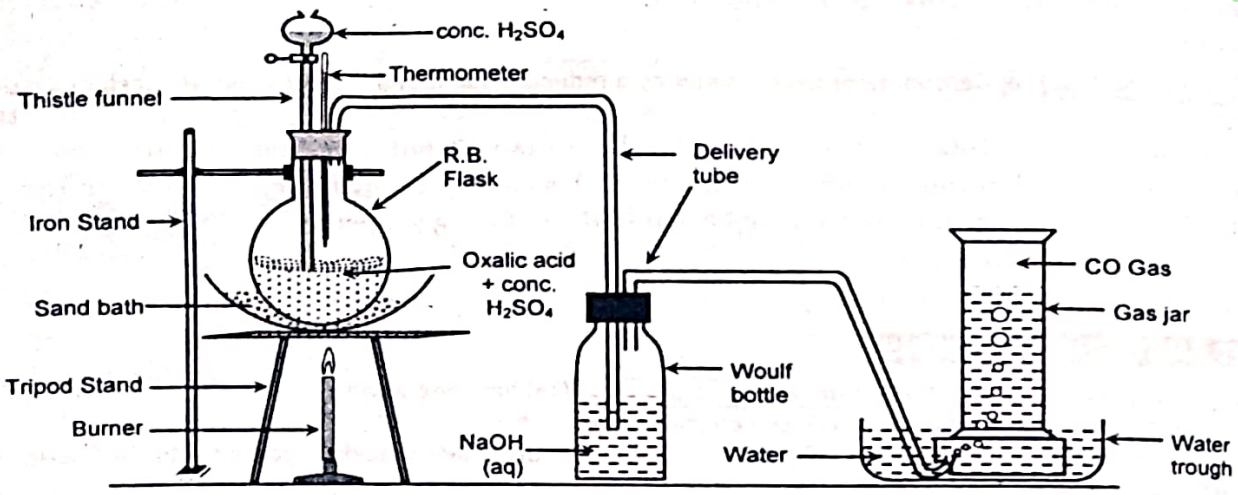


Fig: Laboratory preparation of carbon monoxide from oxalic acid

Action of CO with heated Ni:

When carbon monoxide is passed over heated finely divided nickel at 80°c, nickel tetracarbonyl is formed.

$$Ni + 4CO \xrightarrow{80^\circ C} Ni(CO)_4$$

Nickel tetracarbonyl

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32. 2057 Q.No. 27 Define allotropy. Show that diamond and graphite consist of carbon only. [2+3]

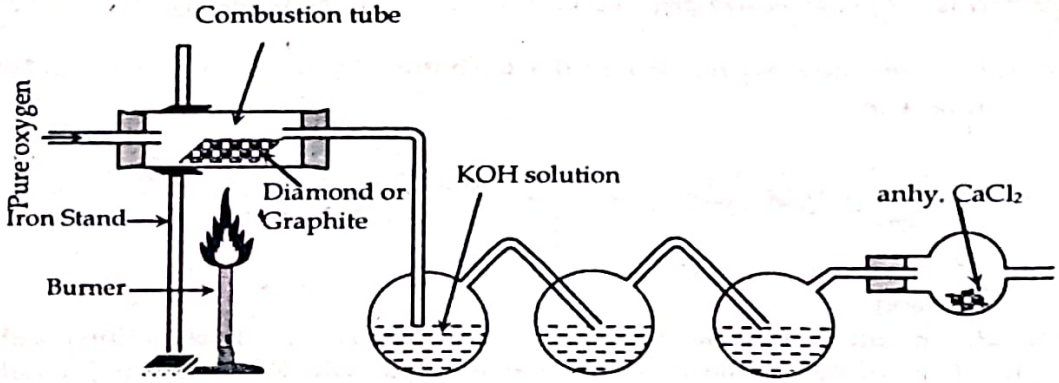
Allotropy: The two or more forms of the same element having same chemical properties but different physical properties are allopropes and the phenomenon is called Allotropy.

Experiment shows that both diamond and graphite contain carbon only:

1 g of diamond is taken in combustion tube and heated in the presence of excess of air. The carbondioxide gas is evolved which is passed through the aqueous solution of KOH. The KOH solution is kept in different bulbs which are kept in series. The carbondioxide gas evolved is absorbed by KOH solution. The weight of CO_2 gas is taken.

The same experiment is done in 1 g of graphite and again weight of CO_2 gas is taken.

Experimentally, it is found that the weight of carbondioxide gas produced by diamond is equal to the weight of carbondioxide produced by graphite. This result shows both diamond and graphite contains same weight of carbon only.



33. 2056 Q.No. 26 How is carbon monoxide gas prepared in the laboratory from oxalic acid crystals? [5]

Please refer to 2059 Q.No. 26

34. 2055 Q.No. 25 2051 Q.No. 4 Group B How is carbon monoxide prepared in the laboratory? [5]

Please refer to 2059 Q.No. 26

35. 2053 Q.No. 4 Group B Give the laboratory method of preparation of carbon monoxide. [5]

Please refer to 2059 Q.No. 26

WRITE ON SHORT NOTES:

36. 2058 Q.No. 33(a) Allotropes of carbon [5]

Allotropes of Carbon: The phenomenon of the existence of an elements in different forms which have different physical properties but similar chemical properties is known as allotropy. Following are the allotropes of carbon:

Crystalline forms: Diamond and Graphite

Diamond: It is purest, crystalline and hardest form of carbon. It occurs in the form of transparent octahedral crystals which usually have curved surface and do not shine much in their natural forms. They are cut at proper angle so as to give rise to large total internal reflection which lends them the usual shine. The carbon atoms are arranged tetrahedrally in diamond by forming sp^3-hybridization. Each sp^3 hybrid orbital carbon atom is linked to its neighbours by four single covalent bonds. This leads to three dimensional network of covalent bonds which makes it very hard and has high melting point and boiling point.



Fig: Diamond

Graphite: The carbon atoms are arranged in regular hexagonal in flat parallel layers resulting the formation of the large plates. Each carbon atoms in these layers is bonded to three others by sp^2hybridization. Each layer or large plate is bonded to adjacent layers by weak Vander Waal force. Due to this each layer can slide each other easily. So, one electron is left non-bonded in each carbon atom. Due to the presence of mobile electrons, graphite is good conductor of heat and electricity.

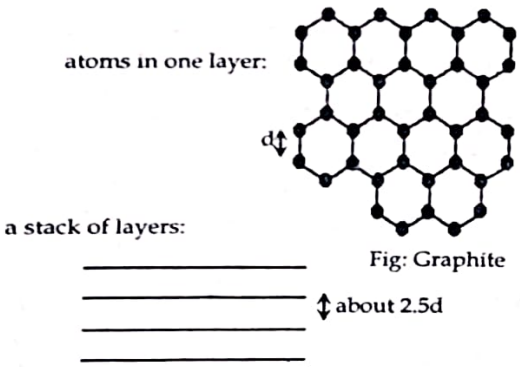


Fig: Graphite

Fullerenes: It is latest discovered crystalline allotrop of carbon. It consists 60 carbon atoms which is bonded in a closed sphere like shape. It is also called bucky ball or buckminister fullerene.

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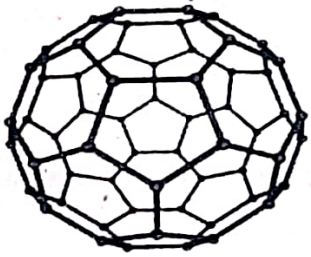


Fig: Fullerene

Amorphous forms: Coke, Charcoal, Lampblack, sugar charcoal, wood charcoal, animal charcoal etc.

Coke: It is balck solid mass which is obtained by the destructive distillation of coal. It is used as reducing agent in metallurgy.

Charcoal: It is black soft form of carbon. The main varieties of charcoal are as:

Lamp black: It is obtained by burning oil in the absence of air or limited supply of air.

Sugar charcoal: It is obtained by heating sugar in the absence of air. It is used as black pigment.

Wood charcoal: It is obtained by destructive distillation of wood in the absence of air.

Animal charcoal: It is obtained by destructive distillation of animal bones.

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11.3 Phosphorous

VERY SHORT ANSWER QUESTIONS

1. **2075 Set A Q.No. 16 Give a balanced chemical reaction for the preparation of phosphine in the laboratory. How does it react with oxygen? [1+1]**

Phosphine (PH_3) gas is prepared in the laboratory by treating white phosphorous with hot and conc. NaOH.

$$P_4 + 3\,NaOH + 3\,H_2O \longrightarrow \underset{\text{Phosphine}}{PH_3} + NaH_2PO_2$$

PH_3 gas reacts with air in the presence of light, vortex ring of white smoke of phosphorous pentoxide (P_2O_5) is obtained.

$$2PH_3 + 4O_2 \longrightarrow P_2O_5 + 3\,H_2O$$

2. **2074 Supp Q.No. 16 Give a balanced chemical reaction for the preparation of PH_3 in the laboratory. What happens when it is treated with O_2. [1+1]**

Phosphine (PH_3) gas is prepared in the laboratory by heating white phosphorous with Conc. NaOH in an inert gas atmosphere.

$$\underset{\text{White}}{P_4} + 3\,NaOH\,(Conc.) + 3\,H_2O \xrightarrow{\Delta} \underset{\text{Phosphine}}{PH_3} + \underset{\text{Sod. hypophosphite}}{NaH_2PO_2}$$

When phosphine gas is treated with oxygen of air to give vortex ring of phosphorous pentoxide on the surface of water.

$$\underset{\text{Phosphine}}{2\,PH_3} + 4\,O_2 \xrightarrow{\Delta} \underset{\substack{\text{Phosphorous pentoxide}\\ \text{(Vortex ring)}}}{P_2O_5} + 3\,H_2O$$

3. **2074 Set B Q.No. 16 Give a balanced chemical reaction for the preparation of orthophosphoric acid. Mention its an important use. [1+1]**

The balanced chemical reaction for the preparation of orthophosphoric acid is given as:

When white phosphorous is treated with conc. HNO_3, orthophosphoric acid (H_3PO_4) is obtained.

$$\underset{\text{White P}}{P_4} + 20\,HNO_3\,(conc.) \longrightarrow \underset{\text{Orthophosphoric acid}}{4\,H_3PO_4} + 20\,NO_2 + 4\,H_2O$$

Use: It is used to make phosphate salts for fertilizers. It is also used in dental cements, in the preparation of albumin derivatives, and in the sugar and textile industries.

4. **2071 (Set D) Q.No. 16 (a) Give balanced chemical equation for the preparation of phosphine [1]**

White phosphorous is allowed to react with hot concentrated aqueous solution of sodium hydroxide, PH_3 gas is obtained.

$$P_4 + 3NaOH + 3H_2O \longrightarrow \underset{\text{Phosphine}}{PH_3}\uparrow + \underset{\text{sodium hypophosphite}}{NaH_2PO_2}$$

5. **2070 Supp. Q.No. 15 (i) Write the molecular formula of Hypophosphoric acid [0.5]**

Hypophosphoric acid: H_2PO_3

6. **2070 Set D Q.No. 15a 2069 (Set B) Q. No. 16c Write the molecular formula of hypophosphorous acid [0.5]**

Hypophosphrous acid: H_3PO_2

7. **2069 (Set B) Q. No. 16b Write molecular formulae of orthophosphoric acid [0.5]**

Orthophosphoric acid: H_3PO_4

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8. 2068 Q.No. 15 ii What happens when: white phosphorous is heated with concentrated solution of Caustic Soda? [2]

White phosphorous is heated with conc. Solution of caustic soda, phosphine gas and sodium hypophosphite are obtained.

$$P_4 + 3\,NaOH + 3H_2O \longrightarrow PH_3\uparrow + 3\,NaH_2PO_2$$

White P — Phosphine — sodium hypophosphite

9. 2067 Q.No. 16 Write balanced chemical equation for the preparation of phosphine gas in the laboratory. [2]

Phosphine gas is prepared in the laboratory by heating white P with NaOH.

$$P_4 + 3NaOH + 3H_2O \longrightarrow PH_3\uparrow + 3NaH_2PO_2$$

10. 2066 Q.No. 17 Name any two allotropes of phosphorous why is phosphorous stored in water? [1+1]

There are two allotropes of phosphorous: White phosphorous and Red phosphorous

Phosphorous is highly reactive and it is easily oxidized in the presence of oxygen at room temperature and burn with greenish glow which is visible in dark. This phenomenon is known as phosphorescence. Due to this reason phosphorous is stored in water.

11. 2065 Q. No. 16 d Give an important uses of each of Red Phosphorus [0.5]

Red phosphorous: It is used to make matches.

12. 2064 Q.No. 16(a) Write chemical action of white phosphorous on conc. nitric acid. [2]

With conc. H_2SO_4: When white P is treated with conc. HNO_3 then phosphoric acid and nitrogen dioxide gas is obtained.

$$P_4 + 20HNO_3 \longrightarrow 4H_3PO_4 + 20NO_2\uparrow + 4H_2O$$

13. 2064 Q.No. 16(b) Write chemical action of white phosphorous on aqueous KOH solution. [2]

With: aq. KOH: When white P is treated with aq. KOH then phosphine gas is evolved.

$$P_4 + 3KOH + 3H_2O \longrightarrow PH_3\uparrow + 3KH_2PO_2$$

14. 2062 Q.No. 15 What happens when white phosphorous is exposed to air? [2]

White phosphorous is highly reactive and catches fire in air and burns with a greenish glow which is visible in dark and phenomenon is known as phosphorescence.

$$P_4 + 3O_2 \longrightarrow P_4O_6$$

15. 2061 Q.No. 13 2057 Q.No. 14 How is white phosphorous converted to red phosphorous? [2]

Please refer to 2068 Q.No. 15 ii

16. 2059 Q.No. 14 What is the effect of heat on ortho phosphoric acid? [2]

When orthophosphoric acid is heated at 250°C then two mole of the acid loose one mole of water and pyrophosphoric acid is obtained.

$$2\,H_3PO_4 \xrightarrow[250^\circ C]{} H_4P_2O_7 + H_2O$$

Orthophosphoric acid (2 mole) — pyrophosphoric acid — (1 mole)

When orthophosphoric acid is heated at 300°C for a long time then one mole of the acid loose one mole of water and metaphosphoric acid is obtained.

$$H_3PO \xrightarrow[300^\circ C]{} HPO_3 + H_2O$$

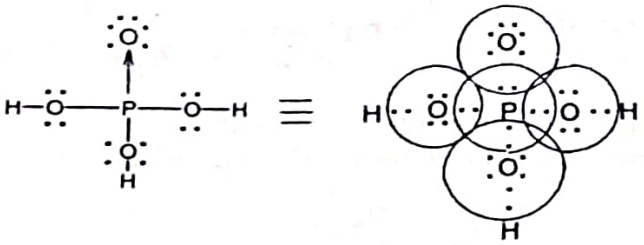
Orthophosphoric acid (1 mole) — metaphosphoric acid — (1 mole)

17. 2056 Q.No. 14 What happens when white phosphorus is heated with aqueous caustic soda? [2]

Please refer to 2068 Q.No. 15 ii

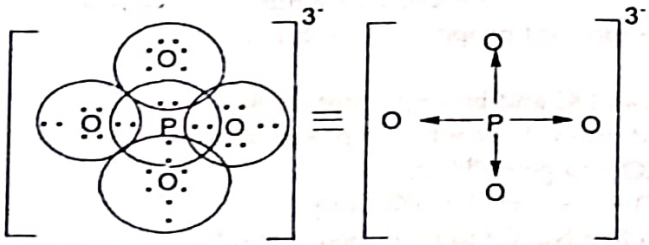
18. 2054 Q.No. 11 **Write the Lewis structure of orthophosphoric acid and phosphate ions.**

Lewis structure of orthophosphoric acid [2]



Lewis structure of phosphate ion

$H_3PO_4 \rightleftharpoons 3H^+ + PO_4^{3-}$



19. 2051 Q.No. 10 Group A **Name different amorphous forms of phosphorous.**

Following are the amorphous forms of phosphorous (a) White P (b) Black P (c) Violet P [2]

SHORT ANSWER QUESTIONS

20. 2063 Q.No. 27 (I) **What happens when: The gas produced by the action of white phosphorous with sodium hydroxide is passed through silver nitrate solution?**

When phosphorous reacts with NaOH then PH_3 gas is obtained. [5]

$$P_4 + 3NaOH + 3H_2O \longrightarrow \underset{\text{Phosphine}}{PH_3\uparrow} + \underset{\text{sodium hypophosphite}}{NaH_2PO_2}$$

Thus, the PH_3 gas obtained is passed through $AgNO_3$ solution then metallic silver along with the formation of phosphorous acid and nitric acid.

$$6AgNO_3 + PH_3 + H_2O \longrightarrow \underset{\text{Metallic silver}}{6Ag\downarrow} + H_3PO_3 + 6HNO_3$$

21. 2061 Q. 28 (e) 2060 Q.No. 27(I) 2055 Q.No. 27(b) **What happens when:**

a. **White phosphorous is heated with strong caustic potash solution.**
b. **White phosphorus is allowed to react with hot concentrated aqueous solution of sodium hydroxide.**
c. **NaOH is heated with yellow phosphorous.** [5]

a. White phosphorous is heated with strong caustic potash solution, PH_3 gas is obtained.

$$P_4 + 3KOH + 3H_2O \longrightarrow \underset{\text{Phosphine}}{PH_3\uparrow} + \underset{\text{Pot. hypophosphite}}{KH_2PO_2}$$

b. White phosphorous is allowed to react with hot concentrated aqueous solution of sodium hydroxide, PH_3 gas is obtained.

$$P_4 + 3NaOH + 3H_2O \longrightarrow \underset{\text{Phosphine}}{PH_3\uparrow} + \underset{\text{sodium hypophosphite}}{NaH_2PO_2}$$

c. NaOH is heated with yellow phosphorous, PH_3 gas is obtained.

$$P_4 + 3NaOH + 3H_2O \longrightarrow \underset{\text{Phosphine}}{PH_3\uparrow} + \underset{\text{sodium hypophosphite}}{NaH_2PO_2}$$

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WRITE SHORT NOTES ON

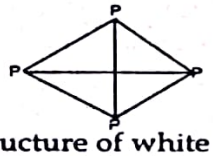
22. 2051 Q.No. 4 Group (c) Phosphorous allotropes.

Generally phosphorous exist in three allotropic forms.

a. **White P:** It is highly toxic and common variety of P. It is formed by heating calcium phosphat with carbon and silica.

$2Ca_3(PO_4)_2 + 10\,C + 6SiO_2 \longrightarrow 6CaSiO_3 + 10\,CO + P_4$

It is highly reactive form. This is due to the tetrahedral structure of P_4 molecule.



Structure of white phosphorous

Following are the important properties of white P

i. It has garlic smell.
ii. Its melting point is 44.1°C and boiling point is 280°C.
iii. It is slowly changed into yellow when exposed to light.
iv. It reacts with aq. KOH to give PH_3 gas.

$P_4 + 3KOH + 3H_2O \longrightarrow PH_3 \uparrow + 3KH_2PO_2$

v. It reacts with metal like Na, Ca to give their phosphide.

$11Na + P_4 \longrightarrow 4Na_3P$(sodium phosphide)

$6Ca + P_4 \longrightarrow 2Ca_3P_2$(calcium phosphide)

vi. It reacts with halogen to form trihalides and with excess pentahalides.

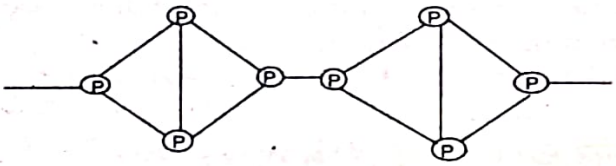
$P_4 + 6Cl_2 \longrightarrow 4PCl_3$

$P_4 + 10Cl_2 \longrightarrow 4PCl_5$

b. **Red P :** It is obtained by heating white P in the absence of air at about 300°C.

P_4 (white) $\xrightarrow[300^\circ C]{}$ P_4(red)

It is less volatile and more stable than white P. This is due to the polymeric structure of red phosphorous.



Polymeric structure of red P

Following are the important properties.

i. It is more stable and less volatile.
ii. Its melting point is 597°C.
iii. It is bad conductor of electricity.
iv. It gives P_2O_5 with oxygen at 300°C.

$P_4 + 5O_2 \longrightarrow 2P_2O_5$

c. **Black P:** It is obtained by heating white P at about 200 – 300°C temperature and 4000 – 12000 atm Pressure.

P_4(white) $\xrightarrow[4000\text{-}12000\ atm.]{200\text{-}300^\circ C}$ P_4(black)

Following are the important properties

i. It conducts electricity moderately.
ii. Its melting point is 587°C.
iii. It has metallic luster property.
iv. It is ignited at 400°C.

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11.4 Sulphur

VERY SHORT ANSWER QUESTIONS

1. 2070 Supp. Q.No. 15 (ii) | 2070 Set'D Q.No. 15b | 2069 Set B Q. No. 16d **Write the molecular formula of hypo.** [0.5]

Molecular formula of Hypo is $Na_2S_2O_3.5H_2O$ (Sodium thiosulphate).

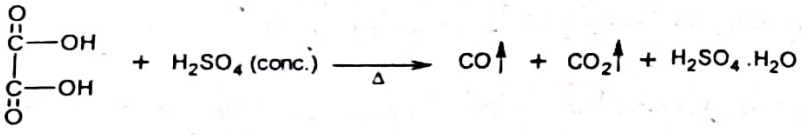
2. 2070 Set C Q.No. 21 **Write the molecular formula of 'Hypo' and also write one use.** [1+1]

Please refer to 2070 Supp. Q.No. 15 (ii)

Use of hypo: It is used in photography as fixing agent.

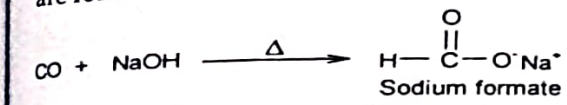
3. 2066 Q.No. 15 **What happens when gas obtained by heating oxalic acid in presence conc. H_2SO_4 is passed through heated caustic soda?** [2]

When conc. H_2SO_4 is heated with oxalic acid then a mixture of CO_2 and CO gas is formed.



Oxalic acid

The mixture of CO_2 and CO gas is passed through heated caustic soda then different products are formed.



Sodium formate

$$CO_2 + 2NaOH \longrightarrow Na_2CO_3 + H_2O$$

Sodium carbonate

4. 2064 Q.No. 15 **Why does conc. H_2SO_4 diluted by adding acid into water but not water into acid in the laboratory?** [2]

In order to dilute an acid, pour acid into water in small amounts and stir constantly. Water is not added to acid, since it is an exothermic process and in this process extensive heat is produced which may cause splashing of acidic solutions, also the container may break and can be fatal to the person. Therefore, conc. H_2SO_4 should always be added to H_2O but never H_2O to acid.

5. 2063 Q.No. 15 **What happens when H_2S is passed through acidified potassium permanganate solution?** [2]

When H_2S gas is passed through the acidified solution of $KMnO_4$ then $KMnO_4$ gets reduced and pink color of $KMnO_4$ is changed into colorless.

$$2KMnO_4 + 3H_2SO_4 \longrightarrow K_2SO_4 + 2MnSO_4 + 3H_2O + 5[O]$$

$$[H_2S + [O] \longrightarrow H_2O + S] \times 5$$

$$2KMnO_4 + 3H_2SO_4 + 5H_2S \longrightarrow K_2SO_4 + 2MnSO_4 + 8H_2O + 5S$$

Pink → Colourless

6. 2060 Q.No. 15 **Write any two differences between the bleaching action of Cl_2 and SO_2.** [2]

Bleaching property: Both Cl_2 and SO_2 act as bleaching agent in the presence of moisture. The process of decolourization of any colouring matter into colourless in the presence of moisture is known as bleaching property. Following are two difference between bleaching action of Cl_2 and SO_2

Sulphur dioxide (SO_2)	Chlorine (Cl_2)
1. The bleaching action of SO_2 is due to the formation of nascent hydrogen. $SO_2 + H_2O \longrightarrow H_2SO_4 + 2[H]$	1. The bleaching action of Cl_2 is due to the formation of nascent oxygen $Cl_2 + H_2O \longrightarrow 2HCl + [O]$
2. It is temporary action.	2. It is permanent action.

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7. **2055 Q.No. 17** **Explain with reason, why:** [2]

a. Conc. H_2SO_4 should always be added to H_2O but never H_2O to the acid?

b. Sugar is charred in contact with conc. H_2SO_4?

a. In order to dilute an acid, pour acid into water in small amounts and stir constantly. Water is not added to acid, since it is an exothermic process and in this process extensive heat is produced which may cause splashing of acidic solutions, also the container may break and can be fatal to the person. Therefore, conc. H_2SO_4 should always be added to H_2O but never H_2O to acid.

b. Conc. H_2SO_4 reacts with table sugar giving a charred mass of carbon. This is due to the dehydration and process is known as dehydration of sugar i.e. charring of sugar.

$C_{12}H_{22}O_{11} + H_2SO_4(conc.) \longrightarrow 12\,C + [H_2SO_4.11H_2O]$

Sugar black

8. **2053 Q.No. 6 A** **Acid rain forms when oxides of sulphur and nitrogen react with water. What are these oxides chemically?** [1.5]

Oxide of sulphur i.e. SO_2 and SO_3 gives sulphurous acid and sulphuric acid with water respectively.

$SO_2 + H_2O \longrightarrow H_2SO_3$ (sulphurous acid)

$SO_3 + H_2O \longrightarrow H_2SO_4$ (sulphuric acid)

Oxide of nitrogen i.e. NO_2 gives nitric acid with water.

$4NO_2 + 2H_2O + O_2 \longrightarrow 4HNO_3$ (nitric acid)

9. **2053 Q.No. 23 A** **Identify a viscous liquid that react with table sugar ($C_{12}H_{22}O_{11}$) giving a charred (black) mass. Give the reaction involved.** [1.5]

Viscous liquid is conc. H_2SO_4 which reacts with table sugar giving a charred mass of carbon. This is due to the dehydration and process is known as dehydration of sugar i.e. charring of sugar.

$C_{12}H_{22}O_{11} + H_2SO_4(conc.) \longrightarrow 12\,C + [H_2SO_4.11H_2O]$

Sugar black

10. **2051 Q.No. 17 A** **How is the moisture present in SO_2 gas removed?** [2]

Pure and dry SO_2 gas is obtained by passing the impure SO_2 gas through Conc. H_2SO_4 which acts as dehydrating agent and collected over Hg.

SHORT ANSWER QUESTIONS

11. **2076 Set B Q.No. 28** **How is sulphur dioxide gas prepared in laboratory? Write reactions to show SO_2 acts as both an oxidising as well as a reducing agent.** [3+2]

Laboratory preparation of SO_2 gas:

Principle: Sulphur dioxide (SO_2) gas is prepared in the laboratory by heating copper turning with conc. H_2SO_4.

$Cu + 2H_2SO_4(conc.) \longrightarrow CuSO_4 + 2H_2O + SO_2\uparrow$

Copper turning Sulphur dioxide

Thus the formed gas is collected in the gas jar by the upward displacement of air.

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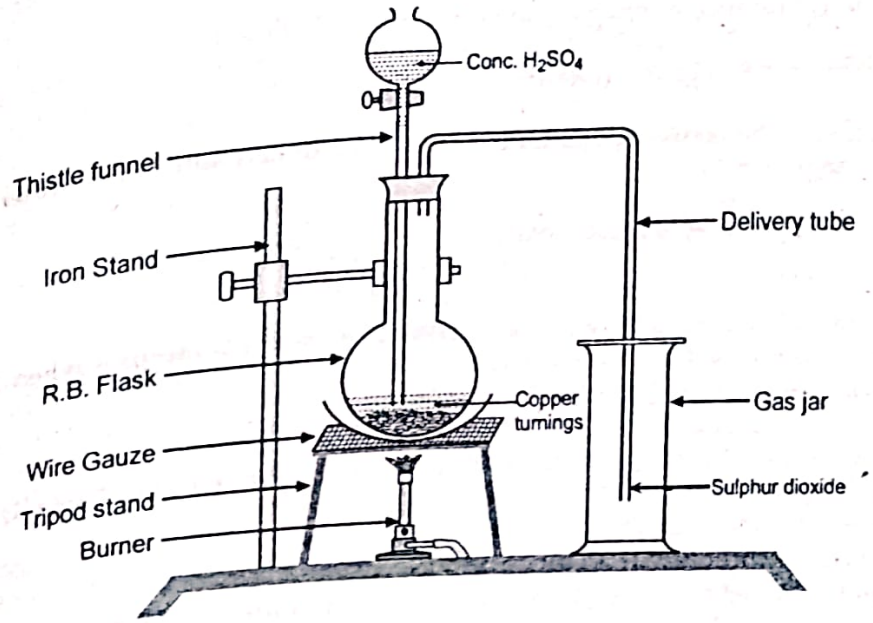


Fig: Laboratory preparation of SO_2 gas

Procedure: Small pieces of copper turning are taken in round bottom flask and conc. H_2SO_4 is poured in the flask with the help of dropping funnel. The flask is put in the wire gauze having tripod stand and heated with burner. The SO_2 gas formed is collected in the gas jar by the upward displacement of air because it is heavier than air.

SO_2 acts as an oxidising agent: SO_2 oxidizes H_2S to sulphur.

$$2H_2S + SO_2 \longrightarrow 2H_2O + 3S$$

SO_2 acts as reducing agent: When SO_2 gas is passed through acidified solution of $KMnO_4$, the pink colour of $KMnO_4$ is discharged. Here, SO_2 acts as reducing agent.

$$2KMnO_4 + 5SO_2 + 2H_2O \longrightarrow K_2SO_4 + 2MnSO_4 + 2H_2O + 2H_2SO_4$$

Pink → Colourless

2076 Set C Q.No. 28 Starting from Iron pyrites, how would you obtain Conc.sulphuric acid? Give a reaction to show Conc.H_2SO_4 acts as,

i. a dehydrating agent

ii. a precipitating agent.

How is Conc. H_2SO_4 diluted with water? **[2+2+1]**

Principle:

Sulphuric acid (H_2SO_4) is manufactured by Contact process. This is modern process. The oxidation of sulphur dioxide SO_2) to sulphur trioxide (SO_3) takes place in contact with the surface of a catalyst during the manufacture of acid, so this process is called contact process.

It involves the following steps:

Step: I Production of Sulphur dioxide (SO_2): Sulphur dioxide is produced by burning sulphur with oxygen or roasting of iron pyrites.

$$S + O_2 \xrightarrow{\Delta} SO_2$$

$$4FeS_2 + 11O_2 \xrightarrow{\Delta} 2Fe_2O_3 + SO_2$$

Step: II Oxidation of sulphur dioxide to sulphur trioxide: Sulphur dioxide is oxidized to sulphur trioxide at 450°C in the presence of Vanadium pentoxide (V_2O_5) catalyst.

$$2SO_2 + O_2 \underset{450\ ^\circ C}{\overset{V_2O_5}{\rightleftharpoons}} 2SO_3 + 45\ Kcal$$

Step: III Absorption of sulphur trioxide in sulphuric acid: Sulphur trioxide thus produced is

absorbed in conc. H_2SO_4 to get fuming sulphuric acid which is called Oleum.

$$SO_3 + \text{Conc. } H_2SO_4 \longrightarrow H_2S_2O_7 \text{ (Oleum)}$$

Step: IV Dillution of Oleum: The oleum is diluted by adding calculated amount of water to obtain conc. H_2SO_4 of desired strength (98%).

$$H_2S_2O_7 \text{ (Oleum)} + H_2O \longrightarrow 2\,H_2SO_4 \text{ (98\%)}$$

Conc.H_2SO_4 acts as:

i. **A dehydrating agent:** Conc. H_2SO_4 removes water molecules from sugar molecules when few drops of acid is added to sugar. This is called dehydrating agent.

$C_{12}H_{22}O_{11} + \text{Conc. } H_2SO_4 \longrightarrow 12C + [H_2SO_4.11H_2O]$

Sugar — Black

ii. **A precipitating agent:** When Conc. H_2SO_4 is added to $BaCl_2$ solution, white ppt of $BaSO_4$ is obtained. This is called precipitating agent.

Conc. $H_2SO_4 + BaCl_2 \longrightarrow BaSO_4 + 2HCl$

White ppt.

Conc. sulphuric acid can be diluted by adding it to water, if water is added to the acid as it is a highly reactive exothermic reaction and also in this process constant stirring with a rod is required. This process is known as dilution.

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13. **2074 Set A Q.No. 28 Describe the Kipp's apparatus method for the manufacture of H_2S. Give a reaction to show H_2S is a reducing agent.** [4+1]

Manufacture of H_2S by Kipp's apparatus:

H_2S gas is prepared in the laboratory by the action of dilute H_2SO_4 on iron sulphide.

$FeS + H_2SO_4 \longrightarrow FeSO_4 + H_2S\uparrow$

Working principle of Kipp's apparatus: H_2S gas is frequently required for salt analysis in the laboratory. The special apparatus which is used for the preparation of H_2S is called Kipp's apparatus. It consists of two parts (i) bulb 'A' with a long stem (ii) base with two communicating bulb 'B' and 'C'. The bulb 'A' is fitted into the mouth of the base as shown in the figure.

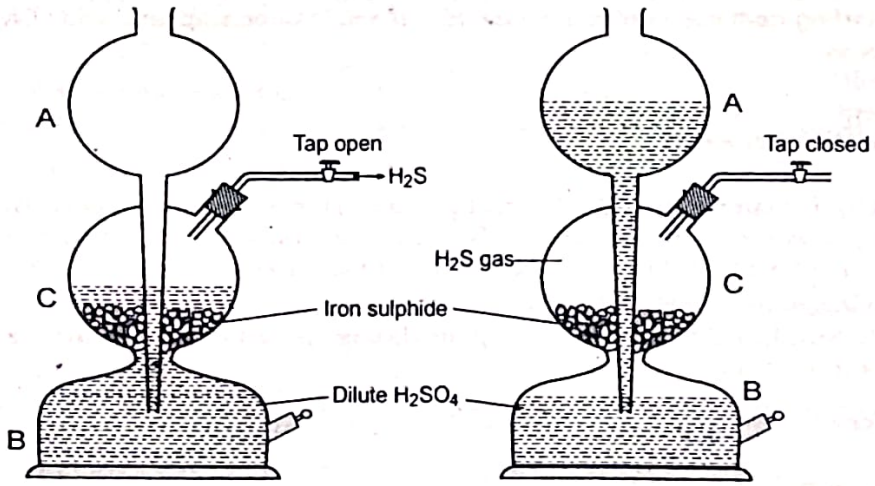


Fig: Kipp's Apparatus

Pieces of FeS are put into the central bulb 'C' and dil. H_2SO_4 is poured into the upper bulb 'A' till the pieces of FeS are covered by acid when the tap is opened. The acid reacts with FeS to give H_2S gas which is used for the analytical purpose.

When tap is closed H_2S produced by the actin of Fes and H_2SO_4 exerts pressure. Due to this, H_2SO_4 falls down the bulb B and arises to the bulb A. This happens till the contact between H_2SO_4 and Fes breaks.

Reducing agent of H_2S: When H_2S gas is passed through ferric chloride solution, it is reduced to ferrous chloride.

$$\underset{\text{Ferric chloride}}{2\,FeCl_3^{+3}} + H_2S \longrightarrow \underset{\text{Ferrous chloride}}{2\,FeCl_2^{+2}} + 2\,HCl + S$$

2073 Supp Q.No. 26 Starting from sulphur, how would you obtain sulphuric acid? Give a reaction of each to show conc. H_2SO_4 act as

i. an oxidising agent **ii. a precipitating agent**

How is conc. H_2SO_4 dilluted? **[2+1+1+1]**

Principle: Sulphuric acid (H_2SO_4) is manufactured by Contact process. This is modern process. The oxidation of sulphur dioxide SO_2) to sulphur trioxide (SO_3) takes place in contact with the surface of a catalyst during the manucature of acid, so this process is called contact process.

It involves the following steps:

Step: I Production of Sulphur dioxide (SO_2): Sulphur dioxide is produced by burning sulphur with oxygen or roasting of iron pyrites.

$$S + O_2 \xrightarrow[\Delta]{} SO_2$$

$$4\,FeS_2 + 11\,O_2 \xrightarrow[\Delta]{} 2\,Fe_2O_3 + SO_2$$

Step: II Oxidation of sulphur dioxide to sulphur trioxide: Sulphur dioxide is oxidized to sulphur trioxide at 450°C in the presence of Vanadium pentoxide (V_2O_5) catalyst.

$$2\,SO_2 + O_2 \underset{450\,^\circ C}{\overset{V_2O_5}{\rightleftharpoons}} 2\,SO_3 + 45\ Kcal$$

Step: III Absorption of sulphur trioxide in sulphuric acid: Sulphur trioxide thus produced is absorbed in conc. H_2SO_4 to get fuming sulphuric acid which is called Oleum,

$$SO_3 + \text{Conc. } H_2SO_4 \longrightarrow H_2S_2O_7 \text{ (Oleum)}$$

Step: IV Dillution of Oleum: The oleum is diluted by adding calculated amount of water to obtain conc. H_2SO_4 of desired strength (98%).

$$H_2S_2O_7 \text{ (Oleum)} + H_2O \longrightarrow 2\,H_2SO_4\ (98\%)$$

i. **Conc. H_2SO_4 act as an oxidising agent:** When conc. H_2SO_4 is reacted with copper turning then SO_2 gas is formed. H_2SO_4 oxidizes copper turning into copper sulphate and reduces itself to SO_2.

$$Cu + \text{conc. } 2H_2SO_4 \longrightarrow CuSO_4 + SO_2\uparrow + 2H_2O$$

ii. **Conc. H_2SO_4 act as a precipitating agent**

Conc. Sulphuric acid (H_2SO_4) acts as a dibasic acid because it has two replaceable H-atoms in its molecules. So, it is a powerful oxidizing agent. It oxidizes carbon to CO_2, S to SO_2, I_2 to iodic acid and P to phosphoric acid.

$$C + 2\,H_2SO_4 \longrightarrow CO_2\uparrow + 2\,H_2O + 2\,SO_2\uparrow$$

$$S + 2\,H_2SO_4 \longrightarrow 2\,H_2O + 3\,SO_2\uparrow$$

$$I_2 + 5\,H_2SO_4 \longrightarrow 2\,HIO_3 + 4\,H_2O + 5\,SO_2\uparrow$$

$$P_2 + 5\,H_2SO_4 \longrightarrow 2\,H_3PO_4 + 2\,H_2O + 5\,SO_2\uparrow$$

Conc. sulphuric acid can be diluted by adding it to water, if water is added to the acid as it is a highly reactive exothermic reaction and also in this process constant stirring with a rod is required. This process is known as dilution.

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15. 2073 Set C Q. No. 26 **Starting from sulphur, how would you obtain sulphuric acid? (reaction only). Prove that conc. H_2SO_4 acts as;** [2+1+1+1]

i. An oxidizing agent

ii. A dehydrating agent

What is the test reaction of sulphate ion?

Principle: Sulphuric acid (H_2SO_4) is manufactured by Contact process. This is modern process. The oxidation of sulphur dioxide SO_2) to sulphur trioxide (SO_3) takes place in contact with the surface of a catalyst during the manucature of acid, so this process is called contact process. It involves the following steps:

Step: I Production of Sulphur dioxide (SO_2): Sulphur dioxide is produced by burning sulphur with oxygen or roasting of iron pyrites.

$$S + O_2 \xrightarrow[\Delta]{} SO_2$$

$$4\,FeS_2 + 11\,O_2 \xrightarrow[\Delta]{} 2\,Fe_2O_3 + SO_2$$

Step: II Oxidation of sulphur dioxide to sulphur trioxide: Sulphur dioxide is oxidized to sulphur trioxide at 450°C in the presence of Vanadium pentoxide (V_2O_5) catalyst.

$$2\,SO_2 + O_2 \underset{450\,^\circ C}{\overset{V_2O_5}{\rightleftharpoons}} 2\,SO_3 + 45\ Kcal$$

Step: III Absorption of sulphur trioxide in sulphuric acid: Sulphur trioxide thus produced is absorbed in conc. H_2SO_4 to get fuming sulphuric acid which is called Oleum.

$$SO_3 + \text{Conc. } H_2SO_4 \longrightarrow H_2S_2O_7 \text{ (Oleum)}$$

Step: IV Dillution of Oleum: The oleum is diluted by adding calculated amount of water to obtain conc. H_2SO_4 of desired strength (98%).

$$H_2S_2O_7 \text{ (Oleum)} + H_2O \longrightarrow 2\,H_2SO_4\ (98\%)$$

Conc. H_2SO_4 acts as:

i. **An oxidizing agent:** When conc. H_2SO_4 is reacted with copper turning then SO_2 gas is formed. H_2SO_4 oxidizes copper turning into copper sulphate and reduces itself to SO_2.

$Cu + \text{conc. } 2H_2SO_4 \longrightarrow CuSO_4 + SO_2\uparrow + 2H_2O$

ii. **A dehydrating agent:** Conc. H_2SO_4 removes water molecules from sugar molecules when few drops of acid is added to sugar. This is known as dehydration of sugar.

$C_{12}H_{22}O_{11} + H_2SO_4(\text{conc.}) \longrightarrow 12\,C + [H_2SO_4.11H_2O]$

Sugar Black

Test for sulphate ion(SO_4^{--}): About 1 mL of salt containing sulphate ion (SO_4^{--}) is taken in clean and dry test tube and 2 – 3 drops of $BaCl_2$ solution is added to the test tube. A white ppt. is obtained which does not dissolve in dil. HCl. This indicates the presence of sulphate ion i.e. SO_4^{--}

$SO_4^{--} + BaCl_2 \longrightarrow BaSO_4\downarrow + 2Cl^-$

White ppt.

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16. 2073 Set D Q. No. 26 **Starting from sulphur, how would you obtain sulphuric acid? (reaction only). How does conc. H_2SO_4 react with;** [2+1+1+1]

i. Sugar ii. P_4

What is conc. Sulphuric acid diluted by adding water but not water to acid?

Preparation of sulphuric acid from sulphur: Please refer to 2073 Set C Q. No. 26

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Reaction of H_2SO_4 with:

Sugar: Conc. H_2SO_4 removes water molecules from sugar molecules when few drops of acid is added to sugar. This is known as dehydration of sugar.

$$\underset{\text{Sugar}}{C_{12}H_{22}O_{11}} + H_2SO_4(\text{conc.}) \longrightarrow \underset{\text{Black}}{12\,C} + [H_2SO_4.11H_2O]$$

Phosphorous: It reacts with H_2SO_4 to give orthophosphoric acid.

$$10\,H_2SO_4 + P_4 \longrightarrow \underset{\text{Ortho phosphoric acid}}{4H_3PO_4} + 10\,SO_2\uparrow + 4\,H_2O$$

Addition of H_2SO_4 with water: In order to dilute an acid, pour acid into water in small amounts and stir constantly. Water is not added to acid, since it is an exothermic process and in this process extensive heat is produced which may cause splashing of acidic solutions, also the container may break and can be fatal to the person. Therefore, conc. H_2SO_4 should always be added to H_2O but never H_2O to acid.

2072 Supp Q. No. 27 How is SO_2 prepared in the laboratory? Write its bleaching actions. [3+2]

Laboratory preparation of SO_2 gas: Please refer to 2076 Set B Q.No. 28

Bleaching action of SO_2 gas: SO_2 has the property of bleaching of most coloured substance. In presence of water it forms H_2SO_3.

$$SO_2 + H_2O \longrightarrow H_2SO_3$$

This H_2SO_3 reduces the coloured substance to colourless substance.

Thus, SO_2 bleaches colour by the process of reduction. The substance bleached by SO_2 regains its colour due to oxidation by atmospheric oxygen.

$$\text{Colourless substance} \xrightarrow{\text{air}} \text{colour substance}$$

2070 Set C Q.No. 26 How is sulphur dioxide prepared in laboratory? What happens when SO_2 is passed through acidified solution of potassium dichromate? [3+2]

Laboratory preparation of SO_2 gas: Please refer to 2076 Set B Q.No. 28

When SO_2 gas is passed through in an orange acidified solution of $K_2Cr_2O_7$, the colour of the solution turns green due to its conversion to $Cr_2(SO_4)_3$ which is green.

$$K_2Cr_2O_7 + 4H_2SO_4 \longrightarrow K_2SO_4 + Cr_2(SO_4)_3 + 4H_2O + 3[O]$$

$$3SO_2 + 3\,[O] \longrightarrow 3SO_3$$

$$3SO_3 + 3\,H_2O \longrightarrow 3\,H_2SO_4$$

$$\underset{\text{Orange}}{K_2Cr_2O_7} + 3SO_2 \longrightarrow H_2SO_4 + K_2SO_4 + \underset{\text{Green}}{Cr_2(SO_4)_3} + H_2O$$

2069 (Set A) Q. No. 27 Write the chemical reaction for the Laboratory preparation of H_2S. How does Kipp's apparatus work to supply H_2S gas in salt analysis? [1+4]

Manufacture of H_2S by Kipp's apparatus: Please refer to 2074 Set A Q.No. 28

2068 Q.No. 26 Write balanced chemical reactions for the laboratory preparation of:

i. Hydrogen Sulphide ii. Sulphurdioxide

What happens when a moist red flower is introduced into a gas jar containing SO_2 gas?

Give a reaction of each to show:

i. SO_2 as an oxidising agent

ii. H_2S as an analytical agent [1+1+1+1+1=5]

Balanced chemical equation for hydrogen sulphide (H_2S): Hydrogen sulphide (H_2S) gas is prepared in the laboratory by the action of dilute H_2SO_4 on iron sulphide.

$$\underset{\text{Iron sulphide}}{FeS} + H_2SO_4 \longrightarrow FeSO_4 + \underset{\text{Hydrogen sulphide}}{H_2S}\uparrow$$

Thus the formed gas is collected in the gas jar by the upward displacement of air.

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ii. **Balanced chemical equation for Sulphur dioxide (SO_2):** Sulphur dioxide (SO_2) gas is prepared in the laboratory by heating copper turning with conc. H_2SO_4.

$Cu + 2H_2SO_4(conc.) \longrightarrow CuSO_4 + 2H_2O + SO_2\uparrow$

Copper turning — Sulphur dioxide

Thus the formed gas is collected in the gas jar by the upward displacement of air.

What happens when

When a moist red flower is introduced into a gas jar containing SO_2 gas, its colour is discharged due to the bleaching action of SO_2 gas.

$SO_2 + 2H_2O \longrightarrow H_2SO_4 + 2[H]$

Nascent hydrogen

Red flower + $[H] \longrightarrow$ Colourless

i. **SO_2 as an oxidizing agent:** Its molecules contains two atoms of oxygen, hence it acts as an oxidizing agent. It oxidizes H_2S to S, Mg to MgO, Fe to FeO, C to CO and CO_2

$2H_2S + SO_2 \longrightarrow 2H_2O + 3S$

$2Mg + SO_2 \longrightarrow 2MgO + S$

$3Fe + SO_2 \longrightarrow 2FeO + FeS$

$3C + 2SO_2 \longrightarrow 2CO + CO_2 + 2S$

ii. **H_2S as an analytical agent:** H_2S gas is used as analytical agent to detect group (II) ions in acidic medium i.e. dil. HCl and group (IIIB) ions in alkaline medium i.e.NH_4Cl and NH_4OH.

In acid medium:

$Hg^{++} + H_2S \longrightarrow HgS\downarrow + 2H^+$

Black ppt.

In alkaline medium:

$Zn^{++} + H_2S \longrightarrow ZnS\downarrow + 2H^+$

White ppt.

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21. **2066 Q.No. 27 Write down the principle and sketch a labelled diagram for the laboratory preparation of H_2S. Why is H_2S called an analytical agent?** [3+2]

Laboratory preparation of H_2S gas:

Principle: Hydrogen sulphide (H_2S) gas is prepared in the laboratory by the action of dilute H_2SO_4 on iron sulphide.

$FeS + H_2SO_4 \longrightarrow FeSO_4 + H_2S\uparrow$

Iron sulphide — Hydrogen sulphide

Thus the formed gas is collected in the gas jar by the upward displacement of air.

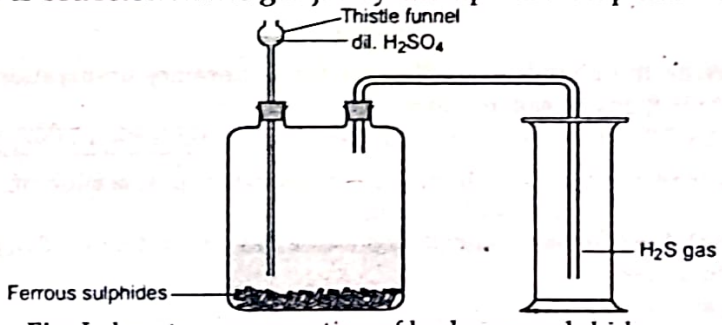


Fig: Laboratory preparation of hydrogen sulphide gas

Procedure: The small pieces of iron sulphide are taken in the Woulf's bottle and dilute H_2SO_4 is added with the help of thistle funnel. The H_2S gas is collected in the gas jar by the upward displacement of air.

Test: H_2S gas is passed to the lead acetate $Pb(CH_3COO)_2$ paper which is turned into black.

$Pb(CH_3COO)_2 + H_2S \longrightarrow PbS\downarrow + 2CH_3COOH$

Lead Sulphide (Black ppt)

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Analytical use of H_2S: H_2S gas is used as analytical agent to detect group (II) ions in acidic medium i.e. dil. HCl and group (IIIB) ions in alkaline medium i.e. NH_4Cl and NH_4OH.

In acidic medium: When H_2S gas is passed through the solution of group (II) metal salts in acidic medium then characteristic coloured ppt. is obtained. These coloured ppt. shows the presence of metal ions in given salts.

$Hg^{++} + H_2S \longrightarrow HgS \downarrow + 2H^+$
Black ppt.

$Cu^{++} + H_2S \longrightarrow CuS \downarrow + 2H^+$
Black ppt.

$Pb^{++} + H_2S \longrightarrow PbS \downarrow + 2H^+$
Black ppt.

In alkaline medium: When H_2S gas is passed through group (IIIB) metal salts in alkaline medium i.e. NH_4Cl and NH_4OH then characteristic coloured ppt. is obtained which show the presence of metal ions.

$Zn^{++} + H_2S \longrightarrow ZnS \downarrow + 2H^+$
White ppt.

$Mn^{++} + H_2S \longrightarrow MnS \downarrow + 2H^+$
Pink ppt.

$Co^{++} + H_2S \longrightarrow CoS \downarrow + 2H^+$
black ppt.

2065 Q. No. 27 How is Sulphur dioxide prepared in laboratory? What happens when SO_2 is passed through acidified solution of potassium permanganate? [3+2]

Laboratory preparation of SO_2 gas: Please refer to 2076 Set B Q.No. 28

When SO_2 gas is passed through the acidified solution of $KMnO_4$ then pink colour of $KMnO_4$ is discharged.

$2KMnO_4 + 5SO_2 + 2H_2O \longrightarrow K_2SO_4 + 2MnSO_4 + 2H_2SO_4$
Pink → Colourless

2064 Q.No. 27 Describe the preparation of H_2S gas in the laboratory. How does it act upon:
a. acidified potassium dichromate solution?
b. SO_2 - water? [3+1+1]

Laboratory preparation of H_2S gas: Please refer to 2066 Q.No. 27

Action of H_2S upon acidified $K_2Cr_2O_7$

When H_2S gas is passed through the acidified solution of $K_2Cr_2O_7$ then orange colour of $K_2Cr_2O_7$ is changed into green. Here H_2S acts as reducing agent which reduces acidified solution of $K_2Cr_2O_7$.

$K_2Cr_2O_7 + 4H_2SO_4 \longrightarrow K_2SO_4 + Cr_2(SO_4)_3 + 4H_2O + 3[O]$

$[H_2S + [O] \longrightarrow H_2O + S] \times 3$

$K_2Cr_2O_7 + 4H_2SO_4 + 3H_2S \longrightarrow K_2SO_4 + Cr_2(SO_4)_3 + 7H_2O + 3S$
Orange → green

Action of H_2S upon SO_2 water

H_2S gas reduces aqueous solution of SO_2 to give sulphur.

$2H_2S + SO_2 \xrightarrow{H_2O} 2H_2O + 3S$

2061 Q.No. 27 How is H_2S gas prepared in the laboratory? Give two reactions to show that H_2S is a reducing agent. [3+2]

Laboratory preparation of H_2S gas: Please refer to 2066 Q.No. 27

Following are the two reactions which show the reducing properties of H_2S.

When H_2S gas is passed through ferric chloride solution then reduced to give ferrous chloride.

$2FeCl_3 + H_2S \longrightarrow 2FeCl_2 + 2HCl + S$
Ferric chloride → ferrous chloride

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When H_2S gas is passed through the acidified solution of $K_2Cr_2O_7$ then orange colour of $K_2Cr_2O_7$ is changed into green. Here H_2S acts as reducing agent which reduces acidified solution of $K_2Cr_2O_7$.

$$K_2Cr_2O_7 + 4H_2SO_4 \longrightarrow K_2SO_4 + Cr_2(SO_4)_3 + 4H_2O + 3[O]$$
$$[H_2S + [O] \longrightarrow H_2O + S] \times 3$$
$$K_2Cr_2O_7 + 4H_2SO_4 + 3H_2S \longrightarrow K_2SO_4 + Cr_2(SO_4)_3 + 7H_2O + 3S$$

Orange → green

25. **2060 Q.No. 27(iii) 2059 Q.No.32(iii) 2053 Q.No.7(a) 2051 Q.No. 7 Group B What happens when:** [5]
   a. **Sulphur dioxide is passed through patassium iodate solution.**
   b. **Hydrogen sulphide is passed through bromine water.**
   c. **Sulphur dioxide gas is passed into an aqueous solution of potassium permanganate.**

Ans

a. **Sulphur dioxide is passed through potassium iodate solution**

When SO_2 gas is passed through KIO_3 solution then SO_2 reduces KIO_3 into iodine and SO_2 is oxidized into H_2SO_4.

$$5SO_2 + 2KIO_3 + 4H_2O \longrightarrow 2KHSO_4 + I_2 + 3H_2SO_4$$

b. **Hydrogen sulphide is passed through bromine water**

When H_2S gas is passed through bromine water, it is oxidized to sulphur and the bromine water is reduced to hydrogen bromide.

$$Br_2 + H_2S \longrightarrow 2HBr + S$$

c. **Sulphur dioxide gas is passed into an aqueous solution of potassium permanganate**

When SO_2 gas is passed through aqueous solution of $KMnO_4$, then pink color of $KMnO_4$ is discharged into colorless. The SO_2 is oxidized to H_2SO_4.

$$2KMnO_4 + 5SO_2 + 2H_2O \longrightarrow K_2SO_4 + 2MnSO_4 + 2H_2SO_4$$

Pink color → colorless

26. **2059 Q.No. 27 Write the chemical reactions involved in the manufacture of sulphuric acid by contact process. How does conc H_2SO_4 react with copper turnings?** [4+1]

Ans **Favourable condition for maximum yield of H_2SO_4:**

The formation of SO_2 to SO_3 is reversible reaction. High concentration of SO_3 leads to high concentration of H_2SO_4. The favourable condition for high concentration of SO_3 is explained by Le-Chatelier's principle.

a. **Concentration:** High concentration of SO_2 and O_2 are used for more production of SO_3.

b. **Temperature:** The formation of SO_3 is exothermic reaction. Low temperature will favour for forward direction. The optimum temperature of about 450°C is supplied.

$$2SO_2 + O_2 \underset{450\,^\circ C}{\overset{V_2O_5}{\rightleftharpoons}} 2SO_3 + 45\ Kcal$$

c. **Pressure:** Here, 3 volumes of reactants produce 2 volumes of products. High pressure will favour for forward direction. The optimum pressure of about 2 atm is supplied.

$$\underbrace{2SO_2 + O_2}_{3\ Volume} \underset{450\,^\circ C}{\overset{V_2O_5}{\rightleftharpoons}} \underbrace{2SO_3}_{2\ Volume} + 45\ Kcal$$

d. **Catalyst:** The rate of reaction is increased by the used of positive catalyst like platinum asbestos or vanadium pentoxide (V_2O_5). In comparison to the platinum asbestos, vanadium pentoxide is cheaper and less easily poisoned but slightly less efficient.

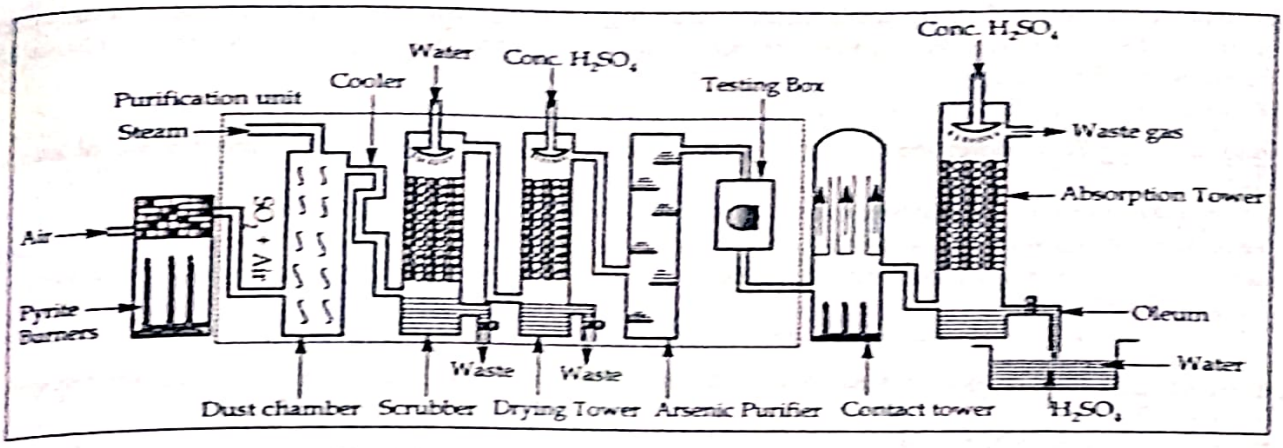


Fig: Manufacture of H_2SO_4 by Contact process

Working plant:

1. **Pyrite burner or Sulphur:** Sulphur dioxide is produced by burning sulphur with oxygen or roasting of iron pyrites in special type of burner made of fire bricks.

$$S + O_2 \xrightarrow{\Delta} SO_2$$

$$4FeS_2 + 11O_2 \xrightarrow{\Delta} 2Fe_2O_3 + SO_2$$

2. **Purification unit:** The impurities present in the SO_2 formed above are removed in the purification unit.
3. **Dust chamber:** The mixtures of gases are passed into dust chamber. The seam is passed from the top of chamber and duct particles are settled down at the bottom.
4. **Water scrubbers:** The gas coming out from dust chamber is passed through cooling pipe and cooled gas is passed through scrubber which is packed with quartz. Water is sprayed from the top of tower and gases are made free from acid, mist and any soluble impurities.
5. **Drying tower:** The gases coming from scrubber are passed through drying tower which is packed with quartz. Conc. H_2SO_4 is sprayed from the top so that moistures are removed.
6. **Arsenic purifier:** This chamber is fitted with many shelves containing $Fe(OH)_3$. Here, oxides of arsenic present in the gases are absorbed by $Fe(OH)_3$.

$$As_2O_3 + 2Fe(OH)_3 \longrightarrow 2FeAsO_3 + 3H_2O$$

7. **Testing box:** Strong beam of light is passed into a gas coming from arsenic purifier in testing box. No scattering of light by the beam indicates the absence of dust particles.
8. **Contact tower:** The pure and dried gas is passed through contact tower. This tower is made by iron and consists of iron tubes which are packed with V_2O_5. The tower is heated upto 450°C. Here, SO_2 combines with O_2 to give SO_3.

$$2SO_2 + O_2 \underset{450\,^\circ C}{\overset{V_2O_5}{\rightleftharpoons}} 2SO_3 + 45\,Kcal$$

9. **Absorption tower:** The SO_3 coming from contact tower is passed through absorption tower which is packed with quartz. It meets with stream of conc. H_2SO_4, oleum is formed.

$$SO_3 + \text{Conc. } H_2SO_4 \longrightarrow H_2S_2O_7 \text{ (Oleum)}$$

A calculated amount of water is added to this oleum to get the desired concentration of acid.

$$H_2S_2O_7 \text{ (Oleum)} + H_2O \longrightarrow 2H_2SO_4 \text{ (98\%)}$$

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Reaction of conc. C_2SO_4 with copper turning: When conc. H_2SO_4 is reacted with copper turning then SO_2 gas is formed. H_2SO_4 oxidizes copper turning into copper sulphate and reduces itself to SO_2.

$$Cu + \text{conc. } 2H_2SO_4 \longrightarrow CuSO_4 + SO_2\uparrow + 2H_2O$$

27. 2058 Q.No. 26 **Write down the flow sheet diagram and principle involved in the manufacture of sulphuric acid.** [5]

Chemical reaction involved in the manufacture of H_2SO_4: Please refer to 2059 Q.No. 27

Reaction of conc. C_2SO_4 with copper turning: When conc. H_2SO_4 is reacted with copper turning then SO_2 gas is formed. H_2SO_4 oxidizes copper turning into copper sulphate and reduces itself to SO_2.

$$Cu + \text{conc. } 2H_2SO_4 \longrightarrow CuSO_4 + SO_2\uparrow + 2H_2O$$

28. 2054,Q.No. 23 **How is hydrogen sulphide obtained in the laboratory? Draw a labelled diagram and give the reaction envolved.** [5]

Please refer to 2066 Q.No. 27

29. 2054 Q.No. 24 **Give two examples of reactions in which H_2SO_4 behaves as:** [5]
i. strong acid **ii. a dehydrating agent**
iii. an oxidising agent

i. **Strong acid:** When H_2SO_4 is treated with NaOH then salt (sodium sulphate) and water is formed.

$$\underset{\text{Sodium hydroxide}}{2NaOH} + \text{dil. } H_2SO_4 \longrightarrow \underset{\text{Sodium sulphate}}{Na_2SO_4} + H_2O$$

ii. **Dehydrating agent:** When conc. H_2SO_4 is treated with formic acid then CO gas is formed.

$$\underset{\text{Formic acid}}{HCOOH} + \text{conc. } H_2SO_4 \xrightarrow{\Delta} \underset{\text{Carbon monoxide}}{CO\uparrow} + [H_2SO_4.H_2O]$$

iii. **Oxidizing agent:** The chemical substance which oxidizes other substance but itself reduced is known as oxidizing agent.

$$\underset{\text{Hydrogen iodide}}{2HI} + \underset{\text{sulphuric acid}}{H_2SO_4} \longrightarrow \underset{\text{sulphur dioxide}}{SO_2} + 2H_2O + \underset{\text{Iodine}}{I_2}$$

30. 2053 Q.No. 1 Group B **Draw a self explanatory diagram for the manufacture of sulphuric acid by Contact process.** [5]

The self explanatory diagram for the manufacture of sulphuric acid by Contact process is given as:

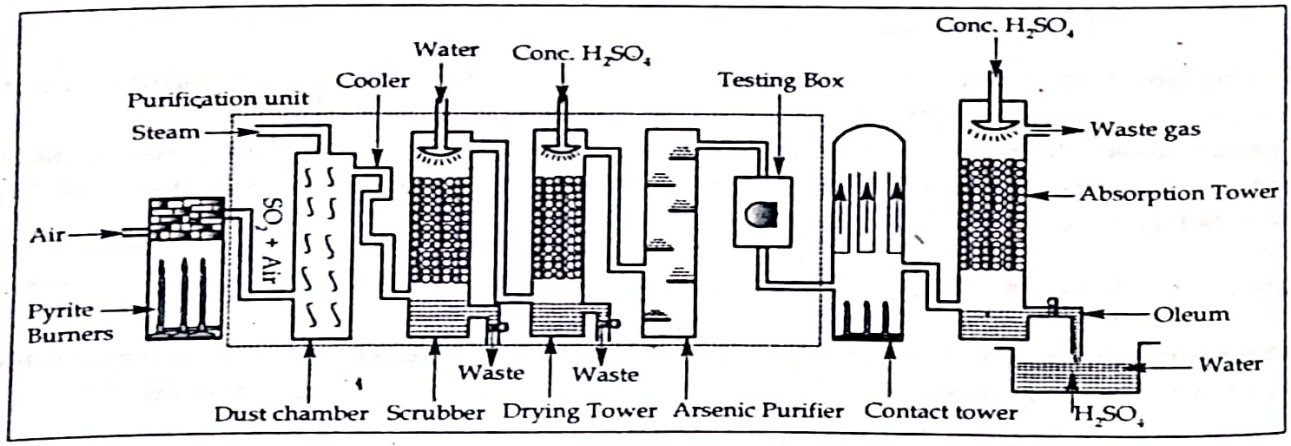


Fig: Manufacture of H_2SO_4 by Contact process

31. 2053 Q.No. 5 Group B **Compare the bleaching properties of SO_2 and Cl_2.** [5]

Bleaching property: Both Cl_2 and SO_2 act as bleaching agent in the presence of moisture. The process of decolourization of any colouring matter into colourless in the presence of moisture is

known as bleaching property. They have different bleaching action which are summarized below

Sulphur dioxide (SO_2)	Chlorine (Cl_2)
1. The bleaching action of SO_2 is due to the formation of nascent hydrogen. $SO_2 + H_2O \longrightarrow H_2SO_4 + 2[H]$	1. The bleaching action of Cl_2 is due to the formation of nascent oxygen $Cl_2 + H_2O \longrightarrow 2HCl + [O]$
2. It is temporary action.	2. It is permanent action.
3. It is weak bleaching agent.	3. It is strong bleaching agent.
4. It is used to bleach silk, wool, feather, starch etc.	4. It is used to bleach cotton, paper, wool pulp etc.
5. Bleaching action of SO_2 is slower and milder.	5. Bleaching action of chlorine is more faster.
6. SO_2 bleach is less toxic.	6. Cl_2 bleach is very toxic.
7. The active ingredient is SO_2	7. The active ingredient is Cl_2, NaClO, $Ca(OCl)_2$

2051 Q.No. 5 Group B **How would you show that sulphuric acid acts as:** **[5]**

a. an acid
b. an oxidizing agent
c. a dehydrating agent

Following are the reactions

An Acid: H_2SO_4 turns blue litmus paper to red. Carbonate and bicarbonate of metal give CO_2 with H_2SO_4.

Blue litmus paper $\longrightarrow$ H_2SO_4 solution $\longrightarrow$ Red litmus paper

$CaCO_3 + H_2SO_4 \longrightarrow CaSO_4 + CO_2 + H_2O$

$2NaHCO_3 + H_2SO_4 \longrightarrow Na_2SO_4 + CO_2 + H_2O$

An oxidizing agent: When conc. H_2SO_4 is reacted with copper turning then SO_2 gas is formed. H_2SO_4 oxidizes copper turning into copper sulphate and reduces itself to SO_2.

$Cu + \text{conc. } 2H_2SO_4 \longrightarrow CuSO_4 + SO_2\uparrow + 2H_2O$

As a dehydrating agent: Conc. H_2SO_4 removes water molecules from sugar molecules when few drops of acid is added to sugar. This is known as dehydration of sugar.

$C_{12}H_{22}O_{11} + H_2SO_4(\text{conc.}) \longrightarrow 12\,C + [H_2SO_4.11H_2O]$

Sugar black

LONG QUESTION ANSWERS

2075 GIE Q.No. 30 **Draw a self explanatory sketch for the manufacture of Sulphuric acid by Contact process and explain the principle and procedure involved in it. How does Conc. H_2SO_4 reacts with**

i. Sugar
ii. Copper

How would you test sulphate ion in its aqueous solution? **[7+1+1+1]**

Manufacture of Sulphuric acid by Contact process: Please refer to **2059 Q.No. 27**

Action of H_2SO_4 with:

Sugar: When conc. H_2SO_4 is dropped over sugars, they turn black due to their dehydration to black particles of carbon. This is called charring of sugars.

$C_{12}H_{22}O_{11} + H_2SO_4(\text{conc.}) \longrightarrow 12\,C + [H_2SO_4.11H_2O]$

Sugar black

Copper: When conc. H_2SO_4 is reacted with copper turning then SO_2 gas is formed. H_2SO_4 oxidizes copper turning into copper sulphate and reduces itself to SO_2.

$Cu + \text{conc. } 2H_2SO_4 \longrightarrow CuSO_4 + SO_2\uparrow + 2H_2O$

2075 Set A Q.No. 32 **2074 Set B Q.No. 32** **Write the principle and process with self-explanatory diagram for the manufacture of sulphuric acid by contact process. What are the action of conc. sulphuric acid on:**

i. sucrose
ii. HI and

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iii. P_4

Give the test of sulphate ion in its aqueous solution.

Manufacture of sulphuric acid by Contact process: Please refer to 2059 Q.No. 27 [6+4]

Action of conc. H_2SO_4 on:

i. **Sucrose:** Conc. H_2SO_4 removes water molecules from sugar or sucrose molecules when few drops of acid is added to sugar. This is known as dehydration of sugar or sucrose.

$$C_{12}H_{22}O_{11} + H_2SO_4(conc.) \longrightarrow 12\,C + [H_2SO_4.11H_2O]$$

Sucrose — Black

ii. **HI:** Conc. H_2SO_4 oxidizes HI into iodine.

$$H_2SO_4 + 2HI \longrightarrow 2H_2O + SO_2 + I_2$$

Iodine

iii. **P_4:** It reacts with H_2SO_4 to give orthophosphoric acid.

$$10\,H_2SO_4 + P_4 \longrightarrow 4H_3PO_4 + 10\,SO_2\uparrow + 4\,H_2O$$

Ortho phosphoric acid

Test of Sulphate (SO_4^{--}) ion:

About 1 mL of salt containing sulphate ion (SO_4^{--}) is taken in clean and dry test tube and 2 - 3 drops of $BaCl_2$ solution is added to the test tube. A white ppt. is obtained which does not dissolve in dil. HCl. This indicates the presence of sulphate ion i.e. SO_4^{--}

$$SO_4^{--} + BaCl_2 \longrightarrow BaSO_4\downarrow + 2Cl^-$$

White ppt.

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35. 2075 Set B Q.No. 30 **Describe laboratory method of preparation of hydrogen sulphide. What is the action of H_2S on (i) acidified $K_2Cr_2O_7$ (ii) $FeCl_3$.**
Write the application of H_2S in salt analysis. [4+2+4]

Laboratory preparation of H_2S: Please refer to 2066 Q.No. 27

Action of H_2S on:

i. **Acidified $K_2Cr_2O_7$:** When H_2S gas is passed through acidified solution of $K_2Cr_2O_7$, orange colour of dichromate is changed into green.

$$K_2Cr_2O_7 + 4H_2SO_4 + 3H_2S \longrightarrow K_2SO_4 + Cr_2(SO_4)_3 + 7H_2O + 3S$$

Orange — Green

ii. **$FeCl_3$:** When H_2S gas is passed through ferric chloride solution, yellow colour of ferric chloride is changed into light green.

$$2FeCl_3 + H_2S \longrightarrow 2FeCl_2 + 2HCl + S$$

Yellow — Light green

Application of H_2S in salt analysis: Please refer to 2066 Q.No. 27

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36. 2074 Supp Q.No. 30 **How is sulphuric acid manufactured by Contact process? Write the action of Conc. H_2SO_4 on**
I. Glucose II. Phosphorous III. Copper
Give an important use of Conc. H_2SO_4 [6+4]

Manufacture of sulphuric acid: Please refer to 2059 Q.No. 27

Action of H_2SO_4 with:

i. **Glucose:** It removes water from glucose. Due to formation of black C-particles, glucose turns into black. This is called charring of sugar.

$$C_6H_{12}O_6 \xrightarrow{\text{Conc. } H_2SO_4} 6\,C + 6\,H_2O$$

Glucose — Black

ii. **Phosphorous:** It reacts with H_2SO_4 to give orthophosphoric acid.

$$10\,H_2SO_4 + P_4 \longrightarrow 4H_3PO_4 + 10\,SO_2\uparrow + 4\,H_2O$$

Ortho phosphoric acid

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iii. **Copper:** When conc. H_2SO_4 is reacted with copper turning then SO_2 gas is formed. H_2SO_4 oxidizes copper turning into copper sulphate and reduces itself to SO_2.

$Cu + \text{conc. } 2H_2SO_4 \longrightarrow CuSO_4 + SO_2\uparrow + 2H_2O$

Important uses of Conc. H_2SO_4:

i. It is used in storage batteries.
ii. It is used for refining petroleum.
iii. It is used for the manufacture of dyes, drugs, explosives etc.
iv. It is used for the manufacture of nitrocellulose product like cotton, wool, linen, rayon, rubber and lacquers.

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37. **2072 Set C Q.No. 30 How is pure sulphur dioxide prepared in the laboratory? How does sulphur dioxide react with:** **[4+3+3]**

i. **acidified $KMnO_4$**
ii. **$Fe_2(SO_4)_3$**
iii. **HI**

How is bleaching action of SO_2 differed from Cl_2?

Laboratory preparation of SO_2 gas: Please refer to 2076 Set B Q No. 28

Reaction of SO_2 with

i. **Acidified $KMnO_4$:** When SO_2 gas is passed through acidified solution of $KMnO_4$, the pink colour of $KMnO_4$ is discharged.

$2KMnO_4 + 3H_2SO_4 \longrightarrow K_2SO_4 + 2MnSO_4 + 3H_2O + 5[O]$
$5SO_2 + 5[O] \longrightarrow 5SO_3$
$5SO_3 + 5H_2O \longrightarrow 5H_2SO_4$

$2KMnO_4 + 5SO_2 + 2H_2O \longrightarrow K_2SO_4 + 2MnSO_4 + 2H_2SO_4$

Pink colour → colourless

ii. **$Fe_2(SO_4)_3$:** When SO_2 gas is passed through a solution of $Fe_2(SO_4)_3$, ferrous sulphate is obtained

$SO_2 + 2H_2O \longrightarrow H_2SO_4 + 2[H]$
$Fe_2(SO_4)_3 + 2[H] \longrightarrow 2FeSO_4 + H_2SO_4$

$Fe_2(SO_4)_3 + SO_2 + 2H_2O \longrightarrow 2FeSO_4 + 2H_2SO_4$

Ferric sulphate → Ferrous sulphate

iii. **HI:** Sulphur dioxide oxidises hydrogen iodide to iodine.

$4HI + SO_2 \xrightarrow[\Delta]{} 2H_2O + S + I_2$

Iodine

Bleaching action of SO_2 differed from Cl_2: Please refer to 2053 Q.No. 5 Group B

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38. **2072 Set D Q.No. 30 How is pure sulphur dioxide prepared in the laboratory? Give its action on:** **[4+3+3]**

i. **acidified $KMnO_4$.** ii. **$Fe_2(SO_4)_3$**
iii. **HI.**

How is bleaching action of SO_2 differs from Cl_2?

Please refer to 2072 Set C Q No. 30

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39. **2072 Set E Q.No. 30 Describe laboratory method of preparation of hydrogen sulphide. What is the action of H_2S on (i) acidified $K_2Cr_2O_7$ (ii) $FeCl_3$? Write the application of H_2S in salt analysis.** **[4+4+2]**

Laboratory method of preparation of H_2S gas: Please refer to 2066 Q No. 27

i. **Action of H_2S on acidified $K_2Cr_2O_7$:** When H_2S gas is passed through the acidified solution of $K_2Cr_2O_7$ then orange colour of $K_2Cr_2O_7$ is changed into green. Here H_2S acts as reducing agent which reduces acidified solution of $K_2Cr_2O_7$.

$K_2Cr_2O_7 + 4H_2SO_4 \longrightarrow K_2SO_4 + Cr_2(SO_4)_3 + 4H_2O + 3[O]$
$[H_2S + [O] \longrightarrow H_2O + S] \times 3$

$K_2Cr_2O_7 + 4H_2SO_4 + 3H_2S \longrightarrow K_2SO_4 + Cr_2(SO_4)_3 + 7H_2O + 3S$

Orange → green

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ii. **Action of H_2S on $FeCl_3$:** When H_2S gas is passed through ferric chloride solution, then it is reduced to ferrous chloride.

$$2FeCl_3 + H_2S \longrightarrow 2FeCl_2 + 2HCl + S$$

Ferric chloride → Ferrous chloride

Application of H_2S in salt analysis: When H_2S gas is passed through the solution of group (II) metal salts in acidic medium then characteristic coloured ppt. is obtained. These coloured ppt. shows the presence of metal ions in given salts.

$$Hg^{++} + H_2S \longrightarrow HgS\downarrow + 2H^+$$

Black ppt.

$$Cu^{++} + H_2S \longrightarrow CuS\downarrow + 2H^+$$

Black ppt.

$$Pb^{++} + H_2S \longrightarrow PbS\downarrow + 2H^+$$

Black ppt.

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40. 2071 Supp Q. No. 31 **Discuss the principle involved in the manufacture of sulphuric acid by Contact process with a neat and self explanatory diagram. How would you show that sulphuric acid acts as:** **[6+2+2]**
a. an acid **b. a dehydrating agent?**

Manufacture of sulphuric acid: Please refer to 2059 Q.No. 27

Sulphuric acid acts as:

a. **An acid:** It reacts with base to form salt and water.

$$H_2SO_4 + 2NaOH \longrightarrow Na_2SO_4 + 2H_2O$$

Acid base → Salt

b. **A dehydrating agent:** It removes water molecule from sugar molecule when few drops of acid is added to sugar.

$$C_{12}H_{22}O_{11} + H_2SO_4\,(conc.) \longrightarrow 12C + [H_2SO_4.11H_2O]$$

Sugar → Black

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41. 2071 (Set C) Q.No. 31 **Describe the principle and stepwise procedure for the manufacture of sulphuric acid by Contact process giving a self explanatory sketch. Why is it called contact process? Write the action of conc. H_2SO_4 with (i) phosphorous (ii) oxalic acid. How would you dilute conc. sulphuric acid?** **[6+1+2+1]**

Manufacture of sulphuric acid: Please refer to 2059 Q.No. 27

In the manufacture of sulphuric acid, oxidation of SO_2 gas to SO_3 gas is carried out in contact with surface of catalyst, so the process is called **Contact process.**

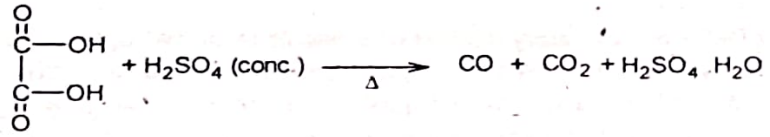
Action of conc. H_2SO_4 with:

i. **Phosphorous:** It reacts with H_2SO_4 to give orthophosphoric acid.

$$10\,H_2SO_4 + P_4 \longrightarrow 4H_3PO_4 + 10\,SO_2\uparrow + 4\,H_2O$$

Ortho phosphoric acid

ii. **Oxalic acid:** When white crystalline oxalic acid crystals are heated with conc. H_2SO_4, one molecule of H_2O is absorbed by it from one molecule of oxalic acid and mixture of carbon monoxide and carbon dioxide is formed.



Oxalic acid

Dilution of conc. H_2SO_4: In order to dilute an acid, pour acid into water in small amounts and stir constantly. Water is not added to acid, since it is an exothermic process and in this process extensive heat is produced which may cause splashing of acidic solutions, also the container may break and can be fatal to the person.

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2071 (Set D) Q.No. 30 **Draw a self explanatory sketch for the manufacture of sulphuric acid by Contact process and explain the principle and procedure involved in it.**
Why is it called contact process? How does conc. H_2SO_4 react with (i) sugar (ii) copper. Write down the test reaction of sulphate ion in its aqueous solution? **[6+1+2+1]**

Manufacture of sulphuric acid: Please refer to 2059 Q No. 27

In the manufacture of sulphuric acid, oxidation of SO_2 gas to SO_3 gas is carried out in contact with surface of catalyst, so the process is called **Contact process.**

Action of conc. H_2SO_4 With:

Sugar: Conc. H_2SO_4 removes water molecules from sugar molecules when few drops of acid is added to sugar. This is known as dehydration of sugar.

$$\underset{\text{Sugar}}{C_{12}H_{22}O_{11}} + H_2SO_4(\text{conc.}) \longrightarrow \underset{\text{Black}}{12\,C} + [H_2SO_4.11H_2O]$$

Copper: When conc. H_2SO_4 is reacted with copper turning then SO_2 gas is formed. H_2SO_4 oxidizes copper turning into copper sulphate and reduces itself to SO_2.

$$Cu + \text{conc. } 2H_2SO_4 \longrightarrow CuSO_4 + SO_2\uparrow + 2H_2O$$

Test of Sulphate (SO_4^{--}) ion:

About 1 mL of salt containing sulphate ion (SO_4^{--}) is taken in clean and dry test tube and 2 – 3 drops of $BaCl_2$ solution is added to the test tube. A white ppt. is obtained which does not dissolve in dil. HCl. This indicates the presence of sulphate ion i.e. SO_4^{--}

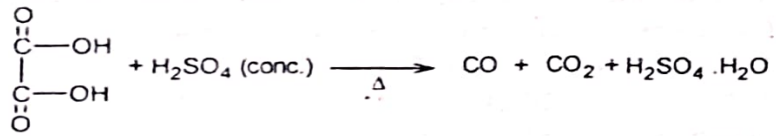
$$SO_4^{--} + BaCl_2 \longrightarrow \underset{\text{White ppt.}}{BaSO_4\downarrow} + 2Cl^-$$

2070 Supp. Q.No. 30 **Sketch a well labeled diagram for the manufacture of sulphuric acid by Contact process. Write physical and chemical principles involved in it. What is the action of conc. H_2SO_4 on;**
i. Oxalic acid ii. Phosphorous iii. $BaCl_2$ solution.
Why does H_2SO_4 always act as an oxidising agent but not reducing agent? **[3+6+1]**

Manufacture of sulphuric acid: Please refer to 2059 Q No. 27

Action of Conc. H_2SO_4 on:

Oxalic acid: When white crystalline oxalic acid crystals are heated with conc. H_2SO_4, one molecule of H_2O is absorbed by it from one molecule of oxalic acid and mixture of carbon monoxide and carbon dioxide is formed.



Oxalic acid

Phosphorous: It reacts with H_2SO_4 to give orthophosphoric acid.

$$10\,H_2SO_4 + P_4 \longrightarrow \underset{\text{Ortho phosphoric acid}}{4H_3PO_4} + 10\,SO_2\uparrow + 4\,H_2O$$

$BaCl_2$ solution: When $BaCl_2$ solution is added to a conc. Solution of H_2SO_4, a white ppt. of barium sulphate is formed which is insoluble is mineral acids.

$$H_2SO_4 + BaCl_2 \longrightarrow \underset{\text{White ppt.}}{BaSO_4\downarrow} + 2HCl$$

Conc. H_2SO_4 act as a precipitating agent:

Conc. Sulphuric acid (H_2SO_4) acts as a dibasic acid because it has two replaceable H-atoms in its molecules. So, it is a powerful oxidizing agent. It oxidizes carbon to CO_2, S to SO_2, I_2 to iodic acid and P to phosphoric acid.

$$C + 2\,H_2SO_4 \longrightarrow CO_2\uparrow + 2\,H_2O + 2\,SO_2\uparrow$$
$$S + 2\,H_2SO_4 \longrightarrow 2\,H_2O + 3\,SO_2\uparrow$$
$$I_2 + 5\,H_2SO_4 \longrightarrow 2\,HIO_3 + 4\,H_2O + 5\,SO_2\uparrow$$
$$P_2 + 5\,H_2SO_4 \longrightarrow 2\,H_3PO_4 + 2\,H_2O + 5\,SO_2\uparrow$$

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44. 2070 Set D Q.No. 31 Starting from iron-pyrites, how would you obtain dilute sulphuric acid by Contact process? Explain with a lablled diagram. Give the action of Conc. H_2SO_4 on (a) sucrose (b) HI. What is the test of sulphate ion? [7+1+1+1]

Manufacture of sulphuric acid: Please refer to 2059 Q.No. 27

a. Action of Conc. H_2SO_4 on:

Sucrose: Conc. H_2SO_4 removes water molecules from sugar or sucrose molecules when few drops of acid is added to sugar. This is known as dehydration of sugar or sucrose.

$$C_{12}H_{22}O_{11} + H_2SO_4(conc.) \longrightarrow 12\,C + [H_2SO_4.11H_2O]$$

Sucrose → Black

b. HI: Conc. H_2SO_4 oxidizes HI into iodine.

$$H_2SO_4 + 2HI \longrightarrow 2H_2O + SO_2 + I_2$$

Iodine

Test of Sulphate (SO_4^{--}) ion:

About 1 mL of salt containing sulphate ion (SO_4^{--}) is taken in clean and dry test tube and 2 – 3 drops of $BaCl_2$ solution is added to the test tube. A white ppt. is obtained which does not dissolve in dil. HCl. This indicates the presence of sulphate ion i.e. SO_4^{--}

$$SO_4^{--} + BaCl_2 \longrightarrow BaSO_4\downarrow + 2Cl^-$$

White ppt.

45. 2069 (Set B) Q. No. 32a

a. Write balanced chemical equation for the preparation of hydrogen sulphide at laboratory and explain with a labelled diagram how Kipp's apparatus works to supply H_2S gas during salt analysis.

b. Give a chemical reaction to show:

i. Conc.H_2SO_4 acts as dehydrating agent

ii. SO_2 acts as bleaching agent.

iii. H_2S as an analytical agent. [1+4+1+2+2]

a. Chemical equation for the preparation of H_2S gas: Please refer to 2074 Set A Q.No. 28

Kipp's apparatus works to supply H_2S gas in salt analysis: Please refer to 2074 Set A Q.No. 28

b.

i. Conc. H_2SO_4 acts as dehydrating agent: Conc. H_2SO_4 removes water molecules from sugar molecules when few drops of acid is added to sugar. This is known as dehydration of sugar.

$$C_{12}H_{22}O_{11} + H_2SO_4(conc.) \longrightarrow 12\,C + [H_2SO_4.11H_2O]$$

Sugar → Black

Test for sulphate ion(SO_4^{--}): About 1 mL of salt containing sulphate ion (SO_4^{--}) is taken in clean and dry test tube and 2 – 3 drops of $BaCl_2$ solution is added to the test tube. A white ppt. is obtained which does not dissolve in dil. HCl. This indicates the presence of sulphate ion i.e. SO_4^{--}

$$SO_4^{--} + BaCl_2 \longrightarrow BaSO_4\downarrow + 2Cl^-$$

White ppt.

ii. SO_2 acts as bleaching agent: SO_2 has the property of bleaching of most coloured substance. In presence of water it forms H_2SO_3.

$$SO_2 + H_2O \longrightarrow H_2SO_3$$

This H_2SO_3 reduces the coloured substance to colourless substance.

Thus, SO_2 bleaches colour by the process of reduction. The substance bleached by SO_2 regains its colour due to oxidation by atmospheric oxygen.

Colourless substance $\xrightarrow{air}$ colour substance

iii. H_2S as an analytical agent: H_2S gas is used as analytical agent to detect group (II) ions in acidic medium i.e. dil. HCl and group (IIIB) ions in alkaline medium i.e.NH_4Cl and NH_4OH.

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In acidic medium: When H_2S gas is passed through the solution of group (II) metal salts in acidic medium then characteristic coloured ppt. is obtained. These coloured ppt. shows the presence of metal ions in given salts.

$Hg^{++} + H_2S \longrightarrow HgS \downarrow + 2H^+$
Black ppt.

$Cu^{++} + H_2S \longrightarrow CuS \downarrow + 2H^+$
Black ppt.

$Pb^{++} + H_2S \longrightarrow PbS \downarrow + 2H^+$
Black ppt.

In alkaline medium: When H_2S gas is passed through group (IIIB) metal salts in alkaline medium i.e. NH_4Cl and NH_4OH then characteristic coloured ppt. is obtained which show the presence of metal ions.

$Zn^{++} + H_2S \longrightarrow ZnS \downarrow + 2H^+$
White ppt.

$Mn^{++} + H_2S \longrightarrow MnS \downarrow + 2H^+$
Pink ppt.

$Co^{++} + H_2S \longrightarrow CoS \downarrow + 2H^+$
black ppt.

2067 Q.No. 31 Starting from Iron pyrites, how would you obtain Sulphuric acid? Draw a self explanatory sketch for it. How does conc. Sulphuric acid react. with (i) Phosphorous, (ii) Sugar. Why is SO_3 not directly absorbed by water? Write molecular formula of hypo. [3+3+1+1+1+1= 10]

Manufacture of sulphuric acid: Please refer to 2059 Q.No. 27

Reaction of H_2SO_4 with

Phosphorous: It reacts with H_2SO_4 to give orthophosphoric acid.

$10\,H_2SO_4 + P_4 \longrightarrow 4H_3PO_4 + 10\,SO_2\uparrow + 4\,H_2O$
Ortho phosphoric acid

Sugar: Conc. H_2SO_4 removes water molecules from sugar molecules when few drops of acid is added to sugar. This is known as dehydration of sugar.

$C_{12}H_{22}O_{11} + H_2SO_4(conc.) \longrightarrow 12\,C + [H_2SO_4.11H_2O]$
Sugar Black

Absorption of SO_3: SO_3 gas is not directly absorbed by water because the reaction is exothermic and produces large amount of heat. Heat causes the formation of a dense fog that are not condensed easily.

Molecular formula of hypo: $Na_2S_2O_3.5H_2O$ (Sodium thiosulphate).

2063 Q.No. 32 Write the principle involved along with a self-explanatory diagram for the manufacture of sulphuric acid by Contact process. Give two reactions each to show that concentrated sulphuric acid is a: (a) Dehydrating agent (b) Oxidising agent [8+1+1]

Manufacture of sulphuric acid: Please refer to 2059 Q.No. 27

As a dehydrating agent: Conc. H_2SO_4 removes water molecules from sugar molecules when few drops of acid is added to sugar. This is known as dehydration of sugar.

$C_{12}H_{22}O_{11} + H_2SO_4(conc.) \longrightarrow 12\,C + [H_2SO_4.11H_2O]$
Sugar Black

Test for sulphate ion(SO_4^{--}): About 1 mL of salt containing sulphate ion (SO_4^{--}) is taken in clean and dry test tube and 2 – 3 drops of $BaCl_2$ solution is added to the test tube. A white ppt. is obtained which does not dissolve in dil. HCl. This indicates the presence of sulphate ion i.e. SO_4^{--}

$SO_4^{--} + BaCl_2 \longrightarrow BaSO_4 \downarrow + 2Cl^-$
White ppt.

b. An oxidizing agent: When conc. H_2SO_4 is reacted with copper turning then SO_2 gas is formed. H_2SO_4 oxidizes copper turning into copper sulphate and reduces itself to SO_2.

$$Cu + \text{conc. } 2H_2SO_4 \longrightarrow CuSO_4 + SO_2\uparrow + 2H_2O$$

---

48. 2062 Q.No. 31 Describe the principle and process for the manufacture of Sulphuric acid with a lebelled diagram by contact method. Why is concentrated acid diluted by adding acid into water but not water into acid? What happens when [7+1+1+1]

a. Copper turning is heated with conc. H_2SO_4.

b. Cane sugar is heated with conc. H_2SO_4.

Manufacture of sulphuric acid: Please refer to 2059 Q.No. 27

Dilution of conc. H_2SO_4: In order to dilute an acid, pour acid into water in small amounts and stir constantly. Water is not added to acid, since it is an exothermic process and in this process extensive heat is produced which may cause splashing of acidic solutions, also the container may break and can be fatal to the person.

a. When conc. H_2SO_4 is reacted with copper turning then SO_2 gas is formed. H_2SO_4 oxidizes copper turning into copper sulphate and reduces itself to SO_2.

$$Cu + \text{conc. } 2H_2SO_4 \longrightarrow CuSO_4 + SO_2\uparrow + 2H_2O$$

b. When conc. H_2SO_4 is dropped over sugars, they turn black due to their dehydration to black particles of carbon. This is called charring of sugars.

$$C_{12}H_{22}O_{11} + H_2SO_4(\text{conc.}) \longrightarrow 12\,C + [H_2SO_4.11H_2O]$$

Sugar — black

---

49. 2060 Q.No. 32

i. How is pure hydrogen sulphide gas prepared from commercial ferrous sulphide in the laboratory?

ii. Write the action of the gas on (a) Lead acetate paper (b) Silver powder (c) acidified potassium dichromate solution.

iii. How is the gas used in qualitative analysis? [5+3+2]

i. Laboratory preparation of hydrogen sulphide gas (H_2S): Please refer to 2066 Q.No. 27

ii. Action of H_2S gas on:

a. Lead acetate paper: Hydrogen sulphide gas (H_2S) is an acidic gas. When H_2S gas is bubbled in a solution of lead acetate, the solution turns black due to its conversion to black lead sulphide.

$$Pb(CH_3COO)_2 + H_2S \longrightarrow PbS\downarrow + 2\,CH_3COOH$$

Lead acetate — Black ppt. — Acetic acid

b. Silver powder: Hydrogen sulphide gas is treated with silver powder, silver lose its lusture property due to the formation of black layer of silver sulphide.

$$4Ag + 2H_2S + O_2 \longrightarrow 2Ag_2S + 2H_2O$$

Black layer

c. Acidified potassium dichromate solution: When H_2S gas is passed through the acidified solution of $K_2Cr_2O_7$ then orange colour of $K_2Cr_2O_7$ is changed into green. Here H_2S acts as reducing agent which reduces acidified solution of $K_2Cr_2O_7$.

$$K_2Cr_2O_7 + 4H_2SO_4 \longrightarrow K_2SO_4 + Cr_2(SO_4)_3 + 4H_2O + 3[O]$$

$$[H_2S + [O] \longrightarrow H_2O + S] \times 3$$

$$K_2Cr_2O_7 + 4H_2SO_4 + 3H_2S \longrightarrow K_2SO_4 + Cr_2(SO_4)_3 + 7\,H_2O + 3S$$

Orange — green

iii. H_2S gas used in qualitative analysis: H_2S gas reduces aqueous solution of SO_2 to give sulphur.

$$2H_2S + SO_2 \xrightarrow{H_2O} 2H_2O + 3S$$

---

50. 2057 Q.No. 31 Describe the preparation of SO_2 in the laboratory. Give its action upon (i) Cl_2 water and (ii) acidified $K_2Cr_2O_7$. [6+2+2]

Laboratory preparation of SO_2 gas: Please refer to 2076 Set B Q.No. 28

Action of SO_2 upon Cl_2 water: When SO_2 gas is bubbled in a suspension of a chlorine in water, SO_2 is oxidized to H_2SO_4 and the chlorine is reduced to the HCl.

$$H_2O + Cl_2 \longrightarrow HCl + HClO$$
$$HClO \longrightarrow HCl + [O]$$
$$SO_2 + [O] \longrightarrow SO_3$$
$$SO_3 + H_2O \longrightarrow H_2SO_4$$
$$SO_2 + 2H_2O + Cl_2 \longrightarrow 2HCl + H_2SO_4$$

ii. **Action of SO_2 upon acidified $K_2Cr_2O_7$:** When SO_2 gas is passed through in an orange acidified solution of $K_2Cr_2O_7$, the colour of the solution turns green due to its conversion to $Cr_2(SO_4)_3$ which is green.

$$K_2Cr_2O_7 + 4H_2SO_4 \longrightarrow K_2SO_4 + Cr_2(SO_4)_3 + 4H_2O + 3[O]$$
$$3SO_2 + 3[O] \longrightarrow 3SO_3$$
$$3SO_3 + 3H_2O \longrightarrow 3H_2SO_4$$
$$K_2Cr_2O_7 + 3SO_2 \longrightarrow H_2SO_4 + K_2SO_4 + Cr_2(SO_4)_3 + H_2O$$

Orange → Green

WRITE ON SHORT NOTES

31. 2053 Q.No. 4a Group C 2055 Q.No. 31a **Uses of H_2S as analytical reagent.**

Hydrogen sulphide is used in a laboratory for the separation of metal ions in groups during salt analysis.

Metals ions such as Cu^{+2}, Pb^{+2}, Cd^{+2}, Bi^{+2}, Hg^{+2},Sn^{+2}, Sn^{+4}, As^{+3}, As^{+5}, Sb^{+3}, Sb^{+5} are placed in group II because their sulphides are insoluble in dil. HCl medium.

Metals ions such as Co^{+2}, Ni^{+2}, Mn^{+2} and Zn^{+2} are placed in group IIIB of the salt analysis table because their sulphides do not precipitate out in HCl medium but they precipitate out in ammoniacal medium in presence of NH_4OH and NH_4Cl.

Hydrogen sulphide (H_2S) gas is used as analytical agent to detect group (II) ions in acidic medium i.e. dil. HCl and group (IIIB) ions in alkaline medium i.e.NH_4Cl and NH_4OH.

In acidic medium: When H_2S gas is passed through the solution of group (II) metal salts in acidic medium then characteristic coloured ppt. is obtained. These coloured ppt. shows the presence of metal ions in given salts.

$Hg^{++} + H_2S \longrightarrow HgS\downarrow + 2H^+$ Black ppt.

$Cu^{++} + H_2S \longrightarrow CuS\downarrow + 2H^+$ Black ppt.

$Pb^{++} + H_2S \longrightarrow PbS\downarrow + 2H^+$ Black ppt.

$Ca^{++} + H_2S \longrightarrow CaS\downarrow + 2H^+$ yellow ppt.

$Sn^{++} + H_2S \longrightarrow SnS\downarrow + 2H^+$ Brown ppt.

$Sn^{4+} + 2H_2S \longrightarrow SnS_2\downarrow + 4H^+$ Dirty yellow ppt.

$2Sb^{+++} + 3H_2S \longrightarrow Sb_2S_3\downarrow + 6H^+$ Orange ppt.

In alkaline medium: When H_2S gas is passed through group (IIIB) metal salts in alkaline medium i.e. NH_4Cl and NH_4OH then characteristic coloured ppt. is obtained which show the presence of metal ions.

$Zn^{++} + H_2S \longrightarrow ZnS\downarrow + 2H^+$ White ppt.

$Mn^{++} + H_2S \longrightarrow MnS\downarrow + 2H^+$ Pink ppt.

$Co^{++} + H_2S \longrightarrow CoS\downarrow + 2H^+$ black ppt.

$Ni^{++} + H_2S \longrightarrow NiS\downarrow + 2H^+$ black ppt.

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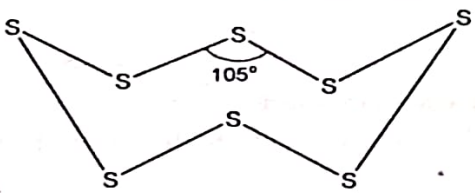
52. 2053 Q.No. 4b Group C 2055 Q.No. 31b **Allotropic forms of sulphur.**

The different forms of the same element having same chemical properties but different physical properties are called allotrops. Sulphur exists in two different allotropic forms (i) Crystalline allotrops (ii) Amorphous allotrops

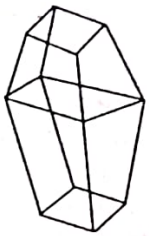
Crystalline allotrops: There are two crystalline allotrops (a) Rhombic or octahedral or alpha sulphur (b) Monoclinic sulphur or prismatic or beta sulphur

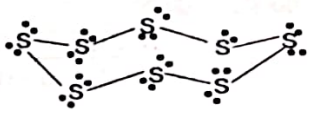
Rhombic or octahedral or alpha (α) sulphur: Following are important properties

i. It is most stable allotrops below 96°c.
ii. It occurs in octahedral form.
iii. It has pale yellow color.
iv. It's m.p. is 112.8°c and b.p. is 445°c.
v. It is bad conductor of heat and electricity.
vi. It has a puckered ring structure of 8 S-atom bonded by single covalent bond.
vii. It is insoluble in water but soluble in CS_2.



Puckered ring structure of α - sulphur

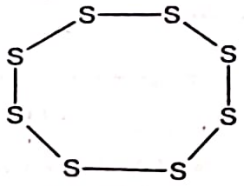




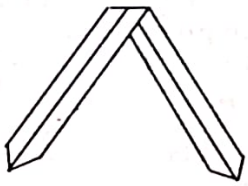
Ring structure

Monoclinic sulphur or prismatic or beta (β) sulphur: Following are important properties

i. It is stable allotropes of sulphur above 96°C.
ii. It occurs in long needle like prism.
iii. It's m.p. is 119°C.
iv. It is insoluble in water but soluble in CS_2.
v. It has a puckered ring structure of 8 S-atom bonded by single covalent bond.



β- sulphur


Monoclinic sulphur

Amorphous allotrops: There ate two forms (a) Plastic sulphur or gama sulphur (b) Milk of sulphur

Plastic sulphur or gama (γ) sulphur: Following are the important properties:

It is unstable forms and on standing at room temp. changes into stable α sulphur.

i. It is super cooled liquid.
ii. It is insoluble in water and CS_2.
iii. It is dark brown mass.
iv. It's density is 1.92 g/mL.

Milk of Sulphur: Following are the important properties

It is also unstable form and on standing at room temp. changes into α sulphur.

i. It is white color mass.
ii. It is insoluble in water and CS_2.
iii. Its density is 1.82 g/mL.

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11.5 Boron and Silicon

VERY SHORT ANSWER QUESTIONS

1. **2076 Set B Q.No. 16** Write down the molecular formula and one use of each of the following: [4×0.5]
   i. Boric acid ii. Borax
   iii. Silica gel iv. Sodium silicate.

   Ans:
   i. **Boric acid:** Formula: H_3BO_3. It is used to prepare borax powder, pigment, pottery glazes, enamels and preservatives for food.
   ii. **Borax:** Formula: $Na_2B_4O_7.10H_2O$. It is used in the manufacture of enamels and glazes for earthen wares.
   iii. **Silica gel:** Formula: $SiO_2.H_2O$. It is used for absorbing moisture and as an absorbent in chromatography.
   iv. **Sodium silicate.** Formula: Na_2SiO_3. It is used for making glass.

2. **2076 Set C Q.No. 16** Write down the molecular formulae and an important use of each of the following: [4×0.5]
   i. Boric acid ii. Borax
   iii. Silica gel iv. Calcium silicate

   Ans:
   i. **Boric acid:** Formula: H_3BO_3. It is used to prepare borax powder, pigment, pottery glazes, enamels and preservatives for food.
   ii. **Borax:** Formula: $Na_2B_4O_7.10H_2O$. It is used in the manufacture of enamels and glazes for earthen wares.
   iii. **Silica gel:** Formula: $SiO_2.H_2O$. It is used for absorbing moisture and as an absorbent in chromatography.
   iv. **Calcium silicate.** Formula: $CaSiO_3$. It is used in roads insulation, bricks root tiles, tables and occurs in cements.

3. **2075 GIE Q.No. 16** Mention one use of each of the following: [4×0.5]
   i. Silica gel ii. Carborundum
   iii. Silica garden iv. Fullerene

   Ans:
   i. **Silica gel:** It is used as an absorbent in chromatography.
   ii. **Carborundum:** It is used as abrasive.
   iii. **Silica garden:** It is used to make magic rocks.
   iv. **Fullerene:** It is used to store hydrogen.

4. **2074 Set A Q.No. 16** Write down the molecular formula and use of each of the following; [1+1]
   i. Boric acid
   ii. Orthophosphoric acid

   Ans:
   i. **Boric acid:** H_3BO_3. It is used to prepare borax powder, pigment, pottery glazes, enamels and preservative for food.
   ii. **Orthophosphoric acid:** H_3PO_4. It is used to make phosphate salts for fertilizers. It is also used in dental cements, in the preparation of albumin derivatives, and in the sugar and textile industries.

5. **2072 Set D Q.No. 16** Give one important application of each of the following: [4×0.5]
   i. Silica gel ii. Carborundum
   iii. Sodium Silicate iv. Borax

   Ans:
   i. It is used for absorbing moisture and as an absorbent in chromatography.
   ii. It is the crystals of silicon carbide and used as abrasive.
   iii. It is used for making glass.
   iv. It is used in the manufacture of enamels and glazes for earthen wares.

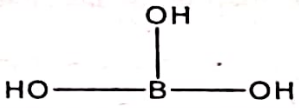
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6. 2070 Supp. Q.No. 15 **Write the molecular formula of** [2×0.5=1]
   i Borax
   ii. Silica gel

i. Borax: $Na_2B_4O_7.10H_2O$
ii. Silica gel: $SiO_2.H_2O$

7. 2070 Set C Q.No. 22 **Write the formulae and uses of borax and boric acid.** [1+1]

Borax: $Na_2B_4O_7.10H_2O$ .It is used to detect basic radicals.
Boric acid: H_3BO_3 it is used to prepare borax power, pigment, pottery glazes, enamels and preservative for food.



8. 2070 Set D Q.No. 15c **Write the molecular formula of borax** [0.5]

Borax: $Na_2B_4O_7.10H_2O$ .It is used to detect basic radicals.

9. 2070 Set D Q.No. 15d **Write the molecular formula of silica gel.** [0.5]

Silica gel: $SiO_2.H_2O$

10. 2069 (Set B) Q. No. 16a **Write molecular formulae of the followings: Borax** [0.5]

Borax: $Na_2B_4O_7.10H_2O$ .It is used to detect basic radicals.

11. 2065 Q. No. 16 a **Give an important uses of each of the following: Boron** [1]

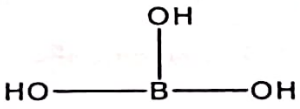
Boron: It is used as moderator in nuclear reactions.

12. 2065 Q. No. 16 c **Give an important uses of each of the following: Silicon** [1]

Silicon: It is used for making semiconductor for transistors and solar cells.

13. 2060 Q.No. 13 **Write the formula of Borax and boric acid.** [2]

Borax: $Na_2B_4O_7.10H_2O$ .It is used to detect basic radicals.
Boric acid: H_3BO_3 it is used to prepare borax power, pigment, pottery glazes, enamels and preservative for food.



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11.6 Noble Gas: Position in Periodic Table, Occurrence and Uses

VERY SHORT ANSWER QUESTIONS

1. **2071 Supp Q. No. 15 2051 Q.No. 12 Group A Why are noble gases chemically inert?** [2]

Ans Noble gases are chemically inert because their octet are already completed i.e. duplet or octet. Electronic configuration of an element are given as:

$He = \underline{1s^2}$

$Ne_{10} = 1s^2\underline{2s^2 2p^6}$

$Ar_{18} = 1s^2 2s^2 2p^6 \underline{3s^2 3p^6}$

2. **2065 Q. No. 16 b Give an important uses of noble gases** [0.5]

Ans Argon is an inert gas which is used in electric bulb and Radon is an inert gas which is used in radiography for cancer.

3. **2063 Q.No. 14 What are noble gases? Write any one use of noble gases.** [2]

Ans The elements which are present in zero group or 18 group of Modern periodic table is known as noble gases. They are very less reactive at normal temperature and pressure.

Use: Argon is inert gas which is used in electric bulb.

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11.7 Environmental Pollution

VERY SHORT ANSWER QUESTIONS

1. 2075 Set B Q.No. 16 **Name the chemicals which are responsible for acid rain. What is the harmful effect of acid rain?** [1+1]

Large amount of oxides of nitrogen and sulphur are evolved into the atmosphere from the industries, automobiles, oil refiners etc. which dissolve in rain water to give different acids like H_2SO_4, H_2SO_3, HNO_3 etc are called acid rain.

Example:

$2SO_2 + O_2 \longrightarrow 2SO_3$

$SO_3 + H_2O \longrightarrow H_2SO_4$

$N_2 + O_2 \xrightarrow{\text{Lightening}} 2NO$

$2NO + O_2 \xrightarrow{\text{Oxidation}} 2NO_2$

$3NO_2 + H_2O \longrightarrow 2HNO_3 + NO$

Effects of acid rain: Acid rain kills the aquatic animals and cause low crops production and damage some valuable things.

2. 2073 Supp Q.No. 16 **Mention a major effect of each of the followings:** [4×0.5]

i. Acid rain ii. Green house effect

iii. Photochemical smog iv. Water pollution

Following are the major effect of:

i. **Acid rain:** It increases the acidity of soil and decreases the fertility of soil.

ii. **Green house effect:** It causes the global warming and may cause the melting of polar ice caps and increasing the sea level leading to coastal flooding.

iii. **Photochemical smog:** It reduces the visibility on the road and causes the numerous accidents.

iv. **Water pollution:** It causes the aquatic animals and aquatic plants.

3. 2073 Set C Q. No. 16 **How is SO_2 responsible for acid rain?**

The sulphur dioxide gas (SO_2) is produced from automobiles or industries which is dissolved in rain water to give acid like H_2SO_4. This acid is responsible for acid rain.

$2SO_2 + O_2 \longrightarrow 2SO_3$

$SO_3 + H_2O \longrightarrow H_2SO_4$

4. 2073 Set D Q. No. 16 **How is SO_2 responsible for acid rain?** [2]

Please refer to 2073 Set C Q. No. 16

5. 2072 Supp Q. No. 15 **Name the major gas for each which are responsible for:** [4×0.5]

i. Green house effect ii. Photo chemical smog

iii. Acid rain iv. Air pollution

i. Green house effect: CO_2 gas

ii. Photo chemical smog: NO, NO_2, CO, hydrocarbon

iii. Acid rain: SO_2, NO_2

iv. Air pollution: CO, CO_2, NO_2, SO_2

6. 2072 Set C Q.No. 16 **What is meant by photochemical smog?** [2]

Photochemical smog: The smog which is formed by the reaction of automobile exhaust in the presence of sunlight is called photochemical smog. Nitric oxide (NO) and nitrogen dioxide (NO_2) are two gases present in photochemical smog.

7. 2072 Set E Q.No. 16 **Oxides of sulphur and nitrogen are responsible for acid rain. Give reason.** [2]

Please refer to 2075 Set B Q No. 16

8. 2071 (Set C) Q.No. 15 **What is meant by photochemical smog? Name any two gases present in it.** [1+1]

Please refer to 2072 Set C Q.No. 16

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10. 2071 (Set D) Q.No. 15 **Name any two gaseous compounds of each which are responsible for:** [1+1]
   a. **Photochemical smog**
   b. **Green house effect**

Ans
a. Nitric oxide (NO) and nitrogen dioxide (NO_2) are two gases which are responsible for photochemical smog.
b. Water vapour and carbondioxide (CO_2) are two gases which are responsible for green house effect.

12. 2070 Set D Q.No. 16 **How is acid rain formed?** [2]

Ans Please refer to 2075 Set B Q.No. 16

11. 2069 (Set B) Q. No. 15 **What are the major components of photochemical smog? Write its effect.** [1+1]

Ans The major components of photochemical smog are the oxides of nitrogen, sulphur, carbon, hydrogen like NO, NO_2, SO_2, N_2O, CO, H_2O_2 etc.
Effect:
The NO_2 gas causes eye and nose irritation.
Photochemical smog cause headache in human beings

12. 2068 Q.No. 16 **What is meant by acid rain? Give one major effect of acid rain.** [1+1]

Ans Please refer to 2075 Set B Q.No. 16

13. 2060 Q.No. 12 **Name any one pollutant of photochemical smog and state one of its effects.** [2]

Ans The major component of photochemical smog is nitrogen dioxide i.e. NO_2 which cause irritation in eyes and nose.

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Unit 12

Metal and Metallurgical Principles

VERY SHORT ANSWER QUESTIONS [2 MARKS]

1. 2076 Set B Q.No. 17 **Distinguish between alloys and amalgams giving an example of each.** [1+1]

Following are the difference between alloys and amalgams

Alloys	Amalgams
1. They are homogeneous mixture of two or more metals, or metals and non-metals.	1. They are alloys containing mercury.
2. Example: Steel	2. Example: Zinc amalgam

2. 2076 Set C Q.No. 17 **Differentiate between flux and slag giving an example of each.** [1+1]

Following are distinction

Flux	Slag
1. A material which is added from outside in the ore during the process of smelting to remove gangue is called flux.	1. Slag is a light, fusible and waste material obtained during the extraction of metals by the chemical combination of gangue and flux.
2. It may be acidic or basic i.e. CaO, SiO_2	2. It is generally double salt i.e. $CaSiO_3$

3. 2075 GIE Q.No. 17 **What is meant by concentration in metallurgy? Name any two process involved in it.** [1+1]

The process of removing gangue (earthly impurities) from an ore is known as concentration or dressing of ore. The two processes that are involved as concentration of ores are Gravity separation method and Magnetic separation method.

4. 2075 Set A Q.No. 17 **Define the following terms giving a suitable example of each.** [1+1]

i. Metalloids **ii. Amalgams**

i. **Metalloids:** The elements that exhibit some properties of metals and some properties of non metals are called metalloids. Example: Boron, silicon, germanium, arsenic, antimony, tellurium, and polonium are metalloids.

ii. **Amalgams:** The alloy of mercury and one or more other metals are called amalgams. Example: Zinc amalgam (Zn-Hg), Sodium amalgam (Na-Hg) etc.

5. 2075 Set B Q.No. 17 2072 Set E Q.No. 17 **Name any four important ores which are found in different parts of Nepal.** [2]

Four important ores which are found in Nepal are:

Metal	Ore	Location
Iron	Haematite	Pulchowki, Bagmati zone, Chitwan,
Lead	Galena	Pulchowki, Lalitpur
Copper	Copper pyrite	Udaypur, Solukhumbu
Magnesium	Magnesite	Udaypur, Sagarmatha zone

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2074 Supp Q.No. 17 **Define the terms: Gangue and Slag, giving proper example of each.** **[2]**

Gangue: The unwanted earthy and silicious impurities associated with the ore is called gangue.
Example: Sand

Slag: The fusible mass which is formed by the combination of flux and infusible impurities of the concentrated ore at high temperature is known as slag. Example: $CaSiO_3$

2074 Set A Q.No. 17 **What is meant by slag? Write an example of it.** **[2]**

The fusible mass which is formed by the combination of flux and infusible impurities of the concentrated ore at high temperature is known as slag.

Example:

$$\underset{\text{Impurity}}{SiO_2} + \underset{\text{Flux}}{CaO} \longrightarrow \underset{\text{Slag}}{CaSiO_3}$$

It is important in metallurgy because it helps for removing the impurities from the concentrated ore during carbon reduction process.

2074 Set B Q.No. 17 **Define the following terms giving a suitable example of each.** **[1+1]**

i. **Gangue**
ii. **Slag**

Please refer to **2074 Supp Q.No 17**

2073 Supp Q.No. 17 **2073 Set C Q. No. 17** **2073 Set D Q. No. 17** **'Every ore is a mineral but every mineral is not ore'. Give reason.** **[2]**

The naturally occurring substance in which the metal is present in free or combined satate is called minerals. If the minerals contains sufficient quantity of metal, such that the metal can be extracted from the minerals economically and conveniently is called ores. So, every ore is mineral but every mineral is not ore.

2072 Supp Q. No. 17 **Differentiate between Pyrometallurgy and Electrometallurgy.** **[1+1]**

Following are the difference:

Pyrometallurgy	Electrometallurgy
The process of extraction of metal from an ore by chemical reduction at high temperature is called pyrometallurgy.	The process of extraction of metal from an ore by electrolytic reduction in the molten or aqueous solution is called electrometallurgy.
Example: $Fe_2O_3 + C \longrightarrow Fe + CO_2$	Example: $NaCl \xrightarrow{\text{Electricity}} Na^+ + Cl^-$ At cathode: $Na^+ + e^- \rightarrow Na$

2072 Set C Q.No. 17 **Write the basic principle of gravity separation method for concentrating an ore. What types of ores are concentrated by this method?** **[1+1]**

Basic principle of gravity for separation method for concentration of ore:
Gravity separation method is based on the difference in densities of the ore and the impurities. The heavier ore particle and lighter impurities are separated from each other.
Generally, oxide ore of metal or hydrated oxide ore is concentrated by this method. Example: Haematite (Fe_2O_3), Bauxite ($Al_2O_3.2H_2O$) etc.

2072 Set D Q.No. 17 **Write the basic principle of forth flotation method for concentrating an ore. What types of ore are concentrated by this process?** **[1+1]**

Forth flotation method is based on principle that the surface of sulphide ore is preferentially wetted with certain oils like pine oil while that of gangue is preferentially wetted with water.
Generally, sulphide ore i.e. ZnS, PbS, etc. is concentrated by froth flotation process.

2071 Supp Q. No. 17 **Define the terms Flux and Gungue.** **[1+1]**

Flux: The additional reagent which combines with infusible gangue present in the roasted or calcinated are to form a fusible mass called as slag. This additional reagent is called flux.
Gangue: The unwanted earthy and silicious impurities associated with the ore is called gangue.

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14. 2071 (Set C) Q.No. 17 Give any two formula of ores of each which are applied for the following metallurgical operations: [1+1]
a. Froth floatation b. Leaching

a. **Froth Floatation:** Copper pyrites ($CuFeS_2$) and Zinc blende (ZnS) are applied for the metallurgical operations.

b. **Leaching:** Bauxite ($Al_2O_3.2H_2O$) and Argentite (Ag_2S) are applied for metallurgical operations.

15. 2071 (Set D) Q.No. 17 What is meant by hydrometallurgy? Give an example of it. [1+1]

Hydrometallurgy: The process of extraction of metal from an ore by dissolving the ore in aq. solution of suitable chemical reagent and subsequent precipitation of the metal by other more reactive metal or precipitating reagent. Example: the silver can be extracted from silver glance by this process:

$$Ag_2S + aq.\ 4NaCN \longrightarrow \underset{\text{Sodium argentocyanide}}{2Na[Ag(CN)_2]} + Na_2S$$

$$2Na[Ag(CN)_2] + Zn \longrightarrow \underset{\text{Sodium zincocyanide}}{Na_2[Zn(CN)_4]} + 2Ag$$

16. 2070 Supp. Q.No. 17 2067 Q.No. 17 Distinguish between flux and slag, giving an example of each. [1+1]

Please refer to 2070 Set C Q No 17

17. 2070 Set C Q.No. 14 2069 (Set B) Q. No. 17 Distinguish between metal and metalloid with an example of each. [1+1]

Difference between metal and metalloid:

Metal	Metalloid
1. The elements which have fewer electron in outermost shell and having tendency to lose electrons to form +ve charge ion is called metal. These elements are kept in left side of periodic table.	1. The elements which show both the properties of metal and non-metal is called metalloid. These elements are kept in boarder line of metal and non-metal in periodic table.
2. It generally forms basic oxides.	2. It generally forms acidic oxides.
3. It is found in left side of periodic table. Example: Sodium (Na).	3. It is found at boarder line between metal and non-metal. Example: Arsenic (As)

18. 2070 Set D Q.No. 17 Write a chemical reaction involved in [2]
a. Carbon reduction process b. Alumino Thermite process.

a. **Carbon reduction process:** In this process, metal oxide is converted into metal by the reduction of carbon.

$$Fe_2O_3 + 3C \longrightarrow 4Fe + 3CO_2\uparrow$$

b. **Alumino Thermite process:** In this process, metal oxide is converted into metal by reduction of aluminium.

$$Cr_2O_3 + 2Al \xrightarrow{\Delta} 2Cr + Al_2O_3$$

19. 2069 (Set A) Q. No. 17 What are the differences between minerals and ores? Give one example of each. [1+1]

Following are the difference between minerals and ores

Ores	Minerals
1. The natural occurring substance which are used for the extraction of metal conveniently and economically are called ores	1. The natural occurring substance which contains metal and found in earth crust is known as minerals.
2. All the ore are minerals. Example: Copper pyrite ($CuFeS_2$) is ore of Copper.	2. Minerals may or may not be ore. Example: Clay is a mineral of Aluminium.

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2069 (Set B) Q. No. 17 **Distinguish between metal and metalloid with one example of each.** [1+1]

Following are difference

Metal	Metalloid
1. It is found in solid state at room temperature and having malleable and ductile properties.	1. It is found in solid state although neither malleable nor ductile properties.
2. It generally forms basic oxides.	2. It generally forms acidic oxides.
3. It is found in left side of periodic table. Example: Sodium (Na).	3. It is found at boarder line between metal and non-metal. Example: Arsenic (As)

2068 Q.No. 17 **Which process is applied for the concentration of sulphide ore and why?** [1+1=2]

For the concentration of sulphide ores i.e. ZnS, PbS etc, Froth floatation process is applied. These ores are soluble in pine oil. In this process the ores are mixed with pine oil and water in a tank and mixed with passing the blowing air where heavier particles are settle down at the bottom of the container and lighter particles i.e. sulphide ore floats as froth which is separated.

2066 Q.No. 18 **What are the main differences between Calcinations and roasting?** [1+1]

Following are distinction

Calcination	Roasting
1. It is the process of heating an ore below its melting point in the absence of air or limited supply of air in order to remove volatile impurities from the ore.	1. It is a process of heating an ore below its melting point in the presence of excess of hot air in order to oxidize it.
2. Example: $FeCO_3 \xrightarrow{\text{Calcination}} FeO + CO_2$	2. Example: $2ZnS + 3O_2 \xrightarrow{\text{Roasting}} 2ZnO + 2SO_2$

2065 Q. No. 18 **What is meant by Slag? Why is it important in metallurgy?** [2]

Please refer to **2074 Set A Q No. 17**

2063 Q.No. 17 **Define the following terms:**

I. Roasting II. Calcination [2]

Roasting: It is a process of heating an ore of metal below its melting point in the presence of excess of air in order to oxidize it. Here, metal can be changed into metal oxide and this process is use for removing moisture and volatile impurities like SiO_2, P_2O_5, As_2O_3 etc.

$2ZnS + 3O_2 \longrightarrow 2ZnO + 2SO_2 \uparrow$

$2PbS + 3O_2 \longrightarrow 2PbO + 2SO_2 \uparrow$

Calcination: The process of heating ores strongly either in limited supply of air or in the absence of air is known as calcinations. This process is used for removing moisture, volatile impurities and CO_2 from carbonates.

$CaCO_3 \xrightarrow[\Delta]{} CaO + CO_2$ (Removing CO_2)

$Al_2O_3.2H_2O \xrightarrow[\Delta]{} Al_2O_3 + 2H_2O$ (Removing moisture)

2062 Q.No. 17 **What is meant by Aluminothermite process?** [2]

The process of reducing the metal oxide into the metal by heating with aluminium metal powder at very high temperature is known as Aluminothermite process. From this method generally chromium and manganese metals are reduced. Example:

$Cr_2O_3 + 2Al \xrightarrow[\Delta]{} 2Cr + Al_2O_3$

$3MnO_2 + 4Al \xrightarrow[\Delta]{} 3Mn + 2Al_2O_3$.

2061 Q.No. 11 **2056 Q.No. 16** **2057 Q.No. 16** **Distinguish between calcination and roasting.** [2]

Please refer to **2066 Q.No. 18**

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27. 2052 Q.No. 15 Group A **Which metals can be extracted from the following ores: Galena, Cinnabar and Argentite** [1.5]

Galena(PbS) : Lead (Pb) metal
Cinnabar(HgS) : Mercury(Hg) metal
Argentite(Ag_2S): Silver(Ag) metal

28. 2051 Q.No. 13 Group A **Name the process for concentration of sulphide ore.** [2]

Froth floatation process is used for the concentration of sulphide ore.

SHORT ANSWER QUESTIONS

29. 2075 Set A Q.No. 29 **Write short notes on.** [2.5 + 2.5]
i. **Froth floatation process**
ii. **Hydrometallurgy**

i. **Froth floatation process:** This method of concentration is based on the variable wet ability of ore and gangue particles in pine oil. This method is suitable for the concentration of sulphide ore like ZnS, PbS, HgS, $CuFeS_2$ etc. The powered ore is mixed with water and pine oil in big tank. The mixture is mixed by passing compressed air. The gangue particles are wetted by water and settled down at the bottom of tank. The ore particles are wetted by pine oil and formed on the surface of liquid as froth. The froth is collected in another vessel and dried. Thus, the ore particles are concentrated by froth floatation process.

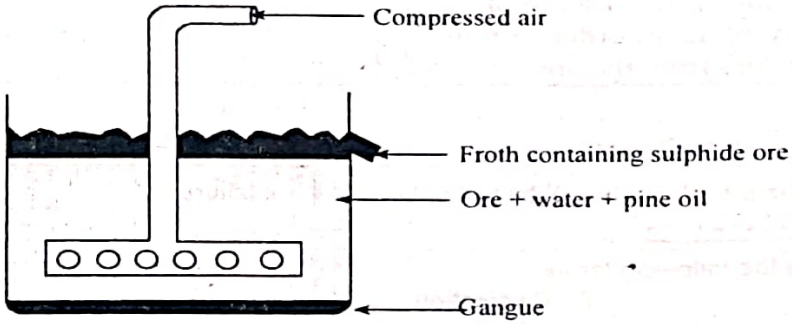


Fig : Forth floatation process

ii. **Hydrometallurgy:** The process of extraction of metal from an ore by dissolving the ore in aq. solution of suitable chemical reagent and subsequent precipitation of the metal by other more reactive metal or precipitating reagent. Example: the silver can be extracted from silver glance by this process:

$$Ag_2S + aq.\ 4NaCN \longrightarrow 2Na[Ag(CN)_2] + Na_2S$$

Sodium argentocyanide

$$2Na[Ag(CN)_2] + Zn \longrightarrow Na_2[Zn(CN)_4] + 2Ag$$

Sodium zincocyanide

30. 2074 Supp Q.No. 29 **Write short notes on:** [2.5+2.5]
i. **Carbon reduction process**
ii. **Froth floatation process.**

i. **Carbon reduction process (Smelting):** It is the process of reducing the ore into metal in presence of coke or coal at very high temperature. This process is applied for those metals which have less affinity with oxygen than for carbon. Examples are Fe, Zn, Sn, Pb, Cd, Cu etc. This process is employed because:

a. Coke or coal reduces metallic oxide to metal and CO, the CO formed in this process also reduces metallic oxide. Therefore, C as well as CO acts as reducing agent.

Coke or coal burn in air producing heat.

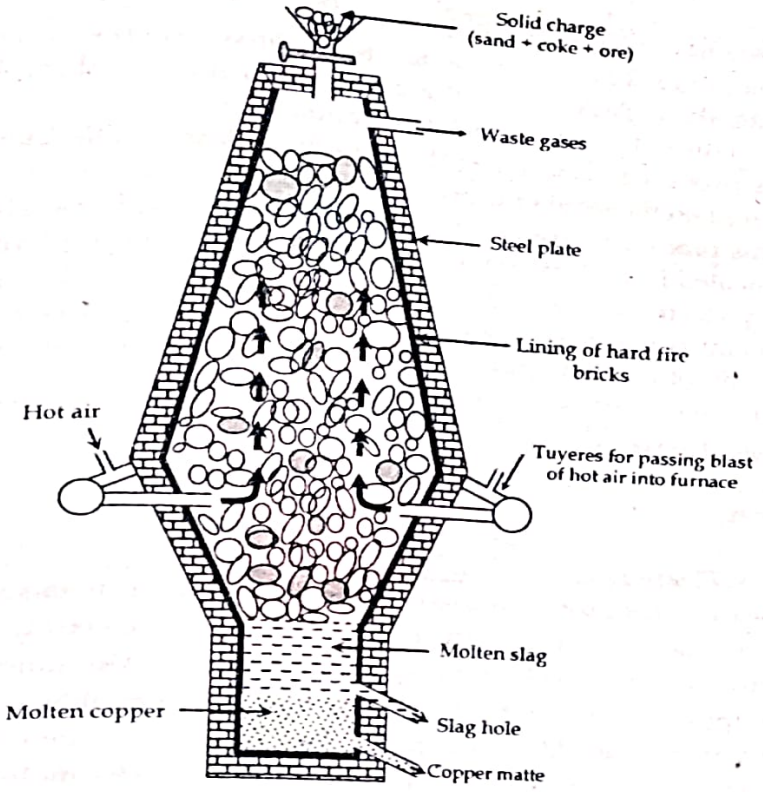


Fig: Blast furnace for smelting of copper ore

Carbon has higher affinity with oxygen is cheap and easily available. **Example:**

$Fe_2O_3 + 3C \longrightarrow 2Fe + 3CO \uparrow$

$Fe_2O_3 + 3CO \longrightarrow Fe + 3CO_2 \uparrow$

$ZnO + C \longrightarrow Zn + CO \uparrow$

$PbO + C \longrightarrow Pb + CO \uparrow$

During carbon reduction process, infusible (earthy, rocky) impurities are converted to fusible mass by adding third chemical substances. This third chemical substance is called flux. The fusible mass formed is called slag. This forms a molten layer on metal surfaces which can be easily removed.

The flux are of two types:

Acidic flux: SiO_2 and $Na_2B_4O_7.10H_2O$

Basic flux: CaO, MgO, $CaCO_3$, $MgCO_3$

The choice of flux depends upon the nature of impurities. If impurities are basic, Acidic flux should be added or vice-versa.

SiO_2	+	CaO	$\longrightarrow$	$CaSiO_3$
Acidic flux		Basic impurities		Slag (fusible mass)
MgO	+	SiO_2	$\longrightarrow$	$MgSiO_3$
Basic flux		Acidic impurities		Slag (fusible mass)

Froth floatation process: Please refer to 2075 Set A Q.No. 29

[2.5+2.5]

2074 Set A Q.No. 29 **Write short notes on:**

i. **Hydrometallurgy**

ii. **Zone of refining**

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i. **Hydrometallurgy**: Please refer to 2075 Set A Q No. 29

ii. **Zone of refining**: The metals obtained from the ores by the above method are generally impur and are called crude metals. Purification of the crude metal may be done by the followin methods depending upon the nature of the metal and impurities.

a. **Liquation process**: This process is used when the impurity is less fusible than the metal itsel The impure metal is heated on the sloping hearth of a furnace.

b. **Distillation process**: This process is used for the purification of volatile metals like Hg, Zn, Cd etc. The crude metal is heated in a retort and its vapours are separately condensed in a receiver

c. **Electro-refining**: Highly electropositive metal like Al, Cu, Ag, Zn, Sn, etc. are refined by thi method. The impure metal is made as anode while the pure metal is made as cathode in th electrolytic cell. A solution of a soluble salt of the metal is used as electrolyte. On passing th electricity, positive charge metal ion is deposited at cathode.

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32. 2074 Set B Q.No. 29 **Write short notes on:** [2.5+2.

i. **Froth floatation process**

ii. **Alumino thermite process.**

i. **Froth floatation process**: Please refer to 2075 Set A Q No. 29

ii. **Alumino thermite process**: This process is used for the extraction of metals such as chromiu which can neither be obtained by carbon-reduction process nor by electrolysis process. In th process the purified chromite ore (Cr_2O_3) is mixed with powdered. Aluminium and an ignitin mixture containing Mg-powder and BaO_2. On igniting them in a crucible, considerable heat evolved and Cr_2O_3 gets reduced by Al to metallic Cr. Two layers separate out. The lower lay is that of chromium metal and the upper layer that of fused slag. The molten slag is remove and Cr-metal is recovered from the lower layer.

$$Cr_2O_3 + 2\,Al \xrightarrow{\Delta} 2Cr + Al_2O_3$$

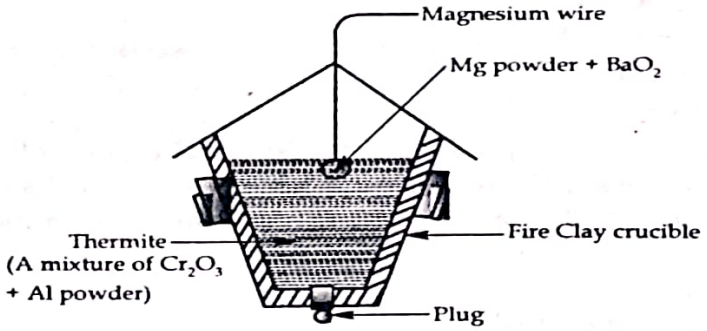


Fig: Alumino Thermite process

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33. 2073 Supp Q.No. 27 **Differentiate between**

i. **Gravity separation and Magnetic separation method.**

ii. **Carbon reduction and electrolytic reduction process.** [2.5+2

i. Following are the difference between gravity separation and magnetic separation method:

Gravity Separation method	Magnetic Separation method
This method is based on the differential specific gravity of gangue and ore particles.	This method is based on the magnetic natur of gangue or particles.
Generally oxides and carbonates ores of metal can be concentrated from this method.	Generally, iron and tin metal ore i concentrated from this method.

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Carbon reduction and electrolytic reduction process:

Carbon reduction	Electrolytic reduction
Here, carbon is used as reducing agent. The roasted or calcinated ore is mixed with coke (C) and suitable flux in a blast furnace.	This reduction is suitable for the extraction of alkali metals and alkaline earth metals.
Generally, oxide ore of metal is reduced by carbon reduction process into metal.	Generally, sodium, potassium, calcium, magnesium metals are reduced to metal by electrolysis process.

2073 Set C Q. No. 27 | 2073 Set D Q. No. 27 **Differentiate between:** [2.5 + 2.5]

i. **Calcination and roasting**

ii. **Carbon reduction and thermite process**

Calcination and roasting:

Calcination	Roasting
1. It is the process of heating metal ore in a limited supply of air or absence of air below its melting point.	1. It is the process of heating the metal ore in the excess of air below its melting point.
2. It is generally done in oxide or carbonate ore of metal.	2. It is generally done in sulphide ore of metal.
3. $Al_2O_3\,2H_2O \xrightarrow{\Delta} Al_2O_3 + 2H_2O$ (Bauxite); $ZnCO_3 \xrightarrow{\Delta} ZnO + CO_2$ (Calamine); $PbCO_3 \xrightarrow{\Delta} PbO + CO_2\uparrow$ (Cerussite)	3. $PbS + 3O_2 \xrightarrow[\Delta]{} 2\,PbO + 2SO_2\uparrow$; $2ZnS + 3O_2 \xrightarrow[\Delta]{} 2ZnO + 2SO_2\uparrow$

Carbon reduction and Alumino Thermite process:

Carbon reduction process	Alumino Thermite process
a. The process of extracting metal by fusion of its oxide ore with carbon is called carbon reduction process.	a. The process of reduction of a metal oxide to metal with the help of aluminium powder as reducing agent is called Alumino Thermite process.
b. In this process, metals like Zn, Sn, Pb, Fe etc. are extracted.	b. In this process, metals like Cr, Mn, Fe etc. are extracted.
c. Here, blast of hot air is passed.	c. Here, magnesium ribbon is burnt.
d. This is endothermic process. $PbO + C + Heat \longrightarrow Pb + CO$	d. This is exothermic process. $Cr_2O_3 + 2\,Al \longrightarrow Al_2O_3 + 2Cr + Heat$
e. This process can be done in Reverberatory furnace.	e. This process can be done in Thermite furnace.

2072 Supp Q. No. 28 **How are metals generally extracted from ores and purified?** [5]

Metals are generally extracted from their ores by the following process:

Crushing and Grinding: The big stones of ore are crushed into small pieces with the help of jaw crusher. The crushed ore is then grinded with the help of ball mill or stamp mills to form powder. This process is called crushing and grinding.

Concentration of ores: The ores are obtained from the earth crust, these are generally associated with a large number of impurities like sand, limestone, quartz, silicates etc. These impurities are called gangue or matrix. The removal of impurities from the powdered ore and increased the percentage of metal is known as concentration. The concentration of ore can be done by the following ways depending upon the nature of the ores.

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i. **Gravity separation method:** This method is based on the difference in densities of the ore particles and impurities. The powered ore is agitated with a running stream of water. The heavier ore particles are settle down at the bottom, while the lighter impurities are washed away with water. Generally, oxide and carbonate ores are concentrated by this method.

ii. **Magnetic separation method:** This method is based on the nature of ores i.e. ore or the impurities are magnetic in nature. The two can be separated from each other by means of magnetic separators.

iii. **Froth floatation method:** This method is suitable for sulphide ore of metal. The process is based on the different wetting properties of ore and gangue particle with water and pine oil. Ore is wetted with oil and impurities are wetted with water.

c. **Calcination and roasting:** Calcination is a process in which ore is heated in the absence of air below their melting point. During calcinations: (i) mass becomes porous (ii) volatile impurities are removed (iii) carbonates ore decompose to oxides. Example:

$Al_2O_3.2H_2O \longrightarrow Al_2O_3 + 2H_2O$

$CaCO_3 \longrightarrow CaO + CO_2$

$2Fe_2O_3.3H_2O \longrightarrow 2Fe_2O_3 + 3H_2O$

Roasting: The process in which ore is heated in the presence of excess of air at temperature below their melting point is called roasting. During roasting (i) sulphide ores are generally converted into oxides (ii) volatile impurities are removed (iii) free S, As and Sb are removed as SO_2, As_2O_3 and Sb_2O_3 respectively.

Example:

$2ZnS + 3O_2 \longrightarrow 2ZnO + 2SO_2$

$CuS + 2O_2 \longrightarrow CuSO_4$

d. **Reduction by carbon (Smelting):** The oxides of less electropositive metals like Pb, Zn,Fe,Sn,Cu etc are reduced by strongly heating them with coal or coke. Reduction of oxide with carbon at high temperature is known as smelting. Here, the calcinated or roasted ore is mixed with coal or coke and flux and heated in a reverberatory furnace or blast furnace in the presence of air.

Example:

$Fe_2O_3 + 3C \longrightarrow 2Fe + 3CO$

$PbO + C \longrightarrow Pb + CO$

The flux reacts with the impurities to form fusible material called slag which is lighter and hence forms the upper layer.

The nature of the flux used depends upon the nature of the impurity to be removed.

i. Acidic flux (Silica or borax) is used to remove the basic impurity like FeO,CaO etc.

SiO_2 + FeO $\longrightarrow$ $FeSiO_3$

Flux impurity slag

ii. Basic flux ($CaCO_3$,$MgCO_3$,Fe_2O_3) is used to remove the acidic impurity like SiO_2.

$CaCO_3 + SiO_2 \longrightarrow CaSiO_3 + CO_2$

e. **Purification or Refining:** The metals obtained from the ores by the above method are generally impure and are called crude metals. Purification of the crude metal may be done by the following methods depending upon the nature of the metal and impurities.

i. **Liquation process:** This process is used when the impurity is less fusible than the metal itself. The impure metal is heated on the sloping hearth of a furnace.

ii. **Distillation process:** This process is used for the purification of volatile metals like Hg, Zn, Cd, etc. The crude metal is heated in a retort and its vapours are separately condensed in a receiver.

iii. **Electro-refining:** Highly electropositive metal like Al, Cu, Ag, Zn, Sn, etc. are refined by this method. The impure metal is made as anode while the pure metal is made as cathode in the electrolytic cell. A solution of a soluble salt of the metal is used as electrolyte. On passing the electricity, positive charge metal ion is deposited at cathode.

2071 Supp Q. No. 28 **Differentiate between calcination and roasting in metallurgy.** **[5]**

Please refer to 2073 Set C Q. No. 27

2070 Supp. Q.No. 29 **Give a brief account for the following process.** **[3+2]**

i. Electrometallurgy ii. Carbon reduction

Electrometallurgy: The process of extraction of metal from an ore by electrolytic reduction in the molten or aqueous solution of the ore.

$NaCl \xrightarrow{\text{Electricity}} Na^+ + Cl^-$

At cathode: $Na^+ + e^- \longrightarrow Na$

Those metals which are solids and can be cast in the form of slabs are purified by electrolysis. Cu, Ag, Au, Zn, Sn, Pb, Co, Ni, etc can be purified by electrolytic method.

On passing electric current through the solution, thick slabs of impure metal dissolve and pure metal gets deposited on the cathodes of pure metal sheets. Finally thick slabs of pure metal are obtained at the cathodes.

Reactions:

$ZnSO_4 \longrightarrow Zn^{++} + SO_4^{--}$

At Cathode:

$Zn^{++} + 2e^- \longrightarrow Zn$ (Reduction)

At Anode:

$Zn \longrightarrow Zn^{++} + 2e^-$ (Oxidation)

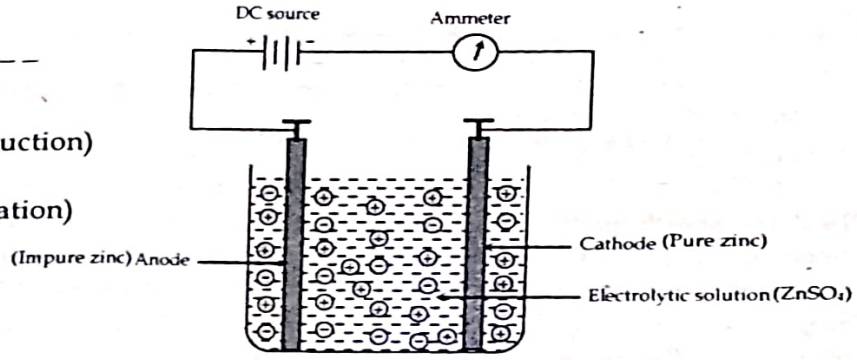


Fig: Electro-refining

Carbon reduction or smelting: Please refer to 2074 Supp Q.No. 29

2069 Set A Q. No. 28 **Describe the smelting process in the extraction of metal from their ores.** **[5]**

Please refer to 2074 Supp Q No. 29

2069 (Set B) Q. No. 30a **Give a brief account of the following terms:**

i. Smelting process

ii. Alumino Thermite process **[2.5+2.5]**

Smelting process: Please refer to 2074 Supp Q No. 29

Alumino Thermite process: Please refer to 2074 Set B Q.No. 29

2052 Q.No. 1 Group B **Give one characteristics relation used as a test for each of the following classes of salts:**

a. carbonates b. chlorides

c. nitrate d. sulphates **[5]**

Test of Carbonates (CO_3^{--}): About 1 mL of aqueous solution of salt is taken in clean test tube and 2 - 3 drops of $BaCl_2$ solution is added. White ppt is obtained. This indicates the presence of carbonate ion in the given salt. The ppt will dissolve in dil. HCl with the evolution of CO_2 gas.

$CO_3^{--} + BaCl_2 \longrightarrow BaCO_3 \downarrow + 2Cl^-$

White ppt

$BaCO_3 + 2$ dil. $HCl \longrightarrow BaCl_2 + H_2O + CO_2$

Test of Chloride (Cl^-): In order to test the presence of Cl^- ion in a given solution, about 1 mL of solution is taken in clean and dry test tube and is acidified with 1-2 drops of conc. HNO_3. Then the acidified solution is heated and cooled under tap water. 1-2 drops of $AgNO_3$ solution is added to it. A white ppt will seen which indicates the presence of Cl^- ion in the given solution.

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$Cl^-(aq.) + AgNO_3(aq.) \longrightarrow AgCl\downarrow + NO_3^-(aq.)$

White ppt

For further confirmation, the white ppt is dissolved in NH_4OH solution and again reappears by adding few drops of dil. HNO_3 solution.

$AgCl + 2NH_4OH \longrightarrow [Ag(NH_3)_2]^+ + 2H_2O + Cl^-$

$[Ag(NH_3)_2]^+ + Cl^- + 2HNO_3 \longrightarrow AgCl\downarrow + 2NH_4^+ + 2NO_3^-$

If ppt is dissolved soon and also reappears soon it confirms the presence of Cl^-.

Test for nitrate (NO_3^-): Nitrate salt solution is taken in test tube and equal volume of conc. H_2SO_4 is added to it. Then the solution is cooled under tap water. A freshly prepared saturated $FeSO_4$ solution is added drop wisely to it slightly from the wall of the test tube, by slightly tilting the test tube. A brown ring formed at the junction of two liquid layers indicates the presence of nitrate ion(NO_3^-)

$KNO_3 + H_2SO_4 \longrightarrow KHSO_4 + HNO_3$

$2HNO_3 \longrightarrow 2NO + H_2O + 3[O]$

$2FeSO_4 + H_2SO_4 + [O] \longrightarrow Fe_2(SO_4)_3 + H_2O$

$2KNO_3 + 5H_2SO_4 + 6FeSO_4 \longrightarrow 2KHSO_4 + 2NO + 4H_2O + 3Fe_2(SO_4)_3$

And, $FeSO_4 + NO \longrightarrow FeSO_4.NO$

Nitrosyl ferrous sulphate

Test for sulphate (SO_4^{--}): About 1 mL of salt containing sulphate ion (SO_4^{--}) is taken in clean and dry test tube and 2 – 3 drops of $BaCl_2$ solution is added to the test tube. A white ppt is obtained which does not dissolve in dil. HCl. This indicates the presence of sulphate ion i.e. SO_4^{--}.

$SO_4^{--} + BaCl_2 \longrightarrow BaSO_4\downarrow + 2Cl^-$

White ppt

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41. 2052 Q.No. 6 Group B What is metallurgy? How metal is extracted from its ore? [5]

The process of extraction of metal from an ores and utilizing them for useful purpose is called metallurgy. It is classified into three types:

i. **Pyrometallurgy:** The process of extraction of metal from an ore by chemical reduction at high temperature is called pyrometallurgy.

$Fe_2O_3 + C \xrightarrow{\Delta} Fe + CO_2\uparrow$

ii. **Electrometallurgy:** The process of extraction of metal from an ore by electrolytic reduction in the molten or aqueous solution of the ore.

$NaCl \xrightarrow{\text{Electricity}} Na^+ + Cl^-$

At cathode: $Na^+ + e^- \longrightarrow Na$

iii. **Hydrometallurgy:** The process of extraction of metal from an ore by dissolving the ore in aq. solution of suitable chemical reagent and subsequent precipitation of the metal by other more reactive metal or precipitating reagent.

Example: The silver can be extracted from silver glance by this process:

$Ag_2S + aq.\ 4NaCN \longrightarrow 2Na[Ag(CN)_2] + Na_2S$

$2Na[Ag(CN)_2] + Zn \longrightarrow Na_2[Zn(CN)_4] + Ag$

There is no any individual process by which all metal can be extracted from an ore. However, general process for the extraction of metal from an ore includes following steps:

a. Preliminary treatment
b. Calcination or Roasting
c. Reduction
d. Refining (Purification)

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Unit 13

Alkali and Alkaline Earth Metals

13.1 Alkali Metals

VERY SHORT ANSWER QUESTIONS [2 MARKS]

2076 Set B Q.No. 18 Why are alkali metals impart characteristic colours when introduced to the flame? [2]

Alkali metals have one electron in outermost shell and having low ionization energy. When alkali metal is heated, the electron present in their outermost shells get excited and the excited electron, when returns back to the original position, emits electromagnetic radiation which gives rise to characteristic colour to the flame. So, alkali metals impart characteristics colour to the flame.

2076 Set C Q.No. 18 Sodium metal burns with air giving golden yellow flame. Why? [2]

The electrons in sodium change energy level when heated. The electrons drops back down in energy, emitting a photon of certain wavelength and impart color. The specific wavelengths emitted are in the golden yellow part of the emission spectrum.

2075 Set B Q.No. 18 Give reason. [1+1]

i. Sodium metal gets tarnished in air.

ii. Carbon reduction process is not applied for the extraction of alkali metals.

When sodium metal is exposed in open air it forms a layer of sodium carbonate on its surface. So, sodium metal gets tarnished in air.

$4Na + O_2 \longrightarrow 2Na_2O$

$Na_2O + H_2O \longrightarrow 2NaOH$

$2NaOH + CO_2 \longrightarrow Na_2CO_3 + H_2O$

Following are the reason which shows why alkali metals cannot be obtained by chemical reduction method.

Alkali metals have greater electron affinity and combines with halogen or oxygen element to form metal chloride or oxide which cannot be calcinated or roasted.

High temperature is required for the reduction of metal oxide or halide of alkali metals with carbon atom.

Alkali metals are themselves strong reducing agent and cannot be reduced by other elements.

2072 Set D Q.No. 18 Give reason:

i. Alkali metal imparts characteristic colour to the flame test. [1]

ii. Sodium metal gets tarnished in air. [1]

Please refer to 2076 Set B Q.No. 18

Please refer to 2075 Set B Q.No. 18

2072 Set E Q.No. 18 Why is carbon reduction process not applied for the extraction of alkali metal? Name any one suitable method for the extraction of these metals. [2]

Following are the reasons which shows why carbon reduction process can not applied for the extraction of alkali metal.

a. Alkali metals have greater electron affinity and combines with halogen or oxygen element to form metal chloride or metal oxide which cannot be calcinated or roasted.
b. High temperature is required for the reduction of metal oxide or halide of alkali metals with carbon atom.
c. Alkali metals are themselves strong reducing agent and cannot be reduced by other elements. Alkali metals can be extracted by electrolysis of their molten chloride.

6. **2070 Set C Q.No. 15 Can sodium be extracted by the electrolysis of aqueous solution of sodium chloride? If not why?** [2]

No, sodium metal cannot be extracted by the electrolysis of aqueous solution of sodium chloride. In the aqueous solution of sodium chloride both Na^+ and H^+ ions are present. The electrode potential of hydrogen is higher than sodium and during electrolysis H^+ ion is reduced easily than Na^+ ion. Due to this hydrogen gas is liberated at cathode. Therefore, sodium metal cannot be extracted by the electrolysis of aqueous sodium chloride.

7. **2070 Set D Q.No. 18 Starting from sodium, how would you prepare $Na_2CO_3.10H_2O$?** [2]

Sodium metal when exposed to air, sodium oxide is formed. Sodium oxide absorbs moisture to give sodium hydroxide which further absorbs carbon dioxide to give finally sodium carbonate.

$4\,Na + O_2 \longrightarrow 2Na_2O$

$Na_2O + H_2O \longrightarrow 2\,NaOH$

$2\,NaOH + CO_2 \longrightarrow Na_2CO_3 + H_2O$

The aqueous solution Na_2CO_3 on crystallization gives washing soda ($Na_2CO_3.10H_2O$)

$$Na_2CO_3 + H_2O \xrightarrow{\text{Crystallization}} \underset{\text{Washing soda}}{Na_2CO_3.10H_2O}$$

8. **2069 (Set A) Q. No. 18 Mention the biological importance of potassium and sodium metals.** [1+1]

Sodium and potassium metal are the main component in biological fluid. Both the metals are found in RBC and control the development and the function of the nerve cell. Most of the enzymatic reactions are controlled by Na^+ and K^+ ions. So, both the metals play vital role in biochemical process.

9. **2069 (Set B) Q. No. 18 How is Caustics Soda converted into:** [1+1]
   i. Washing soda
   ii. Baking soda

i. NaOH to Na_2CO_3 (washing soda)

$$\underset{\text{Caustic soda}}{2\,NaOH} + CO_2 \longrightarrow \underset{\text{Washing soda}}{Na_2CO_3} + H_2O$$

ii. NaOH to $NaHCO_3$ (baking soda)

$$\underset{\text{Caustic soda}}{2\,NaOH} + CO_2 \longrightarrow Na_2CO_3 + H_2O \xrightarrow{CO_2} \underset{\text{Baking soda}}{2NaHCO_3}$$

10. **2068 Q.No. 18 Can Sodium be extracted by the electrolysis of aqueous solution of sodium chloride? If not why?** [2]

No, sodium metal cannot be extracted by the electrolysis of aqueous solution of sodium chloride because aqueous solution of sodium chloride contains the following ions i.e. Na^+, H^+, Cl^-, OH^-. The aqueous solution is electrolyzed, Na^+ and H^+ ion is migrated toward at cathode but the electrode potential of H^+ ion is greater than Na^+ ion. So, H^+ ion is reduced and Na^+ is not. That is why Na metal cannot be extracted.

11. **2060 Q.No. 16 What would happen when the nitrate of an alkali metal is heated?** [2]

When the nitrate of an alkali metal is heated, oxygen gas is liberated.

$$2KNO_3 \xrightarrow[\Delta]{} 2KNO_2 + O_2 \uparrow$$

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2059 Q.No. 18 What is the biological importance of sodium? **[2]**

Sodium is found is RBC and controls the development and function of nerve cell. Excess loss of sodium is accompanied by shock i.e. fall is blood pressure and pulse rate while excessive sodium ions lead to increase the blood pressure.

2058 Q.No. 17 Write the chemical formulae of washing soda and baking soda. What are their uses? **[2]**

Washing soda: $Na_2CO_3.10H_2O$ It is used for washing clothes.

Baking soda: $NaHCO_3$ It is used for making cakes, biscuits etc. in baking industry.

2057 Q.No. 17 What happens when a piece of sodium is dropped into water? **[2]**

When a piece of sodium metal is dropped into water, sodium reacts with water to form hydrogen gas. This reaction is so violent that flash of fires are produced.

$2Na + 2H_2O \longrightarrow 2NaOH + H_2\uparrow$

2056 Q.No. 17 What happens when a piece of sodium is exposed to air? **[2]**

Sodium metal does not react with dry air or oxygen but with moist air it forms a layer of sodium carbonate on its surface.

$4Na + O_2 \longrightarrow 2Na_2O$

$Na_2O + H_2O \longrightarrow 2NaOH$

$2NaOH + CO_2 \longrightarrow Na_2CO_3 + H_2O$

2055 Q.No. 18 What are the chemical formulae of caustic soda, washing soda and baking soda? What are their main uses? **[2]**

Caustic Soda: NaOH It is used for the manufacture of soap, paper etc.

Washing soda: $Na_2CO_3.10H_2O$ It is used for washing clothes.

Baking soda: $NaHCO_3$ It is used for making cakes, biscuits etc. in baking industry.

2053 Q.No.20 Group A Why alkali metals can not be obtained by chemical reduction method? **[1.5]**

Please refer to 2072 Set E Q No. 18

2051 Q.No. 8 Group A What is the main product obtained when sodium is allowed to react with dry ammonia at 300° - 400°C? **[2]**

When sodium is allowed to react with dry ammonia at 300 – 400°C then sodamide and hydrogen gas is formed.

$$2Na + 2NH_3 \xrightarrow{300-400^\circ C} \underset{\text{Sodamide}}{2NaNH_2} + H_2\uparrow$$

SHORT ANSWER QUESTIONS: [5 MARKS]

2066 Q.No. 29 How is sodium hydroxide manufactured? Give a reaction to convert caustic soda into washing soda. **[4+1]**

Manufacture of Sodium hydroxide by Castner-Kellner process: This cell consists of a large rectangular iron vessel divided into three compartments with the help of slate partition. The partition does not touch the bottom. The two outer compartments contain the concentrated brine solution with graphite anode. The central compartment contains water with iron cathode. The bottom of the cell contain layer of mercury which serves as cathode in outer two compartments and anode in central compartment. The mercury is allowed to move from one compartment to other with the help of eccentric wheel.

During electrolysis, at the outer compartment, Sodium ions are discharge or reduce at mercury cathode and forms amalgam. Thus formed sodium amalgam passes into central compartment due to rocking motion of eccentric wheel, and reacts with water forming sodium hydroxide solution with the liberation of hydrogen gas. Sodium hydroxide solution is evaporated to dryness to get crystal of sodium hydroxide. Mercury so produced is sent back to the cell for reuse. By this process 50% NaOH is produced.

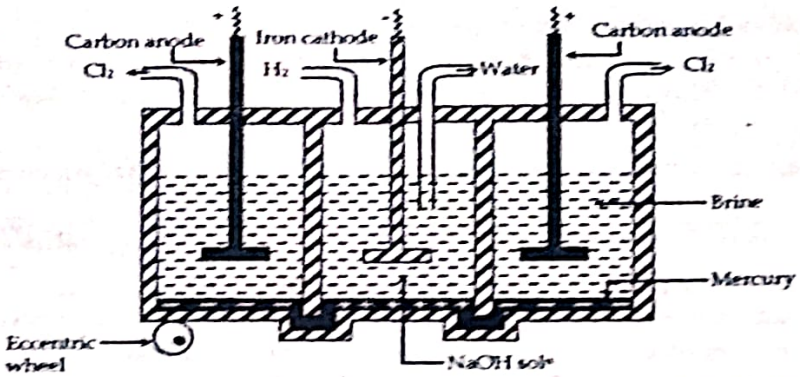


Fig: Castner- Kellner cell for the manufacture of sodium hydroxide

Reaction involved is:

At two outer compartments:

At cathode: $Na^+ + e^- + Hg \xrightarrow{\text{Oxidize}} NaHg$ (sodium amalgam)

At anode: $Cl^- - e^- \xrightarrow{\text{Reduced}} Cl$

$Cl + Cl \longrightarrow Cl_2$

In central compartment

$$NaHg + H_2O \longrightarrow \underset{\text{Caustic soda}}{NaOH} + Hg + \frac{1}{2} H_2$$

Conversion: When carbon dioxide gas is passed through caustic soda, washing soda is obtained.

$$\underset{\text{Caustic soda}}{2NaOH} + CO_2 \longrightarrow \underset{\text{Washing soda}}{Na_2CO_3} + H_2O$$

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20. 2063 Q.No. 28 **Write the principle involved in the extraction of sodium from sodium chloride, and also draw a self-explanatory diagram for the Down's process for the extraction of sodium.** [5]

Sodium metal is very reactive and acts as powerful reducing agent. So, cannot be extracted by reduction of oxide in carbon reduction process. Following are the reasons.

At high temperature sodium may combine with carbon to form sodium carbide.

$$4Na + C \xrightarrow[\Delta]{} Na_4C$$

The affinity of sodium with oxygen is very high.

$$4Na + O_2 \longrightarrow 2Na_2O$$

Sodium metal is extracted from the electrolysis of its fused sodium chlorides using a special electrolytic cell called Down's cell.

Principle: When electricity is passed through fused sodium chloride having graphite as anode and iron ring as cathode. The following reactions occur:

$$\underset{\text{Fused}}{2NaCl} \rightleftharpoons 2Na^+ + 2Cl^-$$

At anode:

$2Cl^- \longrightarrow Cl_2 + 2e^-$ (Oxidation)

At cathode:

$2Na^+ + 2e^- \longrightarrow 2Na$ (Reduction)

The net reaction is

$2NaCl \longrightarrow 2Na + Cl_2$

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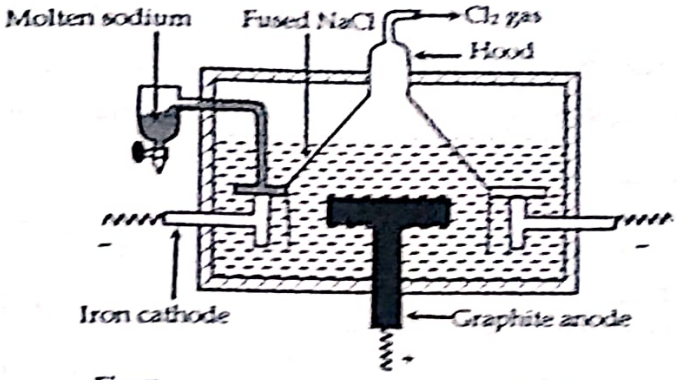


Fig: Down's cell for the extraction of sodium

During electrolysis some $CaCl_2$ is mixed with NaCl to lower down the melting point of NaCl from 815°C to 640°C. So that working temperature of the cell is lowered to 640°C. At this temperature sodium is liberated smoothly and does not react with iron container. At 640°C molten electrolyte (NaCl + $CaCl_2$) does not dissolve molten Na- metal but at 815°C molten electrolyte dissolve sufficient amount of molten Na and its collection becomes difficult. Sodium collects in kerosene oil.

2057 Q.No. 28 **Write down the principles involved in the manufacture of caustic soda by Solvay Kellner's process. What is its action upon white phosphorous?** **[3+2]**

Kellner-Solvay process:

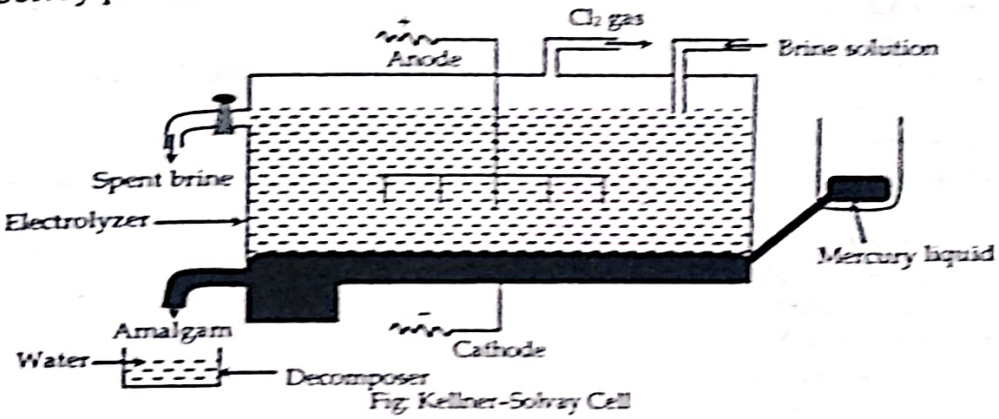


Fig: Kellner-Solvay Cell

Kellner solvay cell consists of big rectangular tank which is called electrolyser. Lower layer is filled with flowing mercury which flows from one end to another end. The layer of mercury acts as cathode. The conc. Brine solution is filled in electrolyzer. The graphite anode is suspended into brine solution. During electrolysis Cl^- ions are oxidized at anode and Cl_2 gas is formed. Na^+ ion is reduced at the mercury cathode and form sodium amalgam. Sodium amalgam is mixed with water which is called decomposer. Sodium reacts with water to form sodium hydroxide.

Following are reactions:

$$NaCl \rightleftharpoons Na^+ + Cl^-$$

At Anode:

$$Cl^- \longrightarrow Cl + e^-$$

$$Cl + Cl \longrightarrow Cl_2$$

At Cathode:

$$Na^+ + e^- \longrightarrow Na$$

$$Na + Hg \longrightarrow Na - Hg$$

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At decomposer:

$$Na\text{-}Hg + H_2O \longrightarrow NaOH + Hg + \frac{1}{2} H_2 \uparrow$$

Action of NaOH on White phosphorous: When NaOH is heated with yellow phosphorous, PH_3 gas is obtained.

$$P_4 + 3NaOH + 3H_2O \longrightarrow \underset{\text{Phosphine}}{PH_3 \uparrow} + \underset{\text{Sodium hypophosphite}}{NaH_2PO_2}$$

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22. 2056 Q.No. 28 How is sodium extracted from sodium chloride using Down's electrolytic cell? [5]

Please refer to 2063 Q.No. 28

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23. 2054 Q.No. 21 Give the characteristics of alkali metals? [5]

The elements of group IA of modern periodic table is known as alkali metals. They are Li, Na, K, Rb, Cs, Fr. The last electron is entered into the s-orbital of the electronic configuration. So, they are called s-block element.

Physical properties:

i. They are very reactive and found in free states.
ii. They have valency 1 i.e. monovalent. So, they have oxidation state +1.
iii. They are highly electropositive metals.
iv. They are soft metals. So, can be cut by knife easily.
v. They are highly malleable and ductile.
vi. They have very low specific gravity.

Chemical properties:

i. They react with water to liberate hydrogen gas.
$2Na + H_2O \longrightarrow Na_2O + H_2 \uparrow$

ii. They are highly electropositive and reduce hydrogen to form metal hydride.
$2Na + H_2 \longrightarrow 2NaH$
$2K + H_2 \longrightarrow 2KH$

iii. They form alkali with oxygen i.e. metal oxide and form base i.e. metal hydroxide with water.
$4Na + O_2 \longrightarrow 2Na_2O$
$Na_2O + H_2O \longrightarrow 2NaOH$

iv. They form water soluble carbonate, sulphate and phosphate with acid.
$2Na + H_2CO_3 \longrightarrow Na_2CO_3 + H_2 \uparrow$
$2Na + H_2SO_4 \longrightarrow Na_2SO_4 + H_2 \uparrow$
$6Na + 2H_3PO_4 \longrightarrow 2Na_3PO_4 + 3H_2 \uparrow$

v. Nitrate of alkali metals form O_2 gas on heating.
$2KNO_3 \xrightarrow{\Delta} O_2 + 2NaNO_2$

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24. 2054 Q.No. 22 Describe the steps involved in the manufacture of sodium carbonate by Solvay's process. [5]

Raw material required:

- Brine solution (NaCl)
- Lime stone ($CaCO_3$)
- Ammonia (NH_3)

Principle: Brine solution is saturated with ammonia gas by passing ammonia. Ammoniacal brine is treated with excess of carbon dioxide, at first ammonium bicaronate is formed Which reacts further with sodium chloride to give sodium bicarbonate.

$$NH_3 + CO_2 + H_2O \longrightarrow NH_4HCO_3$$
$$NH_4HCO_3 + NaCl \longrightarrow NaHCO_3 + NH_4Cl$$

Sodium bicarbonate is sparingly soluble in water in presence of sodium chloride. Hence precipitates out, Which is separated by filtration. The sodium bicarbonate is then calcinated to get sodium carbonate.

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$$2NaHCO_3 \xrightarrow[\Delta]{} Na_2CO_3 + H_2O + CO_2.$$

Working of plant: The solvay ammonia soda process consist of lime kiln for the generation of carbon dioxide, Ammonia generator, brine tank and carbonation tower etc. which works as:

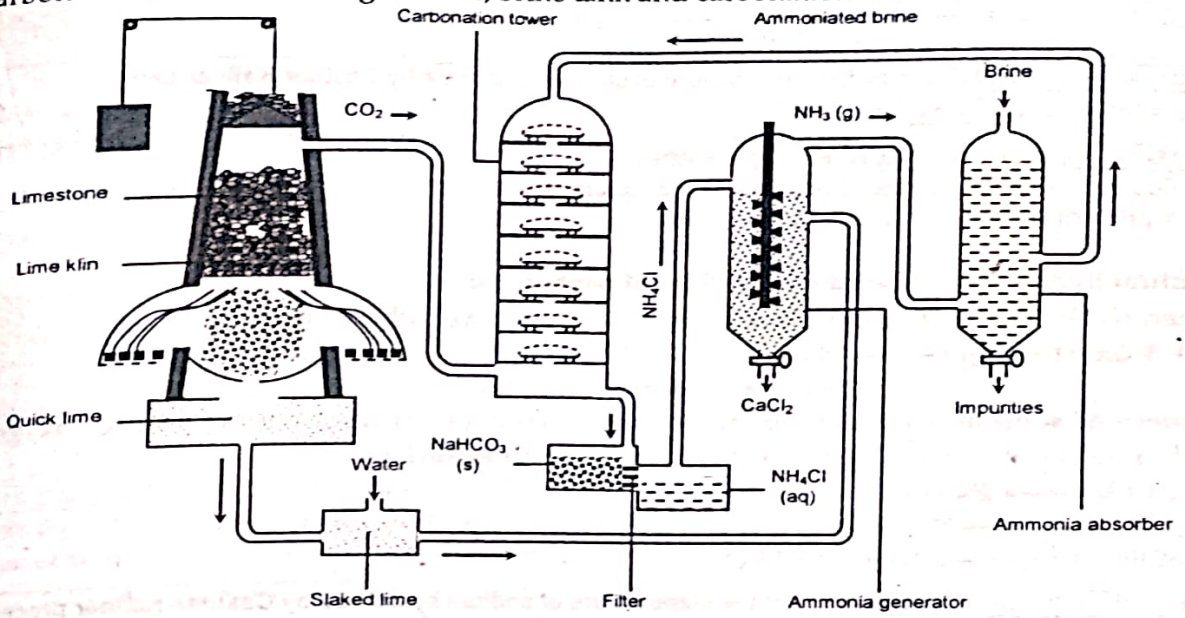


Fig: Solvay process for the manufacture of washing soda

i. The carbon dioxide is generated by heating limestone in lime klin.

$$CaCO_3 \xrightarrow{1000^\circ C} CaO + CO_2$$

ii. The ammonia is generated by heating mixture of ammonium chloride and slaked lime in ammonia generator.

$$NH_4Cl + Ca(OH)_2 \xrightarrow[\Delta]{} CaCl_2 + 2NH_3 + H_2O$$

iii. **Saturation of brine:** Ammonia mixed with a little carbon dioxide from the ammonia generating tower and enter into the ammonia absorbing tower and saturates the brine. Impurities are precipitated as hydroxide and carbonate. This saturated ammoniacal brine is passed to carbonation tower.

$$2NH_3 + H_2O + CO_2 \longrightarrow (NH_4)_2CO_3$$
$$CaCl_2 + (NH_4)_2CO_3 \longrightarrow CaCO_3 \downarrow + NH_4Cl$$

iv. $NH_3 + H_2O \longrightarrow NH_4OH$

$$MgSO_4 + NH_4OH \longrightarrow (NH_4)_2SO_4 + Mg(OH)_2 \downarrow$$

v. **Carbonation tower:** Ammoniacal brine is allowed to enter the carbonating tower from the top and meets an upward stream of carbon dioxide coming from the bottom. Here ammonium bicarbonate is formed which subsequently reacts with sodium chloride to give sparingly soluble sodium bicarbonate which precipitates out.

$$NH_3 + CO_2 + H_2O \longrightarrow NH_4HCO_3$$
$$NH_4HCO_3 + NaCl \longrightarrow NaHCO_3 + NH_4Cl$$

The thick milky liquid coming from the carbonation tower is filtered .The filtrate or mother liquor contains ammonium chloride which is used in ammonia generating tower.

vi. **Recovery of ammonia:** The filtrate from carbonation tower contains ammonium chloride solution flows down the ammonia generating tower while the slaked lime is admitted from the bottom of the tower. Now, ammonium chloride reacts with slaked lime to give ammonia

$$NH_4Cl + Ca(OH)_2 \longrightarrow CaCl_2 + 2NH_3 + H_2O.$$

vi. The residue from carbonation tower is ignited or calcinated to give sodium carbonate which is heated up to crystallization point then we get crystal of washing soda.

$$2NaHCO_3 \xrightarrow[\Delta]{} Na_2CO_3 + H_2O + CO_2 \uparrow$$

$$Na_2CO_3 + 10\,H_2O \xrightarrow[\text{Crystallization point}]{\Delta} Na_2CO_3.10H_2O$$

25. 2052 Q.No. 4 Group B Describe the manufacture of sodium hydroxide by Castner-Kallner cell. [5]

Please refer to 2066 Q.No. 29

26. 2052 Q.No. 7a 2061 Q.No. 28d What happens when
a. Sodium hydroxide is heated with yellow phosphorous.
b. A piece of sodium is exposed to air. [5]

a. **Sodium hydroxide is heated with yellow phosphorous:**
When NaOH is heated with yellow phosphorous, PH_3 gas is obtained.

$$P_4 + 3NaOH + 3H_2O \longrightarrow \underset{\text{Phosphine}}{PH_3 \uparrow} + \underset{\text{sodium hypophosphite}}{NaH_2PO_2}$$

b. **A piece of sodium is exposed to air:** Sodium metal does not react with dry air or oxygen but with moist air it forms a layer of sodium carbonate on its surface.

$$4Na + O_2 \longrightarrow 2Na_2O$$
$$Na_2O + H_2O \longrightarrow 2NaOH$$
$$2NaOH + CO_2 \longrightarrow Na_2CO_3 + H_2O$$

27. 2051 Q.No. 6 Group B Describe in brief the manufacture of sodium hydroxide by Castner-Kellner process. [5]

Please refer to 2066 Q.No. 29

LONG QUESTION ANSWERS: [10 MARKS]

28. 2076 Set B Q.No. 32 Explain the principle and procedure involved in the manufacture of washing soda by ammonia-soda process. Sketch a well-labelled diagram for it. How would you convert washing soda into
i. Soda ash
ii. Sodium silicate respectively?
Write down important uses of washing soda. [6+2+2]

Manufacture of Washing soda by ammonia-soda process: Please refer to 2054 Q.No. 22

Conversion:

i. **Washing soda into Soda ash:** When washing soda is exposec in open air, it looses water of crystallization to get soda ash.

$$\underset{\text{Washing soda}}{Na_2CO_3.10\,H_2O} \longrightarrow \underset{\text{Soda ash}}{Na_2CO_3} + 10\,H_2O$$

ii. **Washing soda into Sodium silicate:** When washing soda is exposec in open air, it looses water of crystallization to get soda ash which on treatment with SiO_2 to get sodium silicate.

$$\underset{\text{Soda ash}}{Na_2CO_3} + SiO_2 \longrightarrow \underset{\text{Sod. silicate}}{Na_2SiO_3} + CO_2$$

Important uses of washing soda:

i. It is used for making glass, soap, and paper industries.
ii. It is used in the manufacture of sodium compounds such as Borax.

29. 2076 Set C Q.No. 32 Explain the principle and procedures involved in the manufacture of washing soda by ammonia soda method. Sketch a well-labelled diagram for it. What happens when washing-soda is
i. Fused with excess and (SiO_2)
ii. Heated upto 75°C.
Write down the uses of washing soda. [6+2+2]

Manufacture of Washing Soda by Ammonia soda method: Please refer to 2054 Q.No. 22

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What happens when

Fused with excess sand (SiO_2): when sodium carbonate is fused with excess of sand, sodium silicate is obtained.

$$Na_2CO_3 + SiO_2 \xrightarrow[\Delta]{} Na_2SiO_3 + CO_2$$

Sodium silicate

Heated upto 750°C: When washing soda is heated upto 750°C, it loses all the water molecule and decomposes to form sodium oxide and carbon dioxide.

$$Na_2CO_3.10H_2O \xrightarrow{\text{below } 100\,^\circ C} Na_2CO_3.H_2O + 9H_2O$$

Washing soda — Sodium carbonate monohydrate

$$Na_2CO_3.H_2O \xrightarrow{\text{above } 100\,^\circ C} Na_2CO_3 + H_2O$$

Sodium carbonate monohydrate — Sodium carbonate anhydrous

$$Na_2CO_3 \xrightarrow[\Delta]{750\,^\circ C} Na_2O + CO_2$$

Sodium oxide

2075 GIE Q.No. 31 **Explain the chemistry of Castner-Kellner process for the manufacture of Caustic Soda. Write down the action of Caustic Soda with Zn. How is Caustic Soda converted into Washing Soda? [7+1+2]**

Manufacture of Caustic soda by Castner-Kellner process: Please refer to 2066 Q.No. 29

Action of caustic soda with Zn:

When sodium hydroxide is treated with Zinc metal, sodium zincate is formed with the evolution of hydrogen gas.

$$Zn + 2NaOH \longrightarrow Na_2ZnO_2 + H_2\uparrow$$

Sodium zincate

Conversion:

$$4Na + O_2 \longrightarrow 2Na_2O$$

$$Na_2O + H_2O \longrightarrow 2NaOH$$

$$2NaOH + CO_2 \longrightarrow Na_2CO_3 + H_2O \xrightarrow{\text{Crystallization}} Na_2CO_3.10H_2O$$

Washing soda

2075 Set A Q.No. 31 **Sketch a well labelled diagram for the manufacture of sodium by Down's process. What are the advantages of this process? Give reactions for the conversion of sodium into washing soda. [6+2+2]**

Manufacture of Sodium metal by Down's process: Please refer to 2063 Q.No. 28

Advantage of Down's process: Following are advantages:

Chlorine is obtained as byproduct which is an important industrial chemical mainly due to growing demand of PVC.

Rock salt and impure salt is directly used.

Conversion sodium to washing soda:

$$4Na + O_2 \longrightarrow 2Na_2O$$

$$Na_2O + H_2O \longrightarrow 2NaOH$$

$$2NaOH + CO_2 \longrightarrow Na_2CO_3 + H_2O \xrightarrow{\text{Crystallization}} Na_2CO_3.10H_2O$$

Washing soda

2075 Set B Q.No. 31 **Sketch a neat and well-labeled diagram for the manufacture of sodium carbonate by Solvey's ammonia process. Explain the chemical principle involved. What is the advantage of this process? Write down the molecular formula of (i) soda ash (ii) baking soda (iii) washing soda. [6+4]**

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Manufacture of Sodium carbonate by Solvay's ammonia process: Please refer to 2054 Q.No. 22

Advantage of Solvay ammonia process:

Following are the merits of Solvay ammonia process

i. It is cyclic process.
ii. All the products are reused except calcium chloride.
iii. The raw materials are cheap.
iv. The products obtained are high purity.

The molecular formula of:

i. Sada ash: Na_2CO_3
ii. Baking soda: $NaHCO_3$
iii. Washing soda: $Na_2CO_3.10H_2O$

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33. 2074 Supp Q.No. 31 Sketch a well labelled diagram for the manufactured of NaOH by Castner–Kellner's method and explain the principle and procedure for it. What in the action of caustic soda on
i. Chlorine ii. Zinc
Convert caustic soda into sodium silicate. [6+2+2]

Manufacture of NaOH by Castner – Kellner's method: Please refer to 2066 Q.No. 29

Action of NaOH with:

i. **Chlorine:** Sodium hydroxide reacts with chlorine, sodium hypochlorite is obtained.

$$2NaOH + Cl_2 \longrightarrow \underset{\text{Sod. hypochlorite}}{NaClO} + NaCl + H_2O$$

ii. **Zinc (Zn):** Sodium hydroxide reacts with zinc metal, sodium zincate is obtained.

$$Zn + 2\,NaOH \longrightarrow \underset{\text{Sod. zincate}}{Na_2ZnO_2} + H_2$$

Conversion

When caustic soda (NaOH) is treated with CO_2 gas, sodium carbonate (Na_2CO_3) is obtained which on treatment with SiO_2 to give sodium silicate (Na_2SiO_3)

$$2\,NaOH + CO_2 \longrightarrow Na_2CO_3 + H_2O$$
$$Na_2CO_3 + SiO_2 \longrightarrow Na_2SiO_3 + CO_2\uparrow$$
$$\overline{2NaOH + SiO_2 \longrightarrow Na_2SiO_3 + H_2O}$$

Caustic soda — Sod. Silicate

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34. 2074 Set A Q.No. 31 Write the principle and process along with self-explanatory diagram for the manufacture of sodium by Down's method. Why is sodium fire at laboratory not extinguished by adding water? Mention any two advantages of Down's process. How is sodium converted into washing soda? [6+1+1+2]

Manufacture of Sodium by Down's process: Please refer to 2063 Q.No. 28

Sodium fire cannot extinguish by adding water because sodium reacts with water to form inflammable hydrogen gas. Therefore, water is not used to extinguish sodium fire.

Two advantages of Down's process:

i. Rock salt and impure salt can directly be used.
ii. The chlorine is obtained as byproduct which is an important industrial use due to growing demand of PVC.

Conversion of Sodium (Na) into Washing soda ($Na_2CO_3.10\,H_2O$):

$$4Na + O_2 \longrightarrow 2\,Na_2O$$
$$Na_2O + H_2O \longrightarrow 2\,NaOH$$
$$2\,NaOH + CO_2 \longrightarrow Na_2CO_3 + H_2O$$
$$Na_2CO_3 + 10\,H_2O \xrightarrow{\text{Crystallization}} \underset{\text{Washing soda}}{Na_2CO_3.10\,H_2O}$$

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2074 Set B Q.No. 31 **Sketch a neat and well labeled diagram for the manufacture of sodium by Down's process. What are the advantages of this process? Give reactions for the conversion of sodium into washing soda. [6+2+2]**

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$$Na_2O + H_2O \longrightarrow 2\ NaOH$$

$$2\ NaOH + CO_2 \longrightarrow Na_2CO_3 + H_2O$$

$$Na_2CO_3 + 10\ H_2O \xrightarrow{\text{Crystallization}} Na_2CO_3.10\ H_2O$$

Washing soda

2073 Supp Q.No. 31 **Sketch a well labeled diagram of Down's Cell for the manufacture of sodium. Explain the principle and procedure involve on it. What are the advantages of this process? Why does sodium impart characteristics colours to the flame? Convert sodium into washings soda. [6+2+2]**

Manufacture of sodium metal from Down's cell: Please refer to 2063 Q.No. 28

Advantage of Down's process: Please refer to 2075 Set A Q.No. 31

Sodium impart characteristics colours to the flame: The electrons in sodium change energy level when heated. The electrons drops back down in energy, emitting a photon of certain wavelength and impart color. The specific wavelengths emitted are in the golden yellow part of the emission spectrum.

Conversion sodium to washing soda: Please refer to 2075 Set A Q.No. 31

2073 Set C Q. No. 31 **Sketch a well-labeled diagram for the manufacture of washing soda by Solvay's ammonia process and explain the principle and procedure for it. What happens when washing soda is: [6+3+1]**

i. **Exposed to air**
ii. **Fused with excess sand (SiO_2)**
iii. **Heated upto 750°C**
iv. **Give two major uses of washing soda.**

Manufacture of washing soda by Solvay's ammonia process: 2054 Q.No. 22

What happens when,

Exposed to air: When washing soda is exposed in open air, it loses nine molecules of water to form sodium carbonate monohydrate.

$$Na_2CO_3.10\ H_2O \xrightarrow{\text{below 100 °C}} Na_2CO_3.\ H_2O + 9\ H_2O$$

Washing soda — Sodium carbonate monohydrate

Fused with excess sand (SiO_2): when sodium carbonate is fused with excess of sand, sodium silicate is obtained.

$$Na_2CO_3 + SiO_2 \xrightarrow[\Delta]{} Na_2SiO_3 + CO_2$$

Sodium silicate

Heated upto 750°C: When washing soda is heated upto 750°C, it loses all the water molecule and decomposes to form sodium oxide and carbon dioxide.

$$Na_2CO_3.10\ H_2O \xrightarrow{\text{below 100 °C}} Na_2CO_3.\ H_2O + 9\ H_2O$$

Washing soda — Sodium carbonate monohydrate

$$Na_2CO_3.\ H_2O \xrightarrow{\text{above 100 °C}} Na_2CO_3 + H_2O$$

Sodium carbonate monohydrate — Sodium carbonate anhydrous

$$Na_2CO_3 \xrightarrow[\Delta]{750\ °C} Na_2O + CO_2$$

Sodium oxide

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Two uses of washing soda are:

i. It is used for softening of hard water.

ii. It is used for the manufacture of soap, water glass, paper, borax, caustic soda etc.

38. 2073 Set D Q. No. 31 Sketch a well-labeled diagram for the manufacture of Caustic soda (NaOH) by Castner Kellner's process. Explain the principle and procedure involve on it. What happens when Caustic soda is: [6+1+

i. Heated with sulphur

ii. Treated with zinc

Manufacture of Caustic soda: Please refer to 2066 Q.No. 29

What happens when,

i. When caustic soda is heated with sulphur, sodium thiosulphate is obtained.

$$6\,NaOH + 4\,S \xrightarrow[\Delta]{} 2\,Na_2S + Na_2S_2O_3 + 3\,H_2O$$

Sodium thiosulphate

ii. When caustic soda is treated with zinc metal, sodium zincate is obtained with the evolution of hydrogen gas.

$$2\,NaOH + Zn \longrightarrow Na_2ZnO_2 + H_2$$

Sodium zincate

39. 2072 Supp Q. No. 30 Describe the manufacture of caustic soda using Kellner-Solvay process. Write the action of NaOH with

i. Chlorine **ii. Sulphur**

iii. Phosphorous **iv. Zinc.**

Manufacture of Caustic soda using Kellner-Solvay process: Please refer to 2066 Q.No. 29 [6+4]

Action of NaOH with:

i. **Chlorine:** Sodium hydroxide reacts with chlorine, sodium hypochlorite is obtained.

$$2NaOH + Cl_2 \longrightarrow NaCl + NaClO + H_2O$$

Sod. hypochlorite

ii. **Suphur:** Sodium hydroxide reacts with sulphur to give sodium thiosulphate.

$$6NaOH + 4S \longrightarrow 2Na_2S + Na_2S_2O_3 + 3H_2O$$

Sod. thiosulphate

iii. **Phosphorous:** Sodium hydroxide reacts with phosphorous to give phosphine gas

$$P_4 + 3NaOH + 3H_2O \longrightarrow PH_3 + 3NaH_2PO_2$$

Phosphine sod.hypophosphite

iv. **Zinc:** Sodium hydroxide reacts with zinc metal, sodium zincate is obtained.

$$Zn + 2\,NaOH \longrightarrow Na_2ZnO_2 + H_2$$

Sod. zincate

40. 2072 Set C Q.No. 31 2072 Set D Q.No. 31 How is sodium metal extracted by Down's process? Why is the mixture of $CaCl_2$ and KF added to NaCl during the extraction of sodium? How is sodium converted into Na_2SiO_3?

Down's process for the extraction of sodium metal: Please refer to 2063 Q.No. 28 [6+2+2]

In order to lower the temperature of NaCl i.e. melting point of NaCl, the mixture of $CaCl_2$ and KF is added to NaCl. The temperature becomes lower from 815°C to 640°C.

Conversion

Sodium into Na_2SiO_3

$$4Na + O_2 \longrightarrow 2Na_2O$$

$$Na_2O + H_2O \longrightarrow 2NaOH$$

$$2NaOH + CO_2 \longrightarrow Na_2CO_3 + H_2O$$

$$Na_2CO_3 + SiO_2 \xrightarrow[\Delta]{} Na_2SiO_3 + CO_2\uparrow$$

Sod. silicate

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2072 Set E Q.No. 31 **Sketch a neat and well-labelled diagram for the manufacture of sodium carbonate by Solvay's ammonia process. Explain the chemical principle involved. What is the advantage of this process? Write down the molecular formula of (i) soda ash (ii) baking soda (iii) washing soda.** **[6+1+1+1+1]**

Manufacture of Sodium carbonate by Solvay's ammonia process:

Please refer to 2054 Q.No. 22

Advantage of Solvay's ammonia process: Please refer to 2075 Set B Q.No. 31

Chemical formula of

Soda ash: Na_2CO_3

Baking soda: $NaHCO_3$

Washing soda: Na_2CO_3

2071 Supp Q. No. 32 **Describe the principle behind manufacture of sodium hydroxide by Kellner Solvay cell. Also give its properties and uses.** **[6+2+2]**

Manufacture of NaOH by Kellner-Solvay cell: Please refer to 2057 Q.No. 28

Physical properties of NaOH:

It is white deliquescent crystalline solid.

It is highly soluble in water.

Its solution possesses a bitter taste and soapy to touch.

Its melting point is 318°C.

Its density is 2.13 gm/cc.

Chemical properties of NaOH:

Action of air: It absorbs CO_2 from air to give Na_2CO_3.

$$2NaOH + CO_2 \longrightarrow Na_2CO_3 + H_2O$$

Basic nature: It reacts with acids to form salt and water.

$$NaOH + HCl \longrightarrow NaCl + H_2O$$

$$2NaOH + H_2SO_4 \longrightarrow Na_2SO_4 + 2H_2O$$

Action with metal: It reacts with metal to form H_2 gas.

$$Zn + 2NaOH \longrightarrow \underset{\text{Sodium zincate}}{Na_2ZnO_2} + H_2\uparrow$$

$$Al + 2NaOH + 2H_2O \longrightarrow \underset{\text{Sod.meta aluminate}}{2NaAlO_2} + 3H_2\uparrow$$

Action with non-metal: It reacts with non-metal like Cl_2, P, S and B etc.

$$6NaOH + 3Cl_2 \xrightarrow{\Delta} \underset{\text{sod. chlorate}}{NaClO_3} + 5NaCl + 3H_2O$$

$$3NaOH + 4P + 3H_2O \xrightarrow{\Delta} \underset{\text{sod.hypophospite}}{3NaH_2PO_2} + \underset{\text{phosphine}}{PH_3}$$

$$6NaOH + 4S \xrightarrow{\Delta} 2Na_2S + \underset{\text{Sod.thiosulphate}}{Na_2S_2O_3} + 3H_2O$$

$$6NaOH + B \xrightarrow{\Delta} \underset{\text{sod. borate}}{2Na_3BO_3} + 3H_2\uparrow$$

Formation of precipitate: It reacts with metal salt to form ppt.

$$FeSO_4 + 2NaOH \longrightarrow Fe(OH)_2\downarrow + Na_2SO_4$$

$$CuSO_4 + 2NaOH \longrightarrow Cu(OH)_2\downarrow + Na_2SO_4$$

Uses:

It is used as laboratory reagent.

It is used in the manufacture of paper, soaps and artificial silk.

It is used in petroleum refining.

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43. 2070 Supp. Q.No. 31 Give any three points to distinguish alkali metals from alkaline earth metals. How is sodium carbonate manufactured by Solvay-ammonia process? Why is it difficult to get potassium carbonate by this method? [3+6+1]

Following are distinction between alkali metals and alkaline earth metals:

Alkali metals	Alkaline earth metals
The elements of Group IA are called alkali metals.	The elements of Group of IIA are called alkaline earth metals.
The outer most electronic configuration is ns^1	The outer most electronic configuration is ns^2
The oxidation state of alkali metals is +1	The oxidation state of alkaline earth metal is +2

Manufacture of sodium carbonate by Solvay ammonia process: Please refer to 2054 Q.No. 22

Potassium carbonate cannot be prepared by Solvay ammonia process. Sodium bicarbonate ($NaHCO_3$) is sparingly soluble in water whereas potassium bicarbonate ($KHCO_3$) is fairly soluble in water. When carbon dioxide gas (CO_2) is passed through ammoniacal brine (NH_3+NaCl) solution, sodium bicarbonate ($NaHCO_3$) gets precipitated while potassium bicarbonate does not get precipitated when CO_2 gas is passed through ammoniacal brine (NH_3 + KCl). Hence, K_2CO_3 cannot be prepared by Solvay ammonia process.

44. 2070 Set C Q.No. 32 Explain the chemistry of Down's process for the extraction of sodium. What happens when: [6+1.5+1.5+1]

a. Sodium is treated with NH_3

b. Sodium is exposed to moist air.

Why is sodium fire not extinguished by adding water in laboratory?

Down's process for the extraction of sodium: Please refer to 2063 Q.No. 28

a. When sodium reacts with ammonia (NH_3), sodamide is obtained along with liberating hydrogen gas.

$$2NH_3 + 2Na \longrightarrow \underset{\text{Sodamide.}}{2NaNH_2} + H_2\uparrow$$

b. When sodium comes in contact with moist air, sodium removes oxygen from water to form hydrogen gas.

$$2Na + H_2O \longrightarrow \underset{\text{Sodium oxide}}{Na_2O} + H_2\uparrow$$

Sodium fire cannot extinguish by adding water because sodium reacts with water to form inflammable hydrogen gas. Therefore, water is not used to extinguish sodium fire.

45. 2070 Set D Q.No. 30 Sketch a well labeled diagram for the manufacturing of sodium hydroxide and explain the principle involved in the process. How does it react with

a. CO_2 b. Zn [6+2+2]

Write any two uses of sodium hydroxide.

Manufacture of sodium hydroxide: Please refer to 2066 Q.No. 29

Reaction of sodium hydroxide (NaOH) with:

a. **CO_2:** When carbondioxide gas is passed through sodium hydroxide solution, sodium carbonate is obtained.

$$2\,NaOH + CO_2 \longrightarrow Na_2CO_3 + H_2O$$

b. **Zn:** When sodium hydroxide is treated with Zinc metal, sodium zincate is formed with the evolution of hydrogen gas.

$$Zn + 2\,NaOH \longrightarrow \underset{\text{Sodium zincate}}{Na_2ZnO_2} + H_2\uparrow$$

Two use of sodium hydroxide (NaOH):

i. It is used in the refining of oil.

ii. It is used in the manufacture of soap.

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2069 (Set A) Q. No. 30 **Sketch a well labeled diagram for the extraction of sodium by Down's process and explain the principle involved in the process.**
a. Why is sodium metal is kept in kerosene?
b. Alkali metal impart characteristic colour to the flame. Give reason. **[6+2+2]**

Extraction of sodium by Down's process: Please refer to 2063 Q No. 28

When sodium reacts with moist air, sodium hydroxide and hydrogen gas is obtained.

$2Na + H_2O \longrightarrow 2NaOH + H_2 \uparrow$

The reaction is so exothermic reaction that the hydrogen gas liberated burns itself and sodium being lighter floates on the surface of water. The reaction is sometimes so violent that explosion takes place if a piece of sodium is put into water. To overcome this difficulty sodium metal is kept in kerosene oil.

Alkali metals have one electron in outermost shell and having low ionization energy. When alkali metal is heated, the electron present in their outermost shells get excited and the excited electron, when returns back to the original position, emits electromagnetic radiation which gives rise to characteristic colour to the flame. So, alkali metals impart characteristics colour to the flame.

Metal	Colours to the flame
Lithium (Li)	Crimson
Sodium (Na)	Golden yellow
Potassium (K)	Violet
Rubidium (Rb)	Reddish violet
Cesium (Cs)	Blue violet

2069 (Set B) Q. No. 30b **How is sodium extracted by Down's process?** **[5]**

Down's process for extraction of sodium: Please refer to 2063 Q No. 28

2068 Q.No. 32 **Write the chemical principle and stepwise procedure involved in the manufacture of sodium carbonate by Solvay process and sketch a well-labelled diagram for it. What are the merits of this process? Give any two use of sodium carbonate. What happens when washing soda is heated?** **[6+2+1+1=10]**

Manufacture of sodium carbonate by Solvay ammonia process: Please refer to 2054 Q.No 22

Advantage of Solvay ammonia process:

Following are the merits of Solvay ammonia process

i. It is cyclic process.
ii. All the products are reused except calcium chloride.
iii. The raw materials are cheap.
iv. The products obtained are high purity.

Following are the two use of sodium carbonate

It is used for the manufacture of soap and detergents.
It is used for detecting basic radical present in white colored salts.

When hydrated sodium carbonate is heated, anhydrous sodium carbonate is formed.

$Na_2CO_3.10H_2O \xrightarrow{\Delta} Na_2CO_3 + 10\,H_2O$

Hydrated anhydrous Sodium carbonate

2067 Q.No. 32 **Explain the Chemistry of Down's Process of extraction of sodium. What happens when:**
i. Sodium is treated with ammonia
ii. Washing soda is heated.
iii. CO_2 is passed through NaOH solution.
iv. Sodium burns with carbon dioxide.
Why is sodium fire not extinguished by adding water? **[5+1+1+1+1+1]**

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Extraction of Sodium by Down's process: Please refer to 2063 Q.No. 28

i. When sodium reacts with ammonia, sodamide is obtained along with liberating hydrogen gas.

$$2NH_3 + 2Na \longrightarrow \underset{\text{Sodamide}}{2NaNH_2} + H_2\uparrow$$

ii. When washing soda is heated, anhydrous sodium carbonate is obtained.

$$\underset{\text{Washing soda}}{Na_2CO_3.10H_2O} \longrightarrow \underset{\substack{\text{anhydrous}\\ \text{sodium carobonate}}}{Na_2CO_3} + 10H_2O$$

iii. When CO_2 gas is passed through NaOH solution, sodium carbonate is obtained.

$$2\,NaOH + CO_2 \longrightarrow \underset{\text{Sodium carbonate}}{Na_2CO_3} + H_2O$$

iv. When sodium is burnt with carbon dioxide, sodium carbonate is obtained.

$$4Na + 3CO_2 \longrightarrow \underset{\text{Sodium carbonate}}{2Na_2CO_3} + C$$

Sodium fire cannot extinguish by adding water because sodium reacts with water to form inflammable hydrogen gas. Therefore, water is not used to extinguish sodium fire.

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50. 2065 Q. No. 32 Explain the principle and process and write a well labelled diagram for the manufacture of Washing Soda by Solvay's Ammonia process. Write the molecular formula of Baking Soda and Soda ash. How would you convert NaOH into Washing Soda? [7+1+2]

Manufacture of sodium carbonate by Solvay ammonia process: Please refer to 2054 Q.No. 22

Molecular formula of Baking soda: $NaHCO_3$

Molecular formula of soda ash: Na_2CO_3

Conversion: NaOH to Na_2CO_3 (washing soda)

$$2\,NaOH + CO_2 \longrightarrow \underset{\text{Washing soda}}{Na_2CO_3} + H_2O$$

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51. 2062 Q.No. 32 How is sodium extracted by Down's process? Sketch a diagram for Down's cell and write reactions involved. What are the difficulties on obtaining sodium by this process and how are they removed? How does sodium react with: [7+1.5+1.5]

a. Moist air b. NH_3

Extraction of sodium by Down's process: Please refer to 2063 Q.No. 28

Following are the difficulties on obtaining sodium metal by Down's process:

a. Sodium chloride melts at about 815°C which is difficult to maintain.

b. Sodium metal boils at about 883°C, hence at electrolysis, sodium metal is liberated in the form of vapours.

c. At high temperature, molten sodium metal forms a metallic for with the fused sodium chloride. The metallic fog is difficult to remove and may cause short circuit the electrolytic cell.

d. At high temperature, sodium and chlorine are produced during electrolysis will corrode the electrolytic cell.

In order to overcome from these difficulties, the mixture of NaCl, $CaCl_2$ and KF are used which decrease the melting point of sodium metal 640°C. At this temperature sodium metal is liberated smoothly and does not react with iron container. Sodium metal is deposited in a vessel containing kerosene oil.

Reaction of sodium with

a. **Moist air:** When sodium comes in contact with moist air, sodium removes oxygen from water to form hydrogen gas.

$$2Na + H_2O \longrightarrow \underset{\text{Sodium oxide}}{Na_2O} + H_2\uparrow$$

b. **NH_3:** When sodium reacts with ammonia, sodamide is obtained along with liberating hydrogen gas.

$$2NH_3 + 2Na \longrightarrow \underset{\text{Sodamide}}{2NaNH_2} + H_2\uparrow$$

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2061 Q.No. 31 **Describe the manufacture of sodium carbonate by ammonia soda process. Also mention the function of limestone in the manufacturing process.** **[8+2]**

Manufacture of sodium carbonate by Solvay ammonia process: Please refer to 2054 Q.No. 22

Function of limestone ($CaCO_3$): Lime stone is used in carbonation tower for the continuous supply of carbon dioxide and calcium oxide. Calcium oxide i.e. lime is dissolved in water to give lime water which is used for the production of ammonia in ammonia recovery tower.

$$CaCO_3 \xrightarrow[1000^\circ C]{} CaO + CO_2 \uparrow$$

$$CaO + H_2O \longrightarrow Ca(OH)_2$$

$$NH_4Cl + Ca(OH)_2 \xrightarrow[\Delta]{} CaCl_2 + 2NH_3 \uparrow + H_2O$$

2059 Q.No. 30 **Describe the extraction of sodium by Down's process. Write the action of sodium with a. NH_3 b. H_2O** **[6+2+2]**

Down's process for the extraction of Sodium: Please refer to Please refer to 2063 Q.No. 28

Action of Sodium metal on:

NH_3: Sodium reacts with liquid ammonia to form sodamide with the evolution of hydrogen gas.

$$2Na + 2NH_3 \longrightarrow \underset{\text{Sodamide}}{2NaNH_2} + H_2 \uparrow$$

H_2O: Sodium reacts with water to form sodium oxide with the liberation of hydrogen gas.

$$2Na + H_2O \longrightarrow \underset{\text{Sodium oxide}}{Na_2O} + H_2 \uparrow$$

2058 Q.No. 32 **Describe the manufacture of sodium hydroxide stressing on principle and diagrammatic sketch. How does it react with white and red phosphorus?** **[10]**

Manufacture of sodium hydroxide: Please refer to 2066 Q.No. 29

Reaction of NaOH on white P: When NaOH is heated with white phosphorous, phosphine gas is obtained.

$$P_4 + 3NaOH + 3H_2O \longrightarrow \underset{\text{Phosphine}}{PH_3} \uparrow + \underset{\text{Sodium hypophosphite}}{NaH_2PO_2}$$

Reaction of NaOH on Red P: Sodium hydroxide (NaOH) does not react with red phosphorous.

WRITE SHORT NOTES ON

2060 Q.No. 33c **Characteristics of alkali metals** **[5]**

Please refer to 2054 Q.No. 21

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13.2 Alkaline Earth Metals

VERY SHORT ANSWER QUESTIONS:

1. 2075 GIE Q.No. 18 **Mention the bleaching action of bleaching powder.** [2]

Bleaching powder bleaches coloured substance into colourless in the presence of moisture.

$CaOCl_2 + HCl \longrightarrow CaCl_2 + HClO$

$HClO \longrightarrow HCl + [O]$

Coloured substance + $[O] \longrightarrow$ Colourless

2. 2075 Set A Q.No. 18 | 2074 Supp Q.No. 18 | 2067 Q.No. 18 **What happens when** [1+1]
   i. **Gypsum salt is heated at 120°C.**
   ii. **Chlorine gas is passed through slaked lime.**

i. When gypsum salt i.e. $CaSO_4.2H_2O$ is heated at 120°C then plaster of paris is obtained.

$$2CaSO_4.2H_2O \xrightarrow{120^\circ C} (CaSO_4)_2H_2O + 3H_2O$$

Plaster of paris

ii. When chlorine gas is passed through dry slaked lime at about 40°c then bleaching powder is formed.

$Ca(OH)_2 + Cl_2 \longrightarrow CaOCl_2 + H_2O$

Slaked lime Bleaching powder

3. 2074 Set A Q.No. 18 | 2074 Set B Q.No. 18 **What happens when;** [1+1]
   i. **Bleaching powder is treated with dil. H_2SO_4**
   ii. **Gypsum salt is heated above 130°C**

i. When bleaching powder is treated with dil. H_2SO_4, calcium sulphate and hydrochloric acid is obtained.

$$CaOCl_2 + H_2SO_4 \longrightarrow CaSO_4 + 2HCl + [O]$$

ii. When gypsum salt is heated above 130°C, plaster of paris is obtained.

$$\underset{\text{Gypsum salt}}{2CaSO_4.2H_2O} \xrightarrow[\Delta]{130^\circ C} \underset{\text{Plaster of paris}}{2CaSO_4.\frac{1}{2}H_2O} + 3H_2O$$

4. 2073 Supp Q.No. 18 **Give a balanced chemical reaction for the preparation of slaked-lime. How would you obtain lime water from slaked-lime?** [1+1]

When water is added on quick lime, the mass swells up giving hissing sound due to absorption of water with the liberation of heat energy and finally crumbles into white powdered hydroxide known as slaked lime and the process is known as slaking of lime.

$CaO + H_2O \longrightarrow Ca(OH)_2 + 15.5\ Kcal$

Quick lime Slaked lime

Slaked line is sparingly soluble in water. The small amount of lime is dissolved water to make saturated solution. The solution is filtered and the clear filtrate is called lime water.

If large amount of lime is mixed with water to make slurry, it looks like milk and is called as milk of lime which is used as white washing.

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2073 Set C Q. No. 18 What is the action of heat on [1+1]

i. Epsom salt ii. Gypsum salt

Action of heat on

Epsom salt: When Epsom salt is heated at 200°C, anhydrous magnesium sulphate is obtained which on further heating at about 800°C, magnesium oxide is obtained.

$$MgSO_4 \cdot 7H_2O \xrightarrow[\Delta]{150\,^\circ C} MgSO_4 \cdot H_2O + 6H_2O$$

$$MgSO_4 \cdot H_2O \xrightarrow[\Delta]{200\,^\circ C} MgSO_4 + H_2O$$

$$MgSO_4 \xrightarrow[\Delta]{800\,^\circ C} MgO + SO_3$$

Gypsum salt: When gypsum salt is heated at 120°C, plaster of paris is obtained.

$$2CaSO_4 \cdot 2H_2O \xrightarrow[\Delta]{120\,^\circ C} 2CaSO_4 \cdot \frac{1}{2}H_2O + 3H_2O$$

Gypsom salt Plaster of paris

2073 Set D Q. No. 18 Give a balanced chemical reaction for the preparation of slaked lime. How would you obtain lime water from slaked lime? [1+1]

Balanced chemical reaction for the preparation of slaked lime:

$$\underset{\text{Quick lime}}{CaO\,(s)} + H_2O\,(l) \longrightarrow \underset{\text{Slaked lime}}{Ca(OH)_2\,(s)}$$

Slaked lime is white amorphous powder which is sparingly soluble in water. An aqueous suspension of slaked lime in water is called lime water or milk of lime.

$$\underset{\text{Slaked lime}}{Ca(OH)_2\,(s)} \xrightarrow{\text{Water } (H_2O)} \underset{\text{Lime water}}{Ca(OH)_2\,(aq.)}$$

2072 Supp Q. No. 18 **2070 Supp. Q.No. 18** Starting from quick lime, how would you prepare bleaching powder? [2]

When quick lime is treated with water slaked lime is obtained.

$$\underset{\text{Quick lime}}{CaO} + H_2O \longrightarrow \underset{\text{Slaked lime}}{Ca(OH)_2} + 15.5\ Kcal$$

Bleaching powder is prepared by heating slaked lime with chlorine gas.

$$\underset{\text{Slaked lime}}{Ca(OH)_2} + Cl_2 \longrightarrow \underset{\text{Bleaching powder}}{CaOCl_2} + H_2O$$

2072 Set C Q.No. 18 Define the terms: [1+1]

i. dead burnt plaster ii. setting of plaster of paris

When plaster of Paris is heated at 200°C, it forms dead burnt plaster. Calcium sulphate obtained by the over-heating of gypsum is known as dead burnt plaster.

It is the property of setting of plaster of paris in the presence of water to a hard mass within 5-15 minutes. This is due to the formation of gypsum.

$$\underset{\text{Plaster of paris}}{2CaSO_4 \cdot H_2O} + 3H_2O \longrightarrow \underset{\text{Gypsum}}{2[CaSO_4 \cdot 2H_2O]}$$

2071 Supp Q. No. 18 Write down the balanced chemical reaction for the preparation of

a. Quick lime b. Plaster of Paris [1+1]

Quick lime (CaO): It is prepared by heating lime stone ($CaCO_3$) at 1000°C.

$$\underset{\text{Lime stone}}{CaCO_3} \xrightarrow[\Delta]{1000\,^\circ C} CaO + CO_2\uparrow$$

Quick lime

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b. Plaster of Paris: It is prepared by heating gypsum salt at 120°C.

$$\underset{\text{Gypsum Salt}}{2CaSO_4} \xrightarrow[\Delta]{120°C} \underset{\text{Plaster of Paris}}{CaSO_4.\frac{1}{2}H_2O} + 3H_2O$$

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10. 2071 (Set D) Q.No. 18 Define the terms: [1+1]

a. dead burnt plaster **b. available chlorine**

Ans

a. When plaster of Paris is heated at 200°C, it forms dead burnt plaster. Calcium sulphate obtained by the over-heating of gypsum is known as dead burnt plaster.

b. It is defined as the percentage of chlorine made available by bleaching powder when treated with dilute acids. The available chlorine present in bleaching powder sample is determined iodometricaliy by treating its solution with an excess of potassium iodide solution in the acidic medium.

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11. 2066 Q.No. 16 Starting from quick lime, how would you prepare lime water? What is meant by milk of lime? [1+1]

Ans Please refer to 2073 Supp Q.No. 18

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12. 2065 Q. No. 17 Write down a chemical reaction to prepare plaster of paris from gypsum. Why is plaster of paris suitable for immobilising of broken limbs? [2]

Ans When gypsum salt i.e. $CaSO_4.2H_2O$ is heated at 120°C then plaster of paris is obtained.

$$2CaSO_4.2H_2O \xrightarrow{120°C} \underset{\text{Plaster of paris}}{(CaSO_4)_2H_2O} + 3H_2O$$

Due to the formation of hard mass with water, plaster of paris is suitable for immobilizing of broken limbs.

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13. 2064 Q.No. 17 What is meant by slaking of lime? How is lime water prepared from slaked lime? [2]

Ans When water is added to the lime, then a hissing sound i.e. snake sound is produced, due to the absorption of water. From this reaction heat energy is liberated and finally it crubles to give white powder which is known as slaked lime and the process is known as a slaking of lime. On further addition of water, a suspension solution is obtained which is filtered and a clear filtrate solution is known as lime water.

$$\underset{\text{Quick lime}}{CaO} + H_2O \longrightarrow \underset{\text{Slaked lime}}{Ca(OH)_2} + 15.5\ Kcal$$

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14. 2062 Q.No. 16 How is plaster of paris prepared? [2]

Ans When gypsum salt i.e. $CaSO_4.2H_2O$ is heated at 120°C then plaster of paris is obtained.

$$2CaSO_4.2H_2O \xrightarrow{120°C} \underset{\text{Plaster of paris}}{(CaSO_4)_2H_2O} + 3H_2O$$

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15. 2062 Q.No. 28(b) Explain with suitable chemical reactions. [2]

a. Quick lime produces hissing sound when added into cold water.

Ans When water is added to quick lime, some water molecules are vapourized, due to evolution of high amount of heat energy and produce hissing sound. This process is called slaking of lime.

$$\underset{\text{Quick lime}}{CaO} + H_2O \longrightarrow \underset{\text{Slaked lime}}{Ca(OH)_2} + 15.5\ Kcal$$

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16. 2055 Q.No. 19 How is quick lime prepared from marble? Give pertinent equation. [2]

Ans When lime stone i.e. marble is heated then quick lime is obtained with the evolution of carbondioxide gas.

$$\underset{\text{Marble}}{CaCO_3} \xrightarrow[\Delta]{} \underset{\text{quick lime}}{CaO} + CO_2\uparrow$$

17. 2053 Q.No. 21 Group A **Write the chemical formula and one of the uses of Epsom salt, plaster of paris and quick lime.** [1.5]

i. **Epsom salt:** $MgSO_4.7H_2O$
Use: It is used in dye industry, tanning industry or dressing for cotton goods.

ii. **Plaster of paris:** $CaSO_4.\frac{1}{2}H_2O$
Use: It is used in surgical bandages for plastering broken bones.

iii. **Quick lime:** CaO
Use: It is used in building construction.

18. 2051 Q.No. 14 Group A **Name the alkaline earth metals and write their symbols also.** [2]

The alkaline earth metals are Berylium (Be), Magnesium (Mg), Calcium (Ca), Stornium (Sr), Barium (Ba) and Radium (Ra)

19. 2051 Q.No. 16 Group A **Give the formulae of Bleaching powder and blue vitriol.** [2]

Bleaching powder = $CaOCl_2$ and Blue vitriol = $CuSO_4.5H_2O$

SHORT ANSWER QUESTIONS

20. 2076 Set B Q.No. 27 **Give the chemistry of plaster of pairs.** [5]

Plaster of Paris $CaSO_4.\frac{1}{2}H_2O$ **or** $(CaSO_4)_2.H_2O$

Plaster of Paris is calcium sulphate hemihydrates.

Preparation:
It is prepared by heating gypsum salt to 120°C.

$$2\,CaSO_4.2H_2O \longrightarrow 2\,CaSO_4.\frac{1}{2}H_2O + 3\,H_2O$$

Gypsum salt Plaster of paris

Properties:
a. It is a white amorphous powder.
b. When plaster of Paris is treated with water then hard mass is formed within 5–15 minutes which is known as setting of plaster due to rehydration process.

$$(CaSO_4)_2 . H_2O + H_2O \longrightarrow CaSO_4 . 2H_2O$$

Plaster of paris Hard mass plaster

Uses:
a. It used for making status, models and other decorative materials.
b. It is used in surgical bandages i.e. plastering fractured bones.

21. 2076 Set C Q.No. 27 2075 GIE Q.No. 29 2070 Set C Q.No. 27 2058 Q.No. 28 **Write down the chemistry of quick lime.** [5]

Quick lime (CaO) Calcium oxide
It is manufactured by heating lime stone in a vertical and rotary kiln to a temperature of about 800-900°C. This is reversible reaction. Therefore carbon dioxide must be removed from the kiln otherwise reactants are formed.

$$CaCO_3 \rightleftharpoons CaO + CO_2\uparrow$$

The temp. should not exceed 1000°C , Because at high temp. Clay present as impurities combines with lime to give fusible silicate. The lumps of lime stone are fed into the kiln through the hopper. Heating is done by burning coke in fire boxes built at both sides of the kiln. The CO_2 formed is swept away by upward drought. The product is removed periodically from the bottom through discharge door into a lime car.

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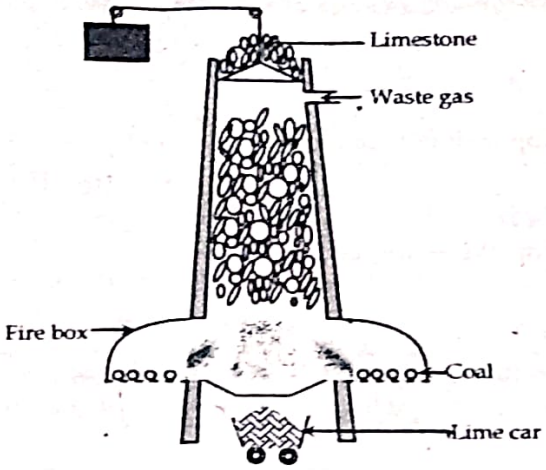


Fig: Lime kiln for the manufacture of quicklime

Properties:

i. It is white, amorphous solid having high melting point of 2597°C.

ii. **Action of heat:** On strong heating at high temperature by oxyacetylene or oxy hydrogen flame, it becomes incandescent and starts emitting brilliant white light called lime light.

iii. **Action of water:** On adding water to lime the mass swells giving hissing sound (due to absorption of water) with the liberation of heat and finally crumbles to give white powder hydroxide. This process is called slaking of lime and product obtained is called slaked lime.

$$CaO + H_2O \longrightarrow \underset{\text{slaked lime}}{Ca(OH)_2} + 15.5\ K\ Cal.$$

Slaked lime is sparingly soluble in water. If small amount of lime is dissolved in water a saturated solution is formed called lime water. Lime water is alkaline in nature and is used to detect the carbon dioxide gas.

$$Ca(OH)_2 + CO_2 \longrightarrow CaCO_3\downarrow$$

If large amount of lime is mixed with a slurry is formed and is used for white washing called milk of lime.

iv. **Action of acid:** Quick lime is basic oxide. So, it reacts with acid or acidic oxide to give salt.

$$CaO + CO_2 \longrightarrow CaCO_3$$
$$CaO + HCl \longrightarrow CaCl_2 + H_2O$$
$$CaO + SiO_2 \longrightarrow CaSiO_3$$

v. **Action of carbon:** When lime is heated with coke to a temperature of about 2000°C, Calcium carbide is formed.

$$CaO + 3C \longrightarrow CaC_2 + CO$$

Uses:

1. For the manufacture of many useful industrial product like Bleaching powder, glass, Washing soda, Caustic soda, Slaked lime etc.
2. For softening of hard water.
3. For white washing.
4. As a flux in metallurgy.
5. As germicide and fungicide
6. In agriculture to reduce soil acidity.

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22. 2075 Set B Q.No. 29 | 2071 (Set C) Q.No. 28 **Write down the chemistry of Epsom salt.** [5]

Epsom salt ($MgSO_4.7H_2O$) Magnesium sulphate heptahydrate

Magnesium sulphate is also known as Epsom salt as it is present in the mineral water of the epsom springs in England called epsomite mineral. It also occurs as Kieserite ($MgSO_4.H_2O$)

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Preparation: $MgSO_4$ is prepared as:

a. By dissolving magnesium metal in dil. H_2SO_4.
$Mg + H_2SO_4 \longrightarrow MgSO_4 + H_2$

b. By the action of dil.H_2SO_4 on magnesia.
$MgO + H_2SO_4 \longrightarrow MgSO_4 + H_2O$

c. By the action of dil.H_2SO_4 on magnesite
$MgCO_3 + H_2SO_4 \longrightarrow MgSO_4 + H_2O + CO_2$

The magnesium sulphate formed upon crystallization, Epsom salt ($MgSO_4.7H_2O$), separates out.

Properties:

i. $MgSO_4.7H_2O$ exists as transparent white crystals which is efflorescent in nature.
ii. It is highly soluble in water.
iii. On hydrolysis, it behaves as weak acid.
$MgSO_4 + H_2O \longrightarrow Mg(OH)_2 + H_2SO_4$
So, it reacts with alkalis to form salt.
$MgSO_4 + NaOH \longrightarrow Mg(OH)_2 + Na_2SO_4$
iv. It is isomorphous with white vitriol ($ZnSO_4.7H_2O$)
v. It forms double salt with alkali metal sulphate ($K_2SO_4MgSO_4.6H_2O$)
vi. On heating to 200°C, It becomes anhydrous. On further heating, it decomposes to form the oxide.

$$MgSO_4 . 7H_2O \xrightarrow[150^\circ C]{} MgSO_4 . H_2O + 6\ H_2O$$

$$MgSO_4 . H_2O \xrightarrow[200^\circ C]{} MgSO_4 + 6\ H_2O$$

$$MgSO_4 \xrightarrow[800^\circ C]{} MgO + SO_3$$

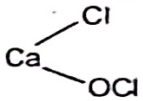
Uses:

i. As a purgative.
ii. In printing, dyeing, soap etc.
iii. In the test of soluble salt.
iv. As laboratory reagent.

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23. 2072 Set C Q.No. 29 | 2072 Set E Q.No. 29 **Write down the chemistry of bleaching powder.** [5]

Bleaching powder



or $CaOCl_2$

Calcium chlorohypochlorite

Preparation

It is prepared by heating chlorine on dry slaked lime at 40°C.

$$Ca(OH)_2 + Cl_2 \xrightarrow{40\ ^\circ C} CaOCl_2 + H_2O$$

Slaked lime — Bleaching powder

Physical properties:

i. It is a pale yellow powder.
ii. It has smell of chlorine gas.
iii. It is soluble in water.

Chemical properties

1. **Action of air:** It reacts with CO_2 of air to give $CaCO_3$ liberating Cl_2 gas.
$CaOCl_2 + CO_2 \longrightarrow CaCO_3 + Cl_2 \uparrow$

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2. **Action of water:** It reacts with cold water to give chloride and hypochlorite.

$$2CaOCl_2 \xrightarrow{\text{cold water}} CaCl_2 + Ca(ClO)_3$$

3. **Action of heat:** It is heated in the presence of $CoCl_2$, $CaCl_2$ and O_2 is obtained.

$$2CaOCl_2 \xrightarrow[\Delta]{CoCl_2} 2\,CaCl_2 + O_2\uparrow$$

4. **Oxidizing agent:** It acts as powerful oxidizing agent.

$CaOCl_2 + HCl \longrightarrow CaCl_2 + HClO$
$HClO \longrightarrow HCl + [O]$
$CaOCl_2 + H_2S \longrightarrow CaCl_2 + H_2O + S$
$CaOCl_2 + 2NH_3 \longrightarrow 3CaCl_2 + 3H_2O + N_2$

5. **Bleaching action:** It bleaches coloured substances to colourless in the presence of moisture.

$CaOCl_2 + HCl \longrightarrow CaCl_2 + HClO$
$HClO \longrightarrow HCl + [O]$
Coloured substance + [O] $\longrightarrow$ colourless

Uses

i. It is used in the manufacture of chloroform.
ii. It is used as oxidizing agent.
iii. It is used as a disinfectant and germicide.
iv. It is used for bleaching clothes.

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24. 2072 Set D Q.No. 29 **Write down the chemistry of lime water.** [5]

➢ Please refer to 2076 Set C Q.No. 27

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25. 2071 Set D Q.No. 28 **Write the chemistry of plaster of pairs.** [5]

➢ Please refer to 2076 Set B Q.No. 27

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26. 2071 Supp Q. No. 32b OR **Describe the preparations, Properties and uses of bleaching powder.** [5]

➢ Please refer to 2072 Set C Q.No. 29

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27. 2070 Set D Q.No. 29 **Give the chemistry of quick-lime. What happens when water is added to quick-lime?** [4+1]

➢ Chemistry of quick lime: Please refer to 2076 Set C Q.No. 27

When water is added to quick lime then slaked lime is formed.

$CaO + H_2O \longrightarrow Ca(OH)_2$
Quick lime — Slaked lime

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28. 2069 (Set B) Q. No. 27 **Give any two characters of alkaline earth metals. How would you obtain**
i. Lime water
ii. Plaster of paris from quick-lime.
Mention any one use of bleaching powder. [2+2+1]

➢ Characteristic of alkaline earth metals:

a. They are divalent elements and are highly electropositive elements.
b. They have oxidation state +2.

i. **Lime water from quick lime:** When water is added to quick lime then slaked lime is formed.

$CaO + H_2O \longrightarrow Ca(OH)_2$
Slaked lime

ii. **Plaster of paris from quick lime:** When quick lime is treated with dil. H_2SO_4 then gypsum salt is formed which on heating at 120°C then plaster of paris is formed.

$CaO + \text{dil. } H_2SO_4 \longrightarrow CaSO_4.2H_2O$
Quick lime — Gypsum salt

$$2(CaSO_4.2H_2O) \xrightarrow[120^\circ C]{} 2[CaSO_4.\tfrac{1}{2}H_2O] + 3H_2O$$
Plaster of paris

One use of bleaching powder: It is used in chlorination and disinfectant of water.

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29. **2068 Q.No. 29** **Give a suitable chemical reaction of each for the preparation of:** **[1+1+1+1+1]**
i. Epsom salt ii. Bleaching powder iii. Quick lime
What happens when water is added to quick lime? What is meant by setting of plaster?

i. Epsom salt: $MgSO_4.7H_2O$

Preparation: $MgSO_4$ is prepared as:

a. By dissolving magnesium metal in dil. H_2SO_4.

$Mg + H_2SO_4 \longrightarrow MgSO_4 + H_2\uparrow$

b. By the action of dil.H_2SO_4 on magnesia.

$MgO + H_2SO_4 \longrightarrow MgSO_4 + H_2O$

c. By the action of dil.H_2SO_4on magnesite

$MgCO_3 + H_2SO_4 \longrightarrow MgSO_4 + H_2O + CO_2\uparrow$

The magnesium sulphate formed upon crystallization, Epsom salt ($MgSO_4.7H_2O$), separates out.

ii. Bleaching powder: $CaOCl_2$ (Calcium Chlorohypochlorite)

Preparation: It is prepared by the action of Chlorine gas on dry slaked lime at a temperature of about 40°C.

$$Ca(OH)_2 + Cl_2 \xrightarrow[40^\circ C]{} CaOCl_2 + H_2O$$

Slaked lime Bleaching powder

iii. Quicklime: CaO

When limestone is heated with coke at 800 – 900°C then powder of quick lime is obtained.

$$CaCO_3 \rightleftharpoons CaO + CO_2\uparrow$$

Quick lime

When water is added to quick lime then slaked lime is formed.

$$CaO + H_2O \longrightarrow Ca(OH)_2$$

Slaked lime

Setting of plaster: When plaster of paris is treated with water then hard mass is formed within 5 – 15 minutes which is known as setting of plaster due to rehydration process.

$(CaSO_4)_2 . H_2O + H_2O \longrightarrow CaSO_4 . 2H_2O$

Plaster of paris Hard mass plaster

30. **2064 Q.No. 28** **Write down the preparation, properties and uses of bleaching powder.** **[5]**

Please refer to **2072 Set C Q.No. 29**

31. **2053 Q.No. 6 Group b** **How is bleaching powder manufactured? Give a neat labelled diagram and reactions involved.** **[5]**

Preparation: It is prepared by the action of Chlorine gas on dry slaked lime at a temperature of about 40°C.

$$Ca(OH)_2 + Cl_2 \xrightarrow[40^\circ C]{} CaOCl_2 + H_2O$$

Slaked lime Bleaching powder

The temperature should be below 40°C otherwise calcium chlorate and calcium chloride will be formed.

Bachmann's Plant: It consists of vertical iron tower with the hopper at the top, to feed lime and two inlets at the bottom. One inlet is for the chlorine gas and other for hot air to be introduced. It has two out lets, one at the bottom for bleaching powder to fall through it and the other near the top for the waste gases. The tower has about eight horizontal shelves fitted with rakes which push down the slaked lime.

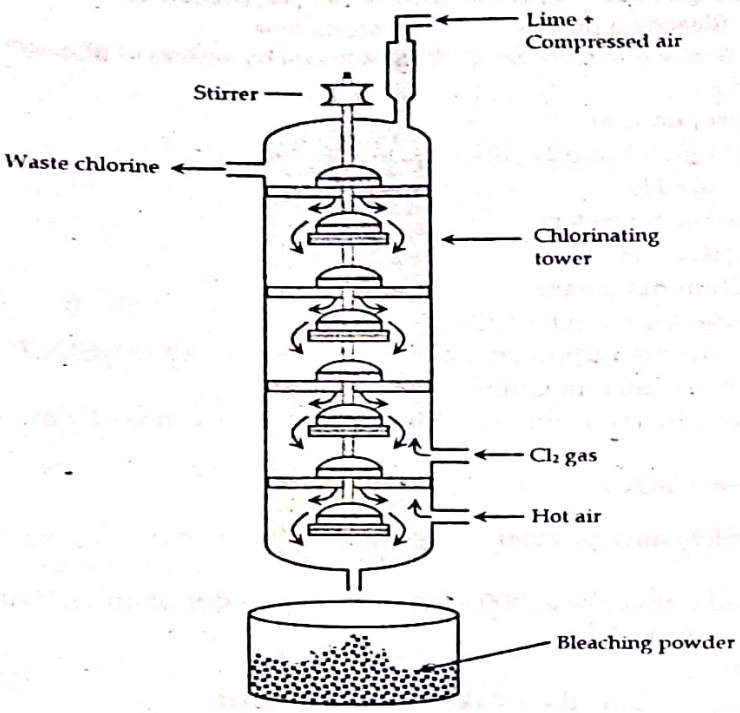


Fig: Preparation of bleaching by Bachmann's process

As the slaked lime moves down. It meets an ascending stream of chlorine gas which converts it to bleaching powder. The unreacted chlorine gas is expelled by the current of dry hot air which escapes from the outlet near the top.

32. 2052 Q.No. 5 Group B Give the characteristics of Alkaline earth metals. [5]

Following are the characteristics of alkaline earth metals:

a. The elements of group IIA of modern periodic table are alkaline earth metals.

i. They are divalent elements and are highly electropositive elements.
ii. They have oxidation state +2.
iii. They are malleable, ductile and good conductor of heat and electricity.
iv. They generally form ionic compounds.
v. They react with hydrogen, oxygen, nitrogen, halogens to form hydride, oxide, nitride, and halides respectively.
vi. They act as reducing agent.

WRITE SHORT NOTES ON

33. 2059 Q.No. 33(b) 2051 Q.No. 4 c Quick lime [5]

Please refer to 2076 Set C Q.No. 27

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Unit 14

Introduction to Organic Chemistry

14.1 Fundamental Principles

VERY SHORT QUESTIONS ANSWERS [2 MARKS]

1. 2072 Supp Q. No. 20 2070 Set D Q.No. 21 **Explain why,**
   i. **Sodium extract is alkaline in nature.** **[1]**
   ii. **Organic compound are combustible.** **[1]**

Ans

i. The unreacted Na-metal present in ignition tube is placed into water during the preparation of sodium extract. Sodium metal reacts with water to form NaOH which makes the solution alkaline. That is why aqueous solution of sodium extract alkaline in nature.

$2Na + 2H_2O \longrightarrow 2Na^+ + 2OH^- + H_2 \uparrow$

ii. Organic compound contains large number of carbon atoms and is made by covalent bond. It is difficult to break bond at ordinary temperature. It requires large amount of heat energy to break the covalent bond. So, organic compound burns in the presence of oxygen and combustion of organic compound is spontaneous process. Hence, organic compounds are combustible in nature.

2. 2071 (Set D) Q.No. 21 **How would you detect the presence of sulphur in the organic compound?** **[1+1]**

Ans To detect the presence of sulphur in the given organic compound, about 1 mL of sodium extract solution is taken in clean and dry test tube. 2–3 drops of sodiumnitroprusside solution is added. The colour of solution becomes violet. This indicates the presence of sulphur in given organic compound.

$$Na_2S + \underset{\text{Sodiumnitroprusside}}{Na_2[Fe(CN)_5NO]} \longrightarrow \underset{\text{Sodiumthionitroprusside (Violet)}}{Na_4[Fe(CN)_5NOS]}$$

3. 2070 Supp. Q.No. 21 **What is the composition of Lassaigne's extract if the organic compound contains nitrogen? Why is it usually alkaline in nature.** **[1+1]**

Ans If the organic compound contains nitrogen as foreign element, the composition of sodium extract or Lassaigne's extract solution becomes

$Na + C + N \longrightarrow \underset{\text{Sodium cyanide}}{NaCN} \rightleftharpoons Na^+ + CN^-$

Sodium extract solution is alkaline in nature: The unreacted Na-metal present in ignition tube is placed into water during the preparation of sodium extract. Sodium metal reacts with water to form NaOH which makes the solution alkaline.

$2Na + 2H_2O \longrightarrow 2Na^+ + 2OH^- + H_2 \uparrow$

4. **2068 Q.No. 22 How would you detect the presence of nitrogen and sulphur together in the organic compound?** [2]

To detect the presence of nitrogen and sulphur in the organic compound, sodium extract is treated with ferric chloride solution,if blood red colour is obtained, that shows the presence of sulphur and nitrogen both.

$Na + C + S + N \xrightarrow{\Delta} NaCNS$ (Sodium thiocyanate)

$3NaCNS + FeCl_3 \longrightarrow Fe(CNS)_3 + 3NaCl$

Ferric thiocyanate(Blood red colour)

5. **2067 Q.No. 21 Why is Lassaigne's extract boiled with concentrated nitric acid while testing for halogen?** [2]

In order to remove the Cyanide (CN^-) and sulphide (S^-) as volatile hydrogen acid, sodium extract is boiled with conc. HNO_3.

$NO_3^- + H^+ + CN^- \longrightarrow HCN \uparrow + NO_3^-$

$2H^+ + 2NO_3^- + S^{2-} \longrightarrow H_2S \uparrow + 2NO_3^-$

If do not boiled with conc.HNO_3, cyanide and sulphide produce also white ppt with $AgNO_3$ solution.

$Ag^+ + CN^- \longrightarrow \underset{\text{White ppt}}{AgCN \downarrow}$

$2Ag^+ + S^{2-} \longrightarrow \underset{\text{White ppt}}{Ag_2S \downarrow}$

6. **2062 Q.No. 22 Why is it necessary to prepare sodium extract for the detection of foreign elements in organic compounds?** [2]

Due to the presence of covalent bond in organic compound, organic compound is generally insoluble in water. To detect the foreign element present in organic compound and to make water soluble, sodium metal is fused with organic compound and foreign elements are changed into their respective ions.

$Na + C + N \longrightarrow NaCN \rightleftharpoons Na^+ + CN^-$

$2Na + S \longrightarrow Na_2S \rightleftharpoons 2Na^+ + S^{2-}$

$Na + C + N + S \longrightarrow NaCNS \rightleftharpoons Na^+ + CNS^-$

$Na + X \longrightarrow NaX \rightleftharpoons Na^+ + X^-$

$(X = Cl^-, Br^-, I^-)$

7. **2059 Q.No. 19 Why is aqueous solution of sodium extract alkaline?** [2]

The unreacted Na-metal present in ignition tube is placed into water during the preparation of sodium extract. Sodium metal reacts with water to form NaOH which makes the solution alkaline. That is why aqueous solution of sodium extract alkaline in nature.

$2Na + 2H_2O \longrightarrow 2Na^+ + 2OH^- + H_2 \uparrow$

8. **2057 Q.No. 19 For detection of elements (N, halogens, S) in organic compounds, why is sodium fusion carried out?** [2]

Due to the presence of covalent bond in organic compound, organic compound is generally insoluble in water. To detect the foreign element present in organic compound and to make water soluble, sodium metal is fused with organic compound and foreign elements are changed into their respective ions.

$Na + C + N \longrightarrow NaCN \rightleftharpoons Na^+ + CN^-$

$2Na + S \longrightarrow Na_2S \rightleftharpoons 2Na^+ + S^{2-}$

$Na + C + N + S \longrightarrow NaCNS \rightleftharpoons Na^+ + CNS^-$

$Na + X \longrightarrow NaX \rightleftharpoons Na^+ + X^-$

$(X = Cl^-, Br^-, I^-)$

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SHORT ANSWER QUESTIONS [5 MARKS]

9. **2075 Set A Q.No. 26 Give the chemistry of the Lassaigne's test for the detection of nitrogen in organic compounds.** **[5]**

Detection of nitrogen by Lassaigne test:

Presence of nitrogen is detected in an organic compound by Lassaigne's method. In this method the organic compound is fused with a piece of sodium in a fusion tube. After complete fusion, the red hot fusion tube is dipped in distilled water contained in a mortar and the whole mass is grinded with a pestle. The hot solution is filtered and the filtrate which is called 'sodium extract' is used for the detection of nitrogen.

The reactions occurs during the process of fusion:

If the organic compound contains nitrogen, sodium cyanide is formed which remains dissolved in the sodium extract.

$$Na + C + N \longrightarrow NaCN$$

Detection of nitrogen:

About 2 ml of sodium extract solution is taken in clean and dry test tube. About 1 ml of freshly prepared ferrous sulphate solution is added to it. The solution is heated and 2 -3 drops of Ferric chloride solution is added. The solution is acidified by adding dil. HCl. The solution becomes bluish green. This indicates the presence of nitrogen in given organic compound.

Reactions:

$$Na + C + N \longrightarrow NaCN$$

$$2NaCN + FeSO_4 \longrightarrow Na_2SO_4 + Fe(CN)_2$$

$$4NaCN + Fe(CN)_2 \longrightarrow \underset{\text{Sodium Ferrocyanide}}{Na_4[Fe(CN)_6]}$$

$$3Na_4[Fe(CN)_6] + 4FeCl_3 \xrightarrow{\text{dil HCl}} \underset{\substack{\text{Ferric ferrocyanide}\\ \text{(bluish green)}}}{Fe_4[Fe(CN)_6]_3} + 12\,NaCl$$

12. **2075 Set B Q.No. 25 What is meant by homologous series? Write a homologous series containing –CHO as functional group. Mention any three important characteristics of homologous series.** **[1+1+3]**

A group of organic compounds, usually listed in order of increasing size, that have a similar structure and whose structure differ only by the number of CH_2 units in the main carbon chain is called homologous series.

The homologous series containing –CHO functional group i.e. Aldehydes are:

General formula: $C_nH_{2n+1}-CHO$

Where, n = number of carbon atom

= 0,1,2,3,4.....etc.

Value of 'n'	Formula	IUPAC name
0	$H-CHO$	Methanal
1	CH_3-CHO	Ethanal
2	CH_3-CH_2-CHO	Propanal
3	$CH_3-CH_2-CH_2-CHO$	Butanal
4	$CH_3-CH_2-CH_2-CH_2-CHO$	Pentanal

Three important characteristics of homologous series are:

1. All the members of a homologous series contain same functional group.
2. All the members of a homologous series have almost similar chemical properties.
3. All the members of a homologous series can be prepared by similar methods, known as general methods of preparation.

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11. 2074 Supp Q.No. 25 2074 Set B Q.No. 26 **Give the chemistry of the Lassaigne's test for the detection of nitrogen in organic Compounds.** **[5]**

Please refer to 2075 Set A Q.No. 26

12. 2074 Set A Q.No. 25 **How would you detect the presence of nitrogen in organic compound by Lassaigne test method.** **[5]**

Please refer to 2075 Set A Q.No. 26

13. 2072 Set C Q.No. 25 2072 Set D Q.No. 25 **What is meant by functional group? Write the functional group of (i) alcohol (ii) ester (iii) acid anhydride (iv) aldehyde. Mention an example of each compound containing these functional group.** **[1+4]**

Function group: Atom or group of atom which shows the properties of an organic compound is called functional group.

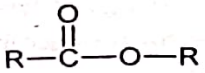
Functional group of following organic compound:

i. **Alcohol:** Hydroxyl group i.e. R – OH group is the functional group of ester. Example:

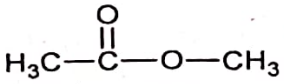
$CH_3 - OH$ — Methyl alcohol

$CH_3 - CH_2 - OH$ — Ethyl alcohol

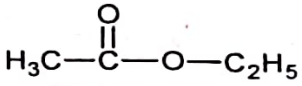
ii. **Ester:** Alkyl alkanoate is the functional group of ester.



Example:

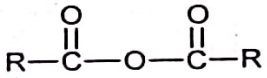


Methyl acetate

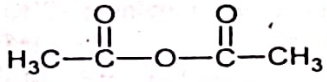


Ethyl acetate

iii. **Acid anhydride:** Anhydride is the functional group of acid anhydride.

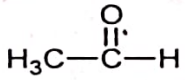


Example:



Acetic anhydride

iv. **Aldehyde:** Formyl group i.e. R—CHO is the functional group of aldehyde. Example:



Acetaldehyde

14. 2072 Set E Q.No. 25 **Why is organic compound fused with sodium metal before testing for foreign elements? Give the Lassaigne's test for nitrogen.** **[1+4]**

Due to the presence of covalent bond in organic compound, organic compound is generally insoluble in water. To detect the foreign element present in organic compound and to make water soluble, sodium metal is fused with organic compound and foreign elements are changed into their respective ions.

$Na + C + N \longrightarrow NaCN \rightleftharpoons Na^+ + CN^-$

$2Na + S \longrightarrow Na_2S \rightleftharpoons 2Na^+ + S^{2-}$

$Na + C + N + S \longrightarrow NaCNS \rightleftharpoons Na^+ + CNS^-$

$Na + X \longrightarrow NaX \rightleftharpoons Na^+ + X^-$

$(X = Cl^-, Br^-, I^-)$

Second part: Please refer to 2075 Set A Q.No. 26

15. **2070 Supp. Q.No. 26** **Define Homologous series and write a series containing -CHO as functional group. What are the structural formulae and IUPAC name of.** **[1+2+2]**

i. **4th member of carboxylic acid**
ii. **1st member of amide**
iii. **3rd member of acid chloride**

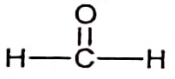
Homologous Series: The series of organic compound having the same general formula and similar chemical properties but different physical properties , one member is differ from other member by single unit $-CH_2$ is known as Homologous series. Each member of homologous series is called "homologoue" and the phenomenon is known as "homology"

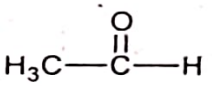
Example: Homologous series of alkene:

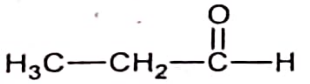
Alkenes are represented by the general formula C_nH_{2n}. The series is obtained by putting n = 2, 3, 4....in the general molecular formula of alkenes.

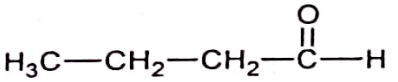
N	Molecular formula	Structural formula	Name
2	C_2H_4	$CH_2=CH_2$	Ethene
3	C_3H_6	$CH_3-CH=CH_2$	Propene
4	C_4H_8	$CH_3-CH_2-CH=CH_2$	But-1-ene
5	C_5H_{10}	$CH_3-CH_2-CH_2-CH=CH_2$	Pent-1-ene
6	C_6H_{12}	$CH_3-(CH_2)_3CH=CH_2$	Hex-1-ene
7	C_7H_{14}	$CH_3-(CH_2)_4CH=CH_2$	Hept-1-ene

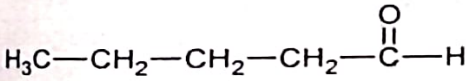
Homologous series containg -CHO functional group.


Methanal


Ethanal

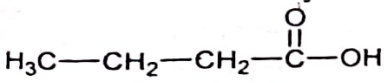

Propanal


Butanal

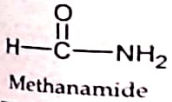

Pentanal

Structural formula and IUPAC name of

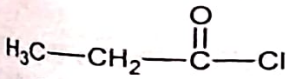
i. **Fourth member of carboxylic acid:**


Butanoic acid

ii. **First member of amide:**


Methanamide

iii. **Third member of acid chloride:**


Propanoyl chloride

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16. 2070 Set C Q.No. 29 **Define Homologous series. What are the characteristic feature homologous series? Give the IUPAC name of the first member of ketone series.** [1+3+1]

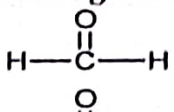
Ans **Homologous Series:** The series of organic compound having the same general formula and similar chemical properties but different physical properties , one member is differ from other member by single unit $-CH_2$ is known as Homologous series. Each member of homologous series is called "homologoue" and the phenomenon is known as "homology"

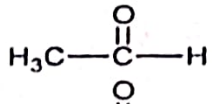
Example: Homologous series of alkene:

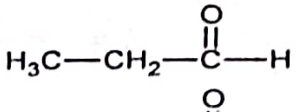
Alkenes are represented by the general formula C_nH_{2n}. The series is obtained by putting n = 2, 3, 4....in the general molecular formula of alkenes.

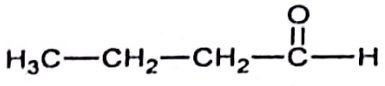
N	Molecular formula	Structural formula	Name
2	C_2H_4	$CH_2{=}CH_2$	Ethene
3	C_3H_6	$CH_3{-}CH{=}CH_2$	Propene
4	C_4H_8	$CH_3{-}CH_2{-}CH{=}CH_2$	But-1-ene
5	C_5H_{10}	$CH_3{-}CH_2{-}CH_2{-}CH{=}CH_2$	Pent-1-ene
6	C_6H_{12}	$CH_3{-}(CH_2)_3CH{=}CH_2$	Hex-1-ene
7	C_7H_{14}	$CH_3{-}(CH_2)_4CH{=}CH_2$	Hept-1-ene

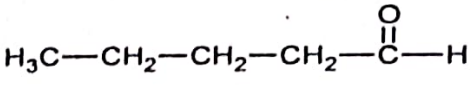
Homologous series containg –CHO functional group.


Methanal


Ethanal


Propanal


Butanal

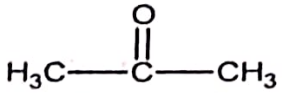

Pentanal

Characteristics of homologous series:

Following are the characteristic of homologous series

i. Each member of homologous series having same functional group.
ii. The general formula of all the members of homologous series is same.
iii. All the member of homologous series has same general method for the preparation.
iv. The physical properties i.e. melting point and boiling point of homologous series show regular increase with increasing molecular weight.
v. One member of homologous series is differed from other than single unit CH_2.

IUPAC name of the first member of ketone series:


Propanone

17. 2070 Set D Q.No. 26 **Define Homologous series and write its important characteristics. What is the IUPAC name of 1st member of ketone?** [1+3+1]

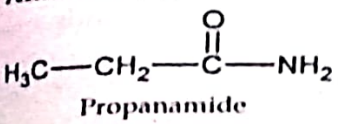
Ans **Homologous Series and Its characteristics:** Please refer to 2070 Set C Q.No. 29

IUPAC name of the first member of ketone series: Please refer to 2070 Set C Q.No. 29

18. 2068 Q.No. 27 What is meant by homologous series? Mention any four characteristics of it and write down the structure formulae of the third member of the following homologous series:
I. Alkanamide II. Alkanol
III. Alkyne IV. Alkanoic acid. [1+2+2=5]

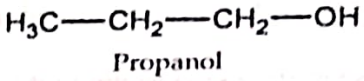
Homologous Series and Its characteristics: Please refer to 2070 Set C Q No. 29
The structure formula of the third member of the following homologous series is given as:

i. Alkanamide



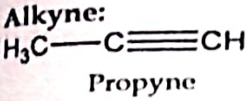
Propanamide

ii. Alkanol



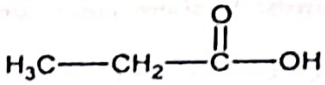
Propanol

iii. Alkyne:



Propyne

iv. Alkanoic acid:



Propanoic acid

19. 2065 Q. No. 29 Define Homologous Series. What are the characteristic features of a homologous series? [1+4]
Homologous Series and Its characteristics: Please refer to 2070 Set C Q No. 29

WRITE SHORT NOTES ON [5 MARKS]

20. 2076 Set B Q.No. 33f 2075 GIE Q.No. 33iii 2071 Supp Q. No. 33b 2066 Q.No. 33 d 2061 Q.No. 33c Detection of nitrogen in the organic compound. [5]
Please refer to 2075 Set A Q No. 26

21. 2076 Set B Q.No. 33iii 2076 Set C Q.No. 33ii 2075 Set A Q.No. 33iv 2074 Supp Q.No. 33(i) 2074 Set A Q.No. 33f 2074 Set B Q.No. 33iv 2073 Supp Q.No. 33f 2073 Set D Q. No. 33 iii 2069 (Set B) Q. No. 33a Characteristics of homologous series. [5]
Please refer to 2070 Set C Q No. 29

22. 2075 GIE Q.No. 33f Homologous series of organic compound. [5]
Please refer to 2070 Supp Q No. 26

23. 2075 Set B Q.No. 33iv 2073 Supp Q.No. 33ii 2073 Set C Q. No. 33iv 2073 Set D Q. No. 33 iv 2072 Set C Q.No. 33d 2072 Set D Q.No. 33d 2071 (Set C) Q.No. 33 (b) 2071 (Set D) Q.No. 33 (d) 2070 Set C Q.No. 33d Lassaigne test of nitrogen. [5]
Please refer to 2075 Set A Q No. 26

24. 2073 Set C Q. No. 33iii Homologous series and its characteristics [5]
Please refer to 2070 Set C Q No. 29

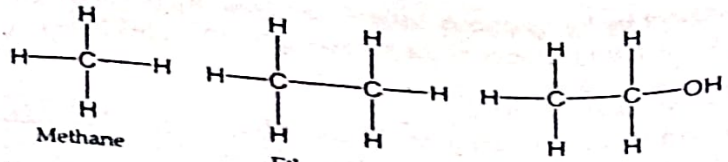
25. 2072 Supp Q. No. 33iii Homologous series of organic compound. [5]
Please refer to 2070 Set C Q No. 29

26. 2072 Set E Q.No. 33ii 2071 Supp Q. No. 33c 2071 (Set C) Q.No. 33 (a) 2069 Set A Q. No. 33c 2064 Q.No. 33(b) 2063 Q.No. 33d 2057, Q.No. 33d Homologous series . [5]
Please refer to 2070 Set C Q No. 29

27. 2071 (Set D) Q.No. 33 (a) Classification of hydrocarbon [5]
Hydrocarbon: Organic compound containing only carbon and hydrogen as the constituent elements are called hydrocarbon.
Classification: The organic compounds are classified into two main types, namely.
Open - chain or acyclic compounds or aliphatic compounds:
The open chain or acyclic compounds are those in which carbon atoms are linked to each other either in linear or branched fashion such that the molecule is having open chain structure. These compounds are also called aliphatic compounds (Greek word: aliphar meaning fat).

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Examples:



2. **Closed chain or cyclic compounds:** Organic compounds with closed chain of atoms are called closed chain compounds or ring compounds.

These compounds are further classified into

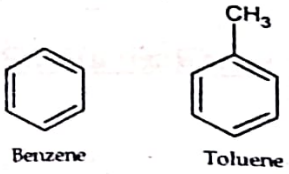
a. Homocyclic or carbocyclic compounds
b. Heterocyclic compounds

a. **Homocyclic compounds:** In these compounds the ring structure is made up of only carbon atoms.

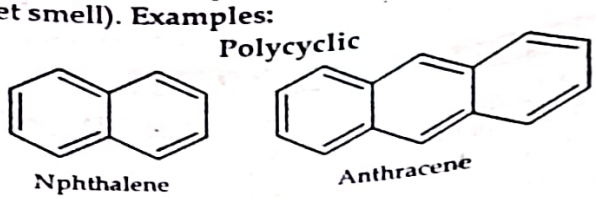
These compounds are further classified into

i. **Aromatic compounds (Benzenoid):** Compounds containing one or more benzene rings in their structure are classified as aromatic benzenoid compounds. Most of these compounds have pleasant odour (Greek: Aroma - sweet smell). **Examples:**

Monocyclic



Polycyclic



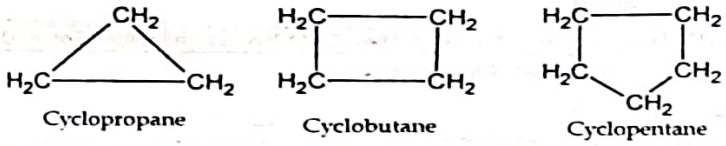
Heterocyclic compounds (Non-benzenoid aromatic): Cyclic compounds in which the ring atoms are made up of hetero atoms like nitrogen, oxygen and sulphur in addition to carbon atoms are called heterocyclic compounds.

Examples:



ii. **Alicyclic compounds:** Cyclic compounds with ring structure containing only carbon atoms are called alicyclic or carbocyclic compounds. Though these compounds possess a ring structure, they behave more like aliphatic compounds.

Examples:



---

28. 2069 (Set A) Q. No. 33d **Detection of foreign element inorganic compound.**

a. **Detection of nitrogen:** Please refer to 2075 Set A Q No. 26

Detection of sulphur: There are two test for sulphur.

i. **Lead acetate test:** Few mL of the sodium extract is taken in a test tube and it is acidified with acetic acid and treated with lead acetate solution. The black ppt is observed. This indicates the presence of sulphur element in the given organic compound.

$2Na + S \longrightarrow Na_2S$

$Na_2S + Pb(CH_3COO)_2 \longrightarrow \underset{\text{Black ppt}}{PbS\downarrow} + 2CH_3COONa$

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Sodium nitroprusside test: Few mL of of the sodium extract is taken in a test tube and treated with aqueous sodium nitroprusside solution. The violet coloured solution is observed. This indicates the presence of sulphur element in the given organic compound.

$$\underset{\text{Sodium nitroprusside}}{Na_2[Fe(NO)(CN)_5]} + Na_2S \longrightarrow \underset{\text{Sod. thionitroprusside Violet solution}}{Na_4[Fe(NOS)(CN)_5]}$$

Detection of halogens:

Silver nitrate test: Few mL of sodium extract is taken in a test tube and it is acidified with dilute HNO_3. The acidified solution is boiled to remove HCN or H_2S completely and thereafter it is treated with $AgNO_3$ solution.

a. Curdy white ppt is observed which is insoluble in HNO_3 but soluble in dil.NH_4OH solution. This indicates the presence of chlorine element present in the given organic compound.
b. Light yellow ppt of AgBr is observed which is insoluble in HNO_3 and insoluble in dil. NH_4OH solution but solution of liquor ammonia. This indicates the presence of bromine element present in the given organic compound.
c. Deep yellow ppt is observed which is insoluble in conc. HNO_3, dil. NH_4OH as well as insoluble in liquor ammonia. This indicates the presence of iodine element present in the given organic compound.

Reaction involved:

$$Na + Cl \longrightarrow NaCl$$

$$NaCl + AgNO_3 \longrightarrow \underset{\text{White ppt}}{AgCl\downarrow} + NaNO_3$$

$$Na + Br \longrightarrow NaBr$$

$$NaBr + AgNO_3 \longrightarrow \underset{\text{Light Yellow ppt}}{AgBr\downarrow} + NaNO_3$$

$$Na + I \longrightarrow NaI$$

$$NaI + AgNO_3 \longrightarrow \underset{\text{Deep yellow ppt}}{AgI\downarrow} + NaNO_3$$

2068 Q.No. 33 c **Detection of sulphur and halogens in organic compound.** **[5]**

Presence of sulphur and halogens is detected in an organic compound by Lassaigne's method. In this method the organic compound is fused with a piece of sodium in a fusion tube. After complete fusion, the red hot fusion tube is dipped in distilled water contained in a mortar and the whole mass is grinded with a pestle. The hot solution is filtered and the filtrate which is called 'sodium extract' is used for the detection of sulphur and halogens.

The reactions occurs during the process of fusion:

If halogens i.e. chlorine, bromine and iodine are present, NaCl, NaBr, and NaI are formed which remain dissolved in the sodium extract.

$$Na + Cl \longrightarrow NaCl$$

$$Na + Br \longrightarrow NaBr$$

$$Na + I \longrightarrow NaI$$

If sulphur is present in the organic compound, Na_2S is formed which remains dissolved in the sodium extract.

$$2Na + S \longrightarrow Na_2S$$

Detection of sulphur and halogen: Please refer to **2069 (Set A) Q. No. 33d**

2066 Q.No. 33 c **Functional group.** **[5]**

Atoms or group of atoms which show the chemical properties of organic compound is known as functional group. All the compounds having same functional group show similar chemical behavior.

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Examples:

Functional Group	Class of compound
-X (-Cl,-Br,-I)	Alkyl halide
-OH	Alcohols
-CHO	Aldehyde
-COOH	Carboxylic acid
-CO	Ketone
-COOR	Ester
-COX	Acyl halide
$-CONH_2$	Amide
$-NO_2$	Nitro compound
-CN	Cyanide
-NC	Isocyanide

Characteristics of functional groups:

i. It determines the physical properties of organic compound.
ii. The chemical properties of organic compound depend upon the functional group present.
iii. The organic compound having different functional group is differed from each other.

---

31. 2058, Q.No. 33(a) sp^3 hybridization

If one s-orbital and three p-orbital of an atom get mixed and undergo hybridization to form four new and equivalent orbital, this type of hybridization is called sp^3-hybridization. In all saturated organic compound, carbon atoms undergo sp^3-hybridization.Exmples: CH_4, C_2H_6, CCl_4, $CHCl_3$, CH_3OH etc.

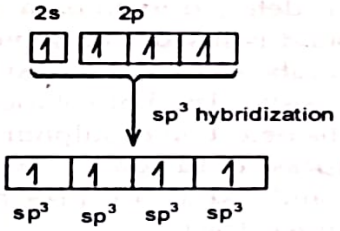
sp^3-hybridization of carbon in the structure of methane:

The electronic configuration of central atom C in methane is

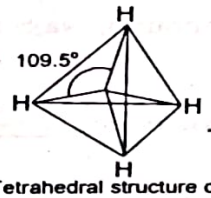
$C_6 = 1s^2 2s^2 2p^2$ [Ground state]

The p-orbital is empty. During bond formation, carbon atom absorbs energy and one 2s electron gets promoted to 2p orbital.

$C_6 = 1s^2 2s^1 2p^3$ [Excited state]



These four sp^3-hybrid orbitals overlap with 1s-orbital of 4 hydrogen atoms to give a methane molecule. These four bonds are directed towards the corners of a regular tetrahedral with bon angle of 109.5°.



Tetrahedral structure of methane

Four sp^3-hybridization orbitals are produced each possessing 25% s-characters and 75% p-characters. They are oriented tetrahedrally with bond angle 109.5°.

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32. 2056, Q.No. 32(a) Homology

Please refer to 2070 Set C Q.No. 29

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4.2 Nomenclature of Organic Compounds

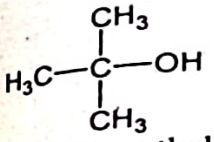
VERY SHORT ANSWERS QUESTIONS [2 MARKS]

2076 Set B Q.No. 19 Give the IUPAC name of the following organic compounds: [1+1]

i. $(CH_3)_3\ C–OH$
ii. $CH_3\ COOCH_3$

The IUPAC name of:

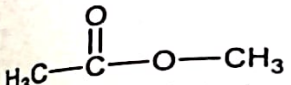
(i)



Word root: Prop
P. Suffix: ane
S. Suffix: 2-ol
Prefix: 2-methyl

IUPAC = 2-methylpropan-2-ol

(ii)



IUPAC = Methylethanoate

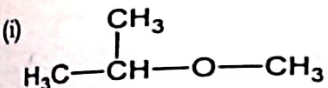
Word root: Eth
P. Suffix: ane
S. Suffix: oate
Prefix: Methyl

2076 Set C Q.No. 19 Give the IUPAC name of the following organic compounds: [1+1]

i. $(CH_3)_2\ CH–OCH_3$
ii. CH_3CONH_2

The IUPAC name

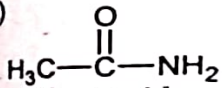
(i)



2-methoxypropane

Word root: Prop
P. Suffix: ane
Prefix: 2-methoxy

(ii)



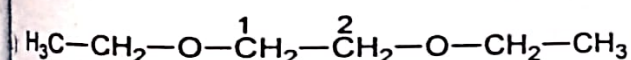
Ethanamide

Word root: Eth
P. Suffix: ane
S. Suffix: amide

2075 GIE Q.No. 19 Give the IUPAC name of the following compounds. [1+1]

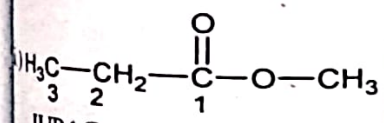
i. $CH_3\text{-}CH_2\text{-}O\text{-}CH_2\text{-}CH_2\text{-}OCH_3$
ii. $CH_3\text{-}CH_2COOCH_3$

The IUPAC name



IUPAC = 1,2-dimethoxyethane

Word root = Eth
P. suffix = ane
Prefix = 1,2-dimethoxy



IUPAC = Methylpropanoate

Word root = Prop
P. suffix = ane
S. suffix = oate
Prefix = Methyl

puspas.com.np

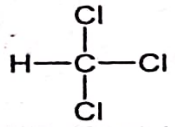
4. **2075 Set A Q.No. 19** **Write down IUPAC name of the following compounds.** [1+1]

i. $CH_3O-CH_2-CH_2-OCH_3$

ii. $CHCl_3$

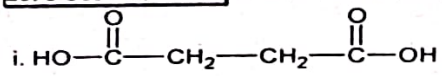
i. $H_3CO-CH_2-CH_2-OCH_3$
IUPAC =1,2-dimethoxyethane

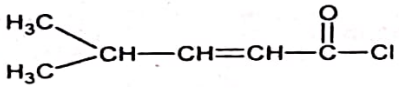
Word root =Eth
P. Suffix = ane
Prefix = 1,2-dimethoxy

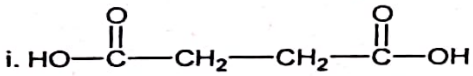
ii. 
IUPAC = 1,1,1-trichloromethane

Word root =Meth
P. Suffix = ane
Prefix = 1,1,1-trichloro

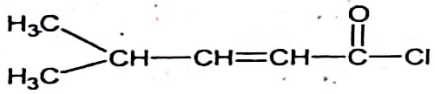
5. **2075 Set B Q.No. 19** **Write down IUPAC name of the following compounds.** [1+1]

i. 

ii. 

i. 
IUPAC: Butane-1,4-dioic acid

Word root: But
P. Suffix: ane
S. Suffix: 1,4-dioic acid

ii. 
IUPAC: 4-methylpent-2-enoyl chloride

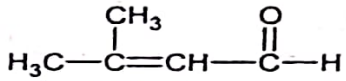
Word root: Pent
P. Suffix: 2-ene
S. Suffix: oyl chloride
Prefix: 4-methyl

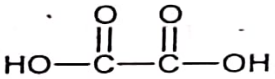
6. **2074 Supp Q.No. 19** **Write down IUPAC name of the following organic compounds.** [1+1]

i. $(CH_3)_2C = CH - CHO$

ii. $COOH$
$|$
$COOH$

The IUPAC name of:

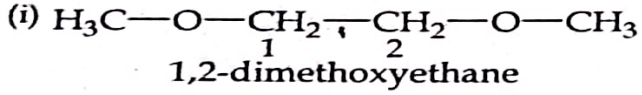
i. 
3-methylbut-2-enal

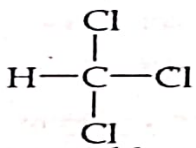
ii. 
Ethane-1,2-dioic acid

7. **2074 Set A Q.No. 19** **Write down IUPAC name of the following organic compounds,** [1+1]

i. $CH_3-O-CH_2-CH_2-O-CH_3$

ii. $CHCl_3$

(i) 
1,2-dimethoxyethane

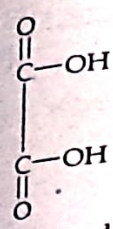
(ii) 
1,1,1-trichloromethane

2074 Set B Q.No. 19 Write down IUPAC name of the following compounds [1+1]

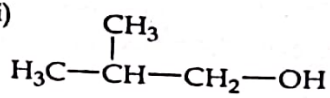
i. $\begin{matrix} COOH \\ | \\ COOH \end{matrix}$

ii. $(CH_3)_2\,CHCH_2\,OH$

The IUPAC name of

(i) 

1,2-ethanedioic acid

(ii) 

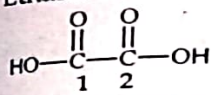
2-methylpropan-1-ol

2073 Supp Q.No. 19 Write down the structure of the following organic compounds. [1+1]

i. **Ethane-1, 2-dioic acid**

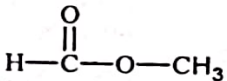
ii. **Methyl methanoate**

Ethane-1, 2-dioic acid



Ethane-1,2-dioic acid

ii. Methyl methanoate



Methyl methanoate

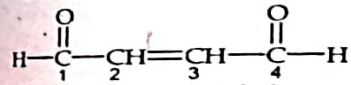
2073 Set C Q. No. 19 Give the structure of the following organic compounds; [1+1]

i. **But-2-ene-1,4-dial**

ii. **Methylmethanoate**

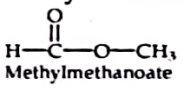
The structure of

But-2-ene-1,4-dial



But-2-ene-1,4-dial

ii. Methylmethanoate



Methylmethanoate

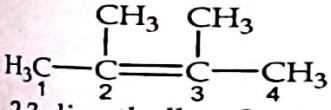
2073 Set D Q. No. 19 Give the structure of the following compounds: [1+1]

i. **2,3-dimethylbut-2-ene**

ii. **Ethylethanoate**

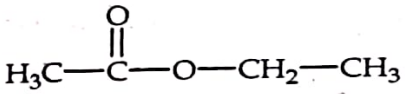
The structure of

2,3-dimethylbut-2-ene:



2,3-dimethylbut-2-ene

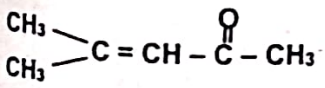
ii. Ethylethanoate:

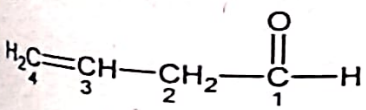


Ethylethanoate

2072 Set C Q.No. 19 Write down IUPAC name of the following compounds: [1+1]

i. $CH_2 = CH - CH_2 - CHO$

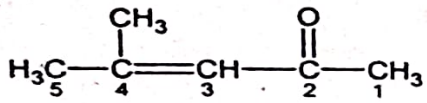
ii. 



Word root = But
P. suffix = -3-ene
S. suffix = -al
IUPAC name = But-3-enal

puspas.com.np

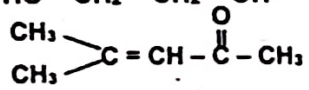
ii.



Word root = pent
Prefix = 4-methyl
P. suffix = -3-ene
S. suffix = –2-one
IUPAC name = 4-methylpent -3-ene–2-one

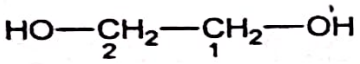
13. **2072 Set D Q.No. 19** **Write down IUPAC name of the following compounds:** [1+1]

i. $HO - CH_2 - CH_2 - OH$

ii. 

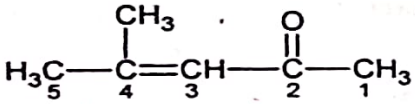
Ans

i.



Word root = Eth
P. suffix = -ane
S. suffix = -1,2-diol
IUPAC name = Ethane-1,2-diol

ii.



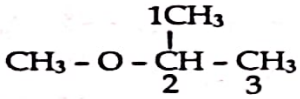
Word root = pent
Prefix = 4-methyl
P. suffix = -3-ene
S. suffix = –2-one
IUPAC name = 4-methylpent -3-en–2-one

14. **2072 Set E Q.No. 19** **Write down IUPAC name of the following compounds:** [1+1]

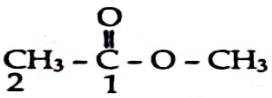
i. $CH_3O - CH(CH_3)_2$ ii. CH_3COOCH_3

Ans

i.



Word root = prop
Prefix = 2-methoxy
P. suffix = –ane
IUPAC name = 2-methoxypropane

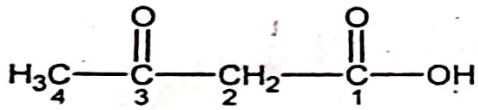
ii. 

Word root = Eth
Prefix = methyl
P. suffix = –ane
S. suffix = -oate
IUPAC name = Methylethanoate

15. **2071 (Set C) Q.No. 19** **Give the IUPAC name of the following compounds:** [1+1]

a. $CH_3—CO—CH_2—COOH$ b. $CH_3—O—CH_2—CH_2—OCH_3$

a.



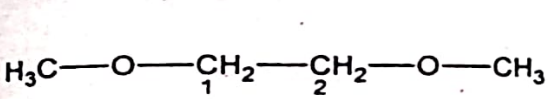
IUPAC = 3-ketobutanoic acid

Word root = But-
Primary suffix = -ane
Secondary prefix = 3-keto
Secondary suffix = -oic acid

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pustaks.com.np

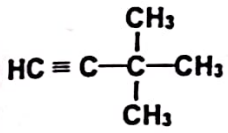
b.

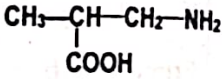


IUPAC = 1,2-dimethoxyethane

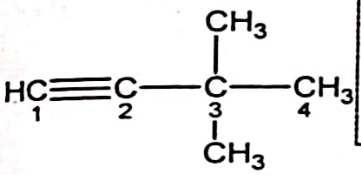
Word root: Eth-
Secondary prefix: 1,2-dimethoxy
Primary suffix: ane

16. **2071 (Set D) Q.No. 19** **Give the IUPAC name of the following compounds.** **[1+1]**

a. 

b. 

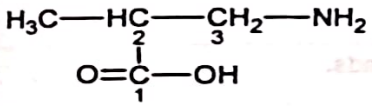
a.



IUPAC = 3,3-dimethylbut-1-yne

Word root: But-
Secondary prefix: 3,3-dimethyl
Primary suffix: 1-yne

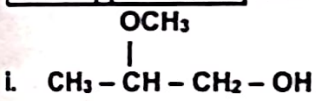
b.

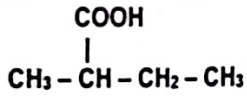


IUPAC = 3-amino-2-methylpropanoic acid

Word root: Prop-
Secondary prefix: 3-amino-2-methyl
Primary suffix: -ane
Secondary suffix: -oic acid

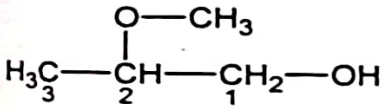
17. **2070 Supp. Q.No. 19** **Write down IUPAC name of the following organic compounds.** **[1+1]**

i. 

ii. 

a.

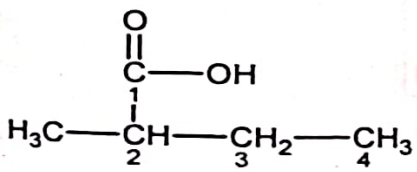
i.



IUPAC = 2-methoxypropan-1-ol

Word root: Prop-
Secondary prefix: 2-methoxy
Primary suffix: ane
Secondary suffix: -1-ol

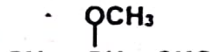
ii.

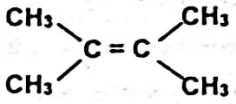


IUPAC = 2-methylbutanoic acid

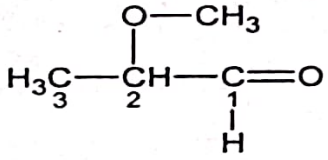
Word root: But-
Secondary prefix: 2-methyl
Primary suffix: ane
Secondary suffix: -oic acid

18. 2070 Set C Q.No. 20 **Write down the IUPAC name of the following compounds.** [1+1]

a. 

b. 

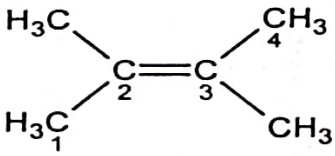
a.



IUPAC = 2-methoxypropanal

Word root = Prop-
Secondary prefix = 2-methoxy
Primary suffix = -ane
Secondary suffix = -al

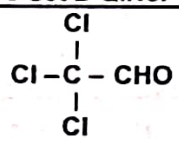
b.



IUPAC = 2,3-dimethylbut-2-ene

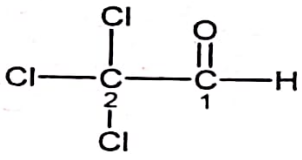
Word root = But-
Primary suffix = -2-ene
Secondary prefix = 2,3-dimethyl

19. 2070 Set D Q.No. 19 **Write down the IUPAC name of the following compounds.** [1+1]

a. 

b. $CHO - CH = CH - CHO$

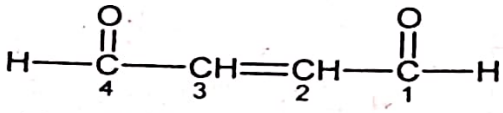
a.



IUPAC = 2,2,2-trichloroethanal

Word root = Eth-
Primary suffix = -ane
Secondary prefix = 2,2,2-trichloro
Secondary suffix = -al

b.

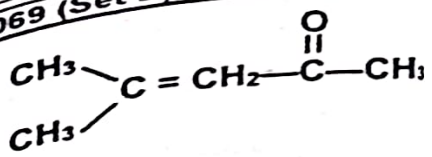


IUPAC = But-2-ene-1,4-dial

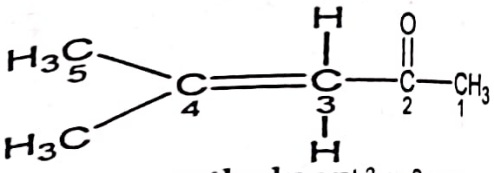
Word root = But-
Primary suffix = -2-ene
Secondary suffix = -1,4-dial

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20. **2069 (Set B) Q. No. 19** Write down the IUPAC name of: [1+1]

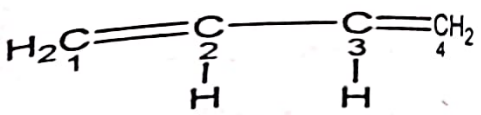
i. 

ii. $CH_2 = CH - CH = CH_2$

(i) 

IUPAC = 4-methylpent-3-en-2-one

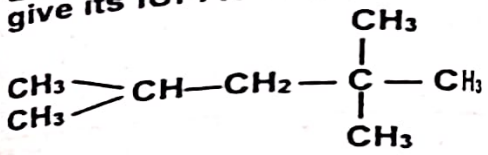
Word root: Pent
Primary suffix: -3-ene
Secondar suffix: -2-one
Prefix: 4-methyl

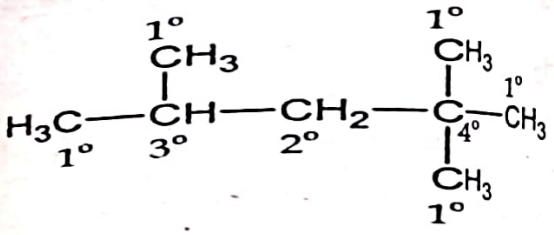
(ii) 

IUPAC = But-1,3-diene

Word root: But
Primary suffix: -1,3-diene

21. **2069 (Set B) Q. No. 20** Indicate the primary, secondary and tertiary carbon of the following hydrocarbon and give its IUPAC name.



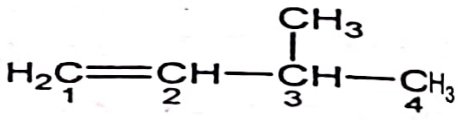


IUPAC = 2,2,4-trimethylpentane

1° = Primary carbon
2° = Secondary carbon
3° = Tertiary carbon
4° = Quarternary carbon

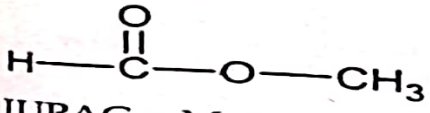
22. **2068 Q.No. 19** Assign the IUPAC name of following compounds:

i. $CH_2 = CH - CH(CH_3)_2$ ii. $HCOOCH_3$



IUPAC = 3-methylbut-1-ene

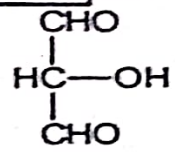
Word root: But
Primary suffix: -1-ene
Prefix: 3-methyl

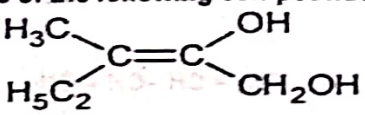


IUPAC = Methylmethanoate

Word root: Meth
Prefix: Methyl
Primary suffix: ane
Secondary suffix:

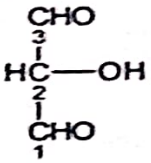
23. 2067 Q.No. 19 Write down the IUPAC name of the following compounds: [1 + 1]

i. 

ii. 

Ans

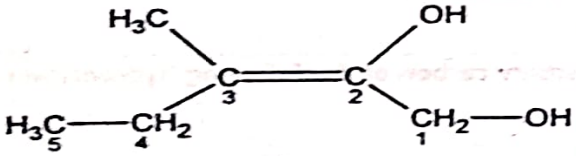
i.



Word root : Prop
Primary suffix: ane
Secondary suffix: 1,3-dial
Prefix: 2-hydroxy

IUPAC = 2-hydroxypropane-1,3-dial

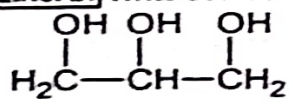
ii.

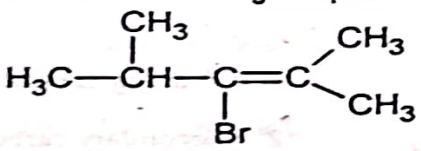


Word root : Pent
Primary suffix: -2-ene
Secondary suffix: -1,2-diol
Prefix: 3-methyl

IUPAC = 3-methylpent-2-ene-1,2-diol

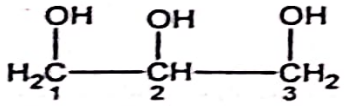
24. 2066 Q.No. 21 Write down the IUPAC name of the following compounds: [1+1]

i. 

ii. 

Ans

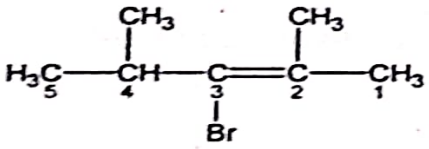
i.



Word root : Prop
Primary suffix: -ane
Secondary suffix: -1,2,3-triol

IUPAC = Propane-1,2,3-triol

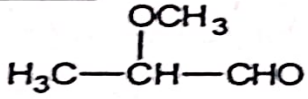
ii.

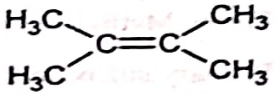


Word root : Pent
Primary suffix: -2-ene
Prefix: 3-bromo-2,4-dimethyl

IUPAC = 3-bromo-2,4-dimethylpent-2-ene

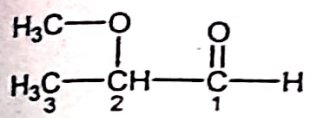
25. 2065 Q. No. 22 Write down the IUPAC name of the following compounds: [2]

a. 

b. 

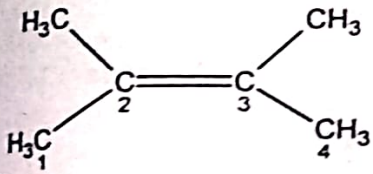
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a.



IUPAC = 2-methoxypropanal

Word root : Prop
Primary suffix: -ane
Secondary suffix: -al
Prefix: 2-methoxy

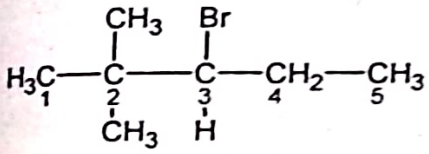


IUPAC = 2,3-dimethylbut-2-ene

Word root : But
Primary suffix: -2-ene
Prefix: 2,3-dimethyl

[2]

2064 Q.No. 21(a) **Write the IUPAC name of $(CH_3)_3$ C CH Br CH_2 CH_3.**

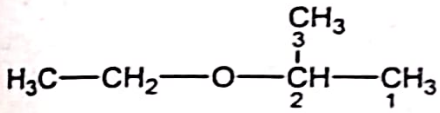


IUPAC = 3-bromo-2,2-dimethylpentane

Word root: Pent
Primary suffix: ane
Prefix: 3-bromo-2,2-dimethyl

[2]

2064 Q.No. 21(b) **Write the IUPAC name of CH_3 CH_2 O $CH(CH_3)_2$.**



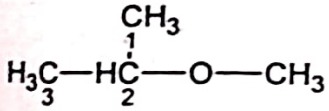
IUPAC = 2-ethoxypropane

Word root: Prop
Primary suffix: ane
Prefix: 2-ethoxy

[2]

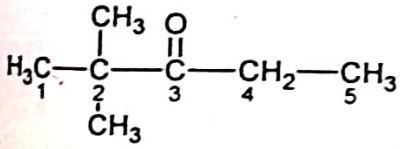
2063 Q.No. 22 **Write the IUPAC name of the following compounds**

i. $(CH_3)_2$ CHO CH_3 **ii. $(CH_3)_3$ C CO CH_2CH_3**



IUPAC =2-methoxypropane

Word root: Prop
Primary suffix: ane
Prefix: 2-methoxy



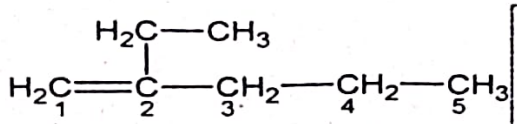
IUPAC = 2,2-dimethylpentan-3-one

Word root: Pent
Primary suffix: ane
Secondary suffix: -3-one
Prefix: 2,2-dimethyl

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29. 2061 Q.No. 22 **Write the structure of the following organic compounds:** [2]
a. 2-Ethylpent -1-ene **b. 2-Chloro-2, 3- dimethylpentane**

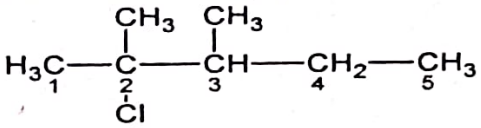
a. 2-ethyl pent-1-ene



IUPAC = 2-ethylpent-1-ene

Word root: Pent
Primary suffix: -1-ene
Prefix: 2-ethyl

b. 2-chloro-2,3-dimethylpentane

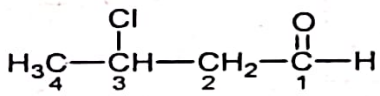


IUPAC = 2-chloro-2,3-dimethylpentane

Word root: Pent
Primary suffix: -ane
Prefix: 2-chloro-2,3-dimethyl

30. 2059 Q.No. 21 **Give the formula of the following organic compounds.** [2]
a. 3 - chlorobutanal **b. 2, 2-dimethylpropane**

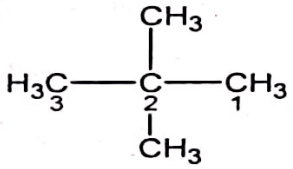
a. 3-chlorobutanal



IUPAC = 3-chlorobutanal

Word root: But
Primary suffix: ane
Secondary suffix: -al
Prefix: 3-chloro

b. 2,2-dimethylpropane

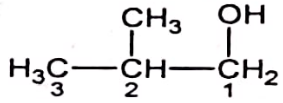


IUPAC = 2,2-dimethylpropane

Word root: Prop
Primary suffix: -ane
Prefix: 2,2-dimethyl

31. 2057 Q.No. 21 **Write the structures of the following organic compounds:** [2]
a. 2 - methylpropan - 1 - ol **b. 3 - methylbutanoic acid**

a. 2-methylpropan-1-ol

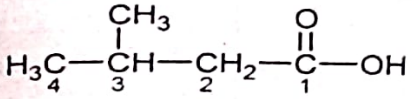


IUPAC = 2-methylpropan-1-ol

Word root: Prop
Primary suffix: ane
Secondary suffix: -1-ol
Prefix: 2-methyl

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[2] b. **3-methylbutanoic acid**



IUPAC = 3-methylbutanoic acid

Word root: But
Primary suffix: ane
Secondary suffix: -oic acid
Prefix: 3-methyl

WRITE SHORT NOTES ON [5 MARKS]

12. 2067 Q.No. 33d **IUPAC rules.** [5]

IUPAC Rules:

The international union of pure and applied chemistry (abbreviated as IUPAC) has done a commendable job in framing set rules for naming organic compounds. Two commonly used systems of nomenclature are described below.

1. Common or Trivial system (2) IUPAC system

[2] **IUPAC Nomenclature of Aliphatic Compounds**

The IUPAC name of a compound essentially consists of three parts.

(a) Root word (b) Suffix (c) Prefix

a. **Root words for alkanes:**

The root words for the first four members are taken from their trivial or common names.

Example:

Meth = for Methane Eth = for Ethane

Prop = for Propane But = for Butane

For the higher homologue, root words are derived from the Greek/Latin number indicating the total number of carbon atoms.

Example:

Pent = is derived from penta for five

Hex = is derived from hexa for six

Hept = is derived from hepta for seven

Oct = is derived from octa for eight

b. **Suffix:**

There are two types of suffixes **Primary suffix** and secondary suffix.

[2] **Primary suffix:**

A primary suffix is added to the **Root word** to indicate whether the parent chain is saturated or unsaturated. Some primary suffixes are given below.

S.No.	Nature carbon chain	Primary Suffix
1.	Saturated	ane
2.	Unsaturated with One double bond Two double bond Three double bond	 ene diene triene
3.	Unsaturated with One triple bond Two triple bond	 yne diyne

Secondary suffix:

Secondary suffix is used to indicate the functional group in the organic compound secondary suffixes for various functional groups are given below.

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S.N.	Class	Functional group	Secondary suffix	IUPAC names
1	Alcohols	-OH	-ol	Alkanol
2	Aldehydes	-CHO	-al	Alkanal
3	Ketones	>C=O	-one	Alkanone
4	Carboxylic acid	-COOH	-oic acid	Alkanoic acid
5	Ester	-COOR	-alkanoate	Alkyl Alkanoate

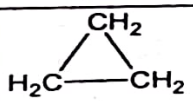
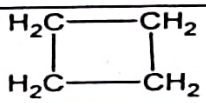
Secondary suffix is added to the primary suffix; ie written after the primary suffix. While adding the secondary suffix to the primary suffix following rules should be followed. If the secondary suffix begins with a vowel, then the terminal e of the primary suffix is dropped before adding the secondary suffix.

If the secondary suffix begins with a consonant, then the last (terminal) e is retained and the secondary suffix is added after e. If the secondary suffix has some numerical prefix, such as, di, tri, etc. before it then the terminal e of the primary suffix is retained.

c. **Prefix:** Prefix is a part of the name which appears before the root word. There are two types of prefixes - primary prefix and secondary prefix.

Primary prefix: A primary prefix is used to distinguish alicyclic (aliphatic cyclic compounds) from acyclic (open chain) compounds. If the given compound is an alicyclic compound, then a prefix cyclo is used just before the root word.

For example

Structure formula	No. of carbon atoms	Word root	Primary Suffix	Primary Prefix	IUPAC name
	3	Prop	ane	Cyclo	Cyclo propane
	4	But	ane	Cyclo	Cyclo butane

Secondary prefix

In the IUPAC system of nomenclature, certain characteristic groups are not considered as functional groups. Such characteristic groups are considered as the **substituents**. Each such group or substituent is denoted by a secondary prefix. Some typical secondary prefixes are listed below.

Substituent Group	Secondary Prefix
-F	Fluoro
-Cl	Chloro
-Br	Bromo
-I	Iodo
$- CH_3$	Methyl
$- C_2H_5$	Ethyl
$CH_3 - CH_2 - CH_2 -$	Propyl
$(CH_3)_2 CH -$	Isopropyl
$(CH_3)_3 C -$	t-Butyl
$- NO_2$	Nitro
$- NH_2$	Amino
- NO	Nitroso
$- OCH_3$	Methoxy
$- OC_2H_5$	Ethoxy

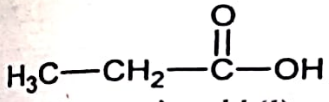
◆

14.3 Structure Isomerism in Organic Compounds

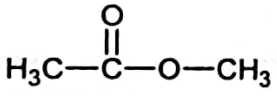
VERY SHORT ANSWER QUESTIONS [2 MARKS]

1. **2075 GIE Q.No. 21 Write down the functional isomer of propanoic acid and give its IUPAC name.** [1+1]

The functional isomer of propanoic acid is methylethanoate.



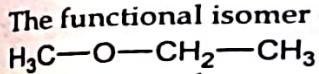
Propanoic acid (I)



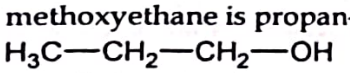
Methylethanoate (II)

2. **2075 Set A Q.No. 22 Write down the functional isomer of (i) Methoxyethane (ii) Propanoic acid and give their structural formula.** [1+1]

i. The functional isomer of methoxyethane is propan-1-ol:

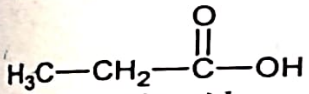


Methoxyethane

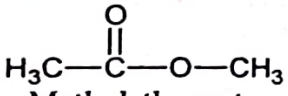


Propan-1-ol

ii. The functional isomer of propanoic acid is methyethanoate:



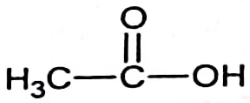
Propanoic acid



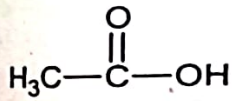
Methylethanoate

3. **2074 Supp Q.No. 22 What is the structural formula of ethanoic acid? Write its functional isomer and IUPAC name.** [1+1]

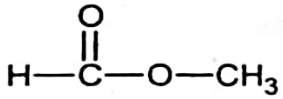
The structure formula of ethanoic acid is



The functional isomer of ethanoic acid is methylmethanoate.



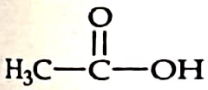
Ethanoic acid



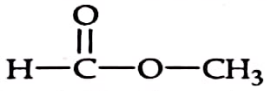
Methylmethanoate

4. **2074 Set A Q.No. 22 Give functional isomers of ethanoic acid and propanone with their structural formula.** [1+1]

The functional isomer of ethanoic acid is methylmethanoate.

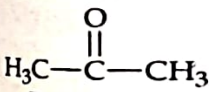


Ethanoic acid

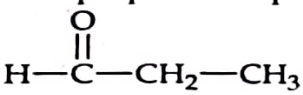


Methylmethanoate

The functional isomer of propanone is propanal.



Propanone



Propanal

[1+1]

5. **2074 Set B Q.No. 22 Write down the functional isomers of**
   i. propan-1-ol ii. methylmethanoate and give their IUPAC name.

The functional isomer of propan-1-ol is methoxyethane



Propan-1-ol Methoxyethane

ii. The functional isomer of methylmethanoate is ethanoic acid.

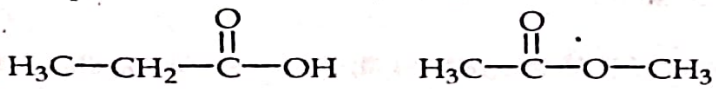


Methylmethanoate Ethanoic acid

---

6. 2072 Supp Q. No. 19 Give possible isomers of $C_3H_6O_2$ and write their IUPAC name. [2]

The possible isomers of $C_3H_6O_2$ are



Propanoic acid Methylethanoate

---

7. 2072 Set C Q.No. 21 Write down the functional isomers of the following compounds and give their IUPAC name: [1+1]

i. $CH_3 - CH_2 CH_2 OH$ ii. $CH_3 - CH_2 - COOH$

i. $CH_3 - CH_2 - CH_2 - OH$ — 1-propanol — Isomer (I)
$CH_3 - O - CH_2 - CH_3$ — methoxyethane — Isomer (II)

ii. $CH_3 - CH_2 - COOH$ — Propanoic acid — Isomer (I)
$CH_3 - COO - CH_3$ — Methyl ethanoate — Isomer (II)

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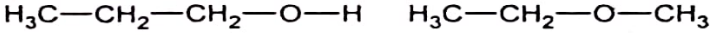
8. 2072 Set D Q.No. 21 Define the terms: Isomerism. [1]

Organic compound having the same molecular formula but different structural formula and hence possessing different properties are called isomers and this phenomenon is called isomerism.

---

9. 2071 Supp Q. No. 19 Give a functional isomer of C_3H_7OH and write it's IUPAC name. [2]

The functional isomers of C_3H_7OH are



Propan-1-ol (Isomer I) Methoxyethane (Isomer I)

---

10. 2070 Set C Q.No. 18 Write the functional isomers of $C_2O_2H_4$ and give their IUPAC name. [1+1]

The isomers of $C_2H_4O_2$

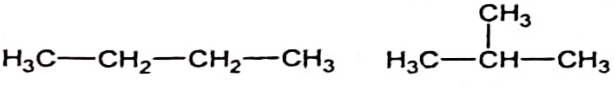


Ethanoic acid Methylmethanoate

---

11. 2069 (Set A) Q. No. 19 Give possible isomers of C_4H_{10} and write their IUPAC name. [1+1]

The possible isomers of C_4H_{10} are



Butane 2-methylpropane

---

12. 2068 Q.No. 20 Write down a functional isomer of $CH_3 - CH_2 - OH$ and give its IUPAC name. [1+1=2]

Functional isomer of $CH_3—CH_2—OH$ is

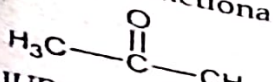
$CH_3—CH_2—OH$ Ethanol

$CH_3—O—CH_3$ Methoxymethane

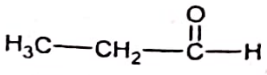
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13. **2066 Q.No. 22** Give the two functional group isomers of C_3H_6O and write their IUPAC name. [1+1]

The functional isomer of C_3H_6O



IUPAC = Propanone



IUPAC = Propanal

14. **2060 Q.No. 19** Write the isomers of $C_2H_4O_2$ and give their IUPAC names. [2]

Please refer to 2070 Set C Q.No. 18

15. **2059 Q.No.20** Write the isomers of C_2H_6O and give their IUPAC names. [2]

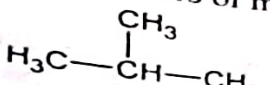
The isomers of C_2H_6O are

CH_3-CH_2-OH Ethanol

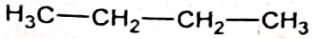
CH_3-O-CH_3 Methoxymethane

16. **2056 Q.No. 19** Write the isomers of C_4H_{10} and give their IUPAC names. [2]

The isomers of molecular formula C_4H_{10} are



2-methylpropane



Butane

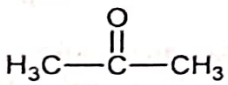
SHORT ANSWER QUESTIONS [5 MARKS]

17. **2067 Q.No. 28** Define isomerism. Write down two structure isomers and their IUPAC names of each of the following: [2.5 × 2]

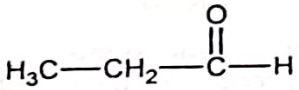
i. C_3H_6O ii. C_4H_8

Isomerism: Organic compound having the same molecular formula but different structural formula and hence possessing different properties are called isomers and this phenomenon is called isomerism.

i. **Structural isomer of C_3H_6O :**

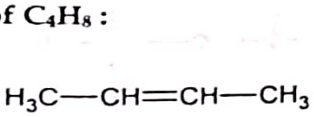


IUPAC = Propanone

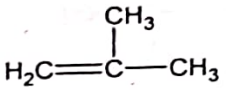


IUPAC = Propanal

ii. **Structural isomer of C_4H_8 :**



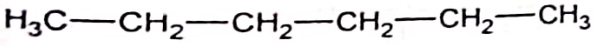
IUPAC = But-2-ene



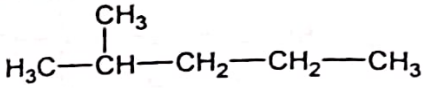
IUPAC = 2-methylpropene

18. **2063 Q.No. 29** Write the possible isomers of C_6H_{14} and give their IUPAC names. [2.5+2.5]

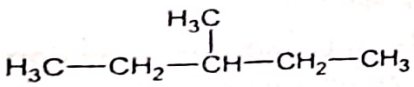
The molecular formula is set in general formula C_nH_{2n+2}. So, the given compound is alkane and having single covalent bond between two carbon atom and show chain isomerism.



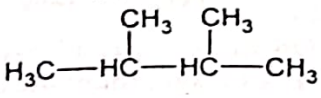
Hexane



2-methylpentane

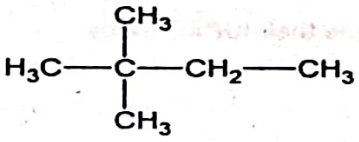


3-methylpentane



2,3-dimethylbutane

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2,2-dimethylbutane

19. 2058 Q.No. 29 **Write down all possible isomers of C_6H_{14} and give their IUPC name.** [5]

Please refer to 2063 Q.No. 29

WRITE SHORT NOTES ON [5 MARKS]

20. 2076 Set C Q.No. 33 | 2070 Supp. Q.No. 33 (d) | 2065 Q. No. 33 c | 2069 (Set B) Q. No. 33b | 2062 Q.No. 33(ii)
Structure isomerism in organic compounds. [5]

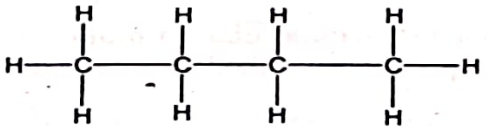
Isomerism: Organic compound having the same molecular formula but different structural formula and hence possessing different properties are called isomers and this phenomenon is called isomerism.

There are two types of isomerism.

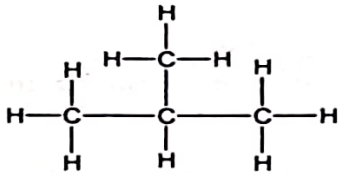
i. Structural isomerism
ii. Stereoisomerism

i. **Structural isomerism:** Organic compound having same molecular formula but different structural formula due to different arrangement of atoms inside their molecules exhibit structural isomerism. There are several types of isomerism.

a. **Chain isomerism:** Organic compound having same molecular formula but having different arrangement of carbon-carbon chains in their molecules are called chain isomers and the phenomenon is called chain isomerism. Example:

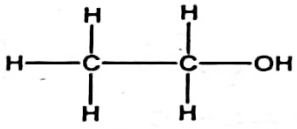


n-butane

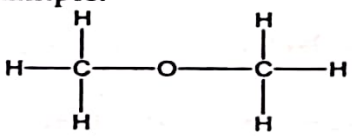


Isobutane

b. **Functional isomerism:** Organic compound having same molecular formula but possessing different functional groups in their molecules are called functional isomers and the phenomenon is called functional isomerism. Example:

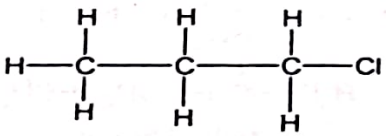


Ethyl alcohol

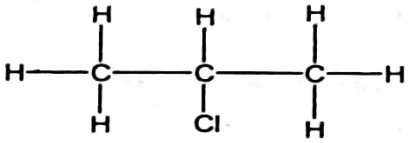


Dimethyl ether

c. **Positional isomerism:** Organic compound having same molecular formula and same functional group attached to different carbon atoms in their molecules are called position isomers and the phenomenon is called position isomerism. Example:



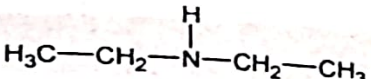
1-chloropropane



2-chloropropane

d. **Metamerism:** Organic compound having same molecular formula and same functional group but having different alkyl groups attached to the functional group are called metamers and the phenomenon is called metamerism. Example:

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Diethyl amine



Methyl n-propyl amine

e. **Tautomerism:** If an organic compound behaves in such a manner as though it possess two or more structural formula the compound is said to be tautomeric and the phenomenon is called tautomerism. Example:



Keto-form of acetyl acetone ⇌ Enol-form of acetyl acetone

21. **2070 Set D Q.No. 33b Isomerism in organic compound. (Structure isomer only)** [5]

Please refer to 2076 Set C Q.No. 33

22. **2057 Q.No. 33(c) Isomers of C_6H_{14}** [5]

Please refer to 2063 Q.No. 29

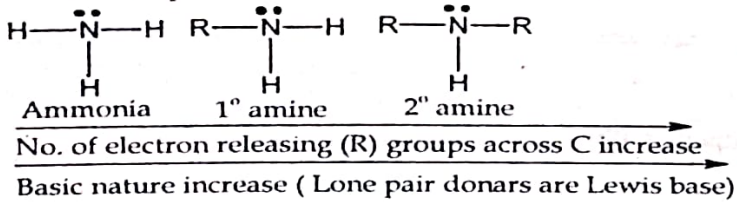
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14.4 Preliminary Idea of Reaction Mechanism

VERY SHORT QUESTIONS ANSWERS [2 MARKS]

1. 2076 Set B Q.No. 20 **Define inductive effect and write its one use.** [1+1]

An inductive effect is an electronic effect due to the polarisation of σ bonds within a molecule or ion. This is typically due to an electronegatvity difference between the atoms at either end of the bond. It is used to explain the basic nature of amines.



2. 2076 Set C Q.No. 20 **What are electrophiles? Write any two examples.** [1+1]

Electrophiles are atoms or molecules known to be electron deficient and that carry a partial (or fully) positive charge and will seek an electron pair to forma covalent bond. Example: CH_3^+, Cl^+

3. 2075 Set B Q.No. 21 **Define the terms.** [1+1]
   i. **Inductive effect**
   ii. **Electrophile**

i. **Inductive effect**: Inductive effect is the displacement of bonding electrons due to difference in electronegativity of bonding atoms leading to the development of polarity in bonds. It increases the acidity of carboxylic acid.

ii. **Electrophile**: The positively charge species which are able to attract towards the electron is known as electrophile. It is also known as electron loving. Example: Br^+,Cl^+

4. 2073 Supp Q.No. 20 **Define inductive effect and give its an important application.** [1+1]

Please refer to 2075 Set B Q.No. 21

5. 2073 Set C Q. No. 20 **What is an electrophile? Give an example of it.** [1+1]

Please refer to 2075 Set B Q No. 21

6. 2073 Set D Q. No. 20 **How is an electrophile differed from nucleophile? Give a suitable example of each.** [1+1]

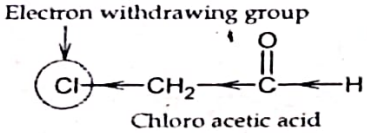
Electrophile is positively charged species which are able to attract towards electron while nucleophile is negatively charged species which are able to attract towards nucleus. Electrophile is electron loving while nucleophile is nucleus loving.
Electrophile: Example; Cl^+, Br^+, $AlCl_3$, BF_3 etc.
Nucleophile: Example; Br^-, Cl^-, H_2O, NH_3 etc.

7. 2071 Supp Q. No. 20 **Explain nucleophiles giving examples.** [1+1]

The positively charge species which are able to attract towards the electron is known as electrophile. It is also known as electron loving. Examples: Cl^+, Br^+, NO_2^+, SO_3H^+, etc.

8. 2071 (Set C) Q.No. 21 **What is meant by inductive effect? Give its one application.** [1+1]

The displacement of sigma electron pair towards the more electronegative atom or group of atoms, inducing polarity is called inductive effect. Inductive effect can be applied to compare the acidic or basic strengths of organic compounds. Chloro acetic acid is stronger than acetic acid because the chloro acetic acid undergoes – I effect due to the presence of electron withdrawing chloro group.



Chloro acetic acid

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9. 2069 Set B Q. No. 21 **What is meant by electrophile? Write suitable example of it.** [1+1]

Please refer to 2075 Set B Q.No. 21

10. 2065 Q. No. 20 **Distinguish between electrophile and nucleophile with an example of each.** [2]

Following are the distinction

Electrophile	Nucleophile
The positively charged species which are able to attract towards electron is known as electrophile. It is also known as electron loving.	The negatively charged species which are able to attract towards nucleus is known as nucleophile. It is also known as nucleus loving.
Example: H^+, Br^+, Cl^+, $AlCl_3$, BF_3 etc	Example: Br^-, Cl^-, OH^-, H_2O, NH_3 etc

11. 2061 Q.No. 21 2057 Q.No. 22 2056 Q.No.20 **Define electrophile and nucleophile giving one example from each.** [2]

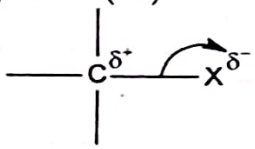
Electrophile: The Lewis acid that accepts a pair of electrons is called electrophile. Example: BF_3

Nuleophile: The Lewis base that donates a pair of electrons is called nucleophile. Example: CN^-

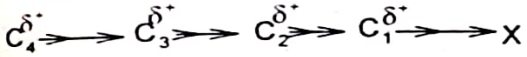
WRITE SHORT NOTES ON [5 MARKS]

12. 2072 Supp Q. No. 33iv **Inductive effect.**

The electron cloud in a sigma bond (σ) between two unlike atoms in not uniform. It is more dense towards the more electronegative of the two atoms i.e. the electron pair forming the sigma bond is slightly displaced towards X, this permanent state of polarization is called the inductive effect. It is represented by arrow (→)

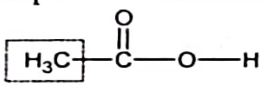


The atom X thus acquires a slight negative charge (δ–) and the carbon atom a slight positive charge (δ+) i.e. the bond is polarized. If the electronegative atom is joined to a chain of carbon atoms, the positive charge on the carbon atom is related to the other carbon atoms.



Depending upon the nature of groups attached to the carbon chain, there are two types of inductive effect.

Positive inductive effect or + I effect : If the group attached to carbon atom in the carbon chain is less electronegative than carbon, the carbon atom gets partial negative charge and group gets partial positive charge because the bonding electrons are displaced towards carbon atom. Such inductive effect is known as positive inductive effect. Examples: $-CH_3$, $-COO^-$, $-CH_2R$, $-CR_3$ etc.



Electron releasing group

Negative inductive effect or + I effect: If the groups attached to carbon atom in carbon chain are more electronegative, the bonding pair are mostly displaced towards more electronegative atom. Carbon atom acquires a partial positive charge and other atom acquires partial negative charge. Such inductive effect is called as negative inductive or – I effect. Examples: $-NO_2$, CN, -COOH, -F, -Cl, -I, -OR, -OH etc.



Electron withdrawing group

13. 2063 Q.No. 33(c) **Inductive effect**

Please refer to 2072 Supp Q. No. 33iv

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Unit 15

Hydrocarbons

15.1 Sources

VERY SHORT ANSWER QUESTIONS [2 MARKS]

1. 2075 GIE Q.No. 22 2072 Set D Q.No. 21ii **Define octane number.** [2]

It is defined as the percentage of iso-octane by volume in a mixture of iso-octane and n-heptane which has same anti-knocking properties as the fuel under examination.

2. 2072 Supp Q. No. 21 **What do you understand by anti-knocking agent? Give an example of it.** [2]

The chemical compound which reduce the knocking property of fuel when added to the gasoline or petrol or improve the octane number is called anti-knocking agent.
Example: Iron carbonyl, Tetraethyl lead (TEL)

3. 2072 Set E Q.No. 21 **Define the terms:** [1+1]
   i. **octane number**
   ii. **gasoline additive**

i. **Octane number:** It is defined as the percentage of iso-octane by volume in a mixture of iso-octane and n-heptane which has same anti-knocking properties as the fuel under examination.

ii. **Gasoline additive:** The chemical compound which reduce the knocking property of fuel when added to the gasoline or petrol or improve the octane number is called anti-knocking agent or gasoline additives.

4. 2071 (Set C) Q.No. 22 **Define antiknocking agent and write an example of it.** [1+1]

The chemical compound which reduce the knocking property of fuel when added to the gasoline or petrol or improve the octane number is called anti-knocking agent.
Example: Iron carbonyl, Tetraethyl lead (TEL)

5. 2071 (Set D) Q.No. 22 **Define gasoline additive and give an example of gasoline addative.** [1+1]

The chemical compound which reduce the knocking property of fuel when added to the gasoline or petrol or improve the octane number is called anti-knocking agent or gasoline additives.
Example: Iron carbonyl, Tetraethyl lead (TEL).

6. 2070 Set C Q.No. 9 2070 Set D Q.No. 22 2067 Q.No. 22 **What is the function of Tetraethyl Lead (TEL) in gasoline?** [2]

When TEL i.e. Tetraethyl lead is added to the gasoline, it improves the quality of gasoline by increasing its octane number.

7. **2066 Q.No. 20 Which terminology is used to grade the quality of fuel? Define the terminology.** [1+1]

The octane number is used to grade the quality of a fuel. Higher the value of octane number, better the quality of fuel. Generally all the fuel that have octane number 80 or above are graded as good fuel. Octane number is defined as the percentage of iso-octane by volume in the given mixture of iso-octane and n-heptane which has the same antiknocking properties as the fuel under examination.

8. **2065 Q. No. 21 What are anti-knocking agents? Name one important anti-knocking agent.** [2]

Please refer to 2072 Supp Q. No. 21

9. **2064 Q.No. 19 What is meant by the octane number of a fuel is 80?** [2]

It means fuel has 80% anti-knocking property and 20% mixture of iso-octane and heptanes.

10. **2062 Q.No. 19 A fuel has octane number 80. What does it mean?** [2]

Please refer to 2064 Q.No. 19

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15.2 Alkanes

VERY SHORT ANSWER QUESTIONS [2 MARKS]

1. 2076 Set B Q.No. 22 **Write suitable chemical reaction for the preparation of methane from**
   i. **Sodium ethanoate (CH_3COONa)**
   ii. **Methyl magnesium iodide (CH_3MgI).** **[1+1]**

Preparation of methane from:

i. **Sodium ethanoate (CH_3COONa):** When sodium ethanoate is heated with soda lime (NaOH + CaO), methane gas is obtained.

$$\underset{\text{Sod. ethanoate}}{H_3C-\overset{\overset{O}{\|}}{C}-OCH_3} \xrightarrow[\Delta]{NaOH + CaO} \underset{\text{Methane}}{CH_4} + Na_2CO_3$$

ii. **Methyl magnesium iodide (CH_3MgI):** When methyl magnesium iodide is treated with water, methane is obtained.

$$\underset{\text{Methyl magnesium iodide}}{H_3C-MgI} + H_2O \longrightarrow \underset{\text{Methane}}{CH_4} + Mg(OH)I$$

---

2. 2076 Set C Q.No. 21 **Identify Ⓐ and give its IUPAC name.** **[2]**

$$\begin{matrix}CH_3\\CH_3\end{matrix}>CH-Br \xrightarrow[\Delta]{Na\ /\ dryether} Ⓐ$$

The reaction sequence is given as:

$$\underset{\text{2-bromopropane}}{\begin{matrix}H_3C\\H_3C\end{matrix}>CH-Br} + \underset{\text{2-bromopropane}}{Br-HC<\begin{matrix}CH_3\\CH_3\end{matrix}} \xrightarrow[\Delta]{Na\ /\ Dry\ ether} \underset{\text{2,3-dimethylbutane}}{\begin{matrix}H_3C\\H_3C\end{matrix}>CH-HC<\begin{matrix}CH_3\\CH_3\end{matrix}}$$

---

3. 2074 Supp Q.No. 20(ii) 2074 Set B Q.No. 20ii 2069 Set A Q. No. 22a **Write an example of each of the followings:**
   Wurtz reaction **[1]**

Two molecules of chloroethane react with sodium metal in the presence of dry ether, n-butane is formed.

$$\underset{\text{Chloroethane}}{H_3C-CH_2-Cl} + 2Na + \underset{\text{Chloroethane}}{Cl-CH_2-CH_3} \xrightarrow{Dry\ Ether} \underset{\text{n-Butane}}{H_3C-CH_2-CH_2-CH_3} + 2NaCl$$

---

4. 2074 Set A Q.No. 20 **Write reaction for the preparation of Methane from,** **[1+1]**
   i. **CH_3MgBr**
   ii. **CH_3COONa**

i. When methyl magnesium bromide (CH_3MgBr) is treated with cold water, methane is obtained.

$$\underset{\text{Methyl magnsium bromide}}{H_3C-MgBr} + H_2O \longrightarrow \underset{\text{Methane}}{CH_4} + Mg(OH)Br$$

ii. When sod. Acetate is heated with soda-lime, methane is obtained.

$$\underset{\text{Sod. Acetate}}{H_3C-\overset{\overset{O}{\|}}{C}-ONa} + NaOH \xrightarrow[\Delta]{CaO} \underset{\text{Methane}}{CH_4} + Na_2CO_3$$

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5. 2073 Supp Q.No. 22 **How is methane prepared from** [1+1]
   i. CH_3MgBr
   ii. $CH_3COO\ Na$

i. When methyl magnesium bromide is treated with cold water, methane is obtained.

$$H_3C—MgBr + H_2O \longrightarrow CH_4 + Mg(OH)Br$$

Methyl magnesium bromide — Methane

ii. When sodium acetate is heated with soda-lime (NaOH+CaO), methane gas is obtained.

$$H_3C—\overset{\overset{O}{\|}}{C}—ONa + NaOH \xrightarrow[\Delta]{CaO} CH_4 + Na_2CO_3$$

Sodium acetate — Methane

6. 2073 Set C Q. No. 22 2073 Set D Q. No. 22 **How would you prepare methane from** [1+1]
   i. **Chloromethane**
   ii. **Sodium ethanoate**

i. **Methane from chloromethane:** When chloromethane is reduced with reducing agent Ni/H_2, methane is obtained.

$$H_3C—Cl \xrightarrow[2[H]]{Ni/H_2} CH_4$$

Chloromethane — Methane

ii. **Methane from sodium ethanoate:** When sodium ethanoate is heated with soda-lime (NaOH + CaO), methane is obtained.

$$H_3C—\overset{\overset{O}{\|}}{C}—ONa \xrightarrow[\Delta]{NaOH + CaO} CH_4 + Na_2CO_3$$

Sodium ethanoate — Methane

7. 2072 Set C Q.No. 20i **Write an example of each of the following: decarboxylation reaction**

When sodium salt of carboxylic acid is heated with sodalime i.e. NaOH + CaO, alkane is formed. This reaction is called decarboxylation reaction.

$$H_3C—\overset{\overset{O}{\|}}{C}—ONa + NaOH \xrightarrow[\Delta]{CaO} CH_4 + Na_2CO_3$$

Sod.acetate — Methane

8. 2072 Set D Q.No. 22ii 2062 Q.No.20 **What happens when sodium acetate is heated with soda-lime?** [1]

When sodium acetate is heated with soda-lime, methane is obtained.

$$H_3C—\overset{\overset{O}{\|}}{C}—ONa + NaOH \xrightarrow[\Delta]{CaO} CH_4 + Na_2CO_3$$

Sod.acetate — Methane

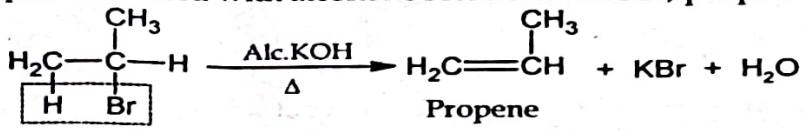
9. 2072 Set E Q.No. 20 **What products would you expect when 2-bromopropane is heated** [1+1]
   i. **with Na/dry ether**
   ii. **with alc. KOH**

When 2-bromopropane is heated with sodium metal in the presence of dry ether, 2,3 - dimethylbutane is obtained.

$$H_3C—\overset{\overset{CH_3}{|}}{CH}—Br + 2\,Na + Br—\overset{\overset{CH_3}{|}}{CH}—CH_3 \xrightarrow[\Delta]{Dry\ ether} H_3C—\overset{\overset{CH_3}{|}}{CH}—\overset{\overset{CH_3}{|}}{CH}—CH_3 + 2\,NaBr$$

2-bromopropane — 2-bromopropane — 2,3-dimethylbutane

ii. When 2-bromopropane is heated with alcoholic solution of KOH, propene is obtained.

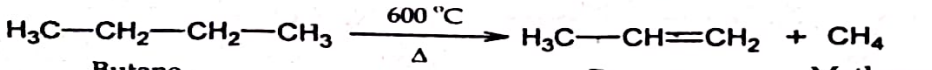


2-bromopropane Propene

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10. 2071 Supp Q. No. 22 What is cracking of petroleum? [2]

When long chain alkanes are heated above boiling point with or without a catalyst to form lower members of alkanes, alkenes and hydrogen is called cracking of petroleum.

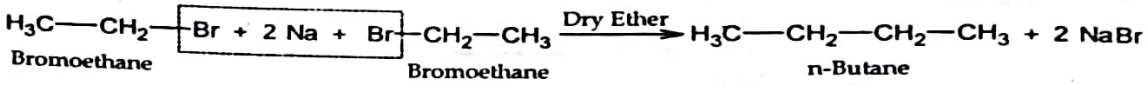


Butane Propene Methane

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11. 2070 Set C Q.No. 17 2066 Q.No. 19a Write the chemical reaction when, Bromoethane is heated with sodium metal in presence of dry ether. [2]

When bromoethane is heated with sodium metal in the presence of dry ether, butane is formed. This reaction is known as **Wurtz reaction.**

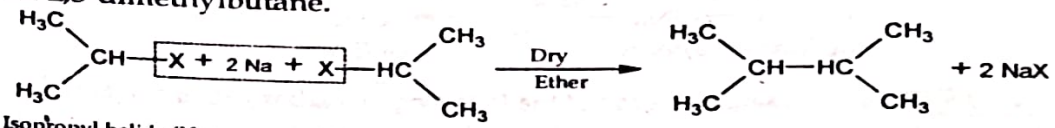


Bromoethane Bromoethane n-Butane

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12. 2070 Set D Q.No. 20 2064 Q.No. 20 A holoalkane 'X' undergoes Wurtz reaction to give 2, 3 - dimethylbutane as the major product. Identify 'X' and write chemical reaction. [1+1]

The halo alkane (x) is isopropyl halide, When heated with sodium metal in the presence of dry ether to form 2,3-dimethylbutane.

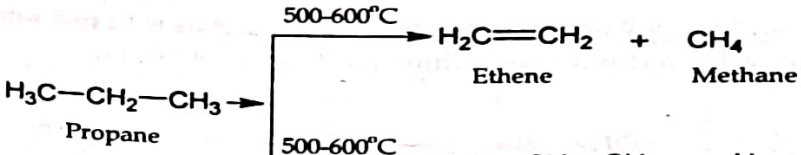


Isopropyl halide (X) Isopropyl halide (X) 2,3-dimethylbutane

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13. 2069 Set A Q. No. 21 What is cracking? Mention any one example of it. [1+1]

The process of breaking of high molecular weight hydrocarbon into low molecular weight hydrocarbon by the application of high temperature in the absence of air is known as cracking or pyrolysis. Example:

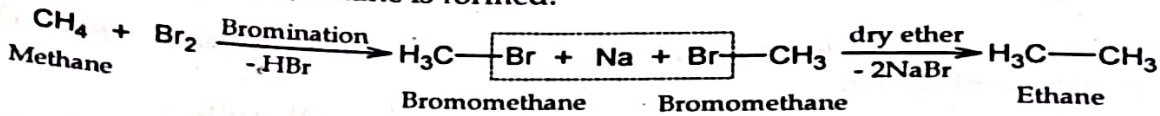


Propane Ethene Methane Propene

---

14. 2064, Q.No. 22 Convert methane to ethane. [2]

Methane is treated with bromine, bromomethane is formed which on heated with sodium metal in the presence of dry ether, ethane is formed.



Methane Bromomethane Bromomethane Ethane

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15. 2063 Q.No.20 **What is meant by Green house effect? Name any one gas contributing to the Green house effect.** [2]

The atmosphere that surrounds the earth acts like the glass or plastic roof and wall of a green house. When solar energy reaches the earth passing through the atmosphere surrounding the earth, the CO_2, water vapour, etc. present in the atmosphere absorb most of the solar energy and gets heated and excited. The excess energy present in them is converted into heat. Consequently, the earth is warmed up resulting with the increase of earth's temperature. However, when earth cools, the energy is re-emitted from the earth's surface in the form of infrared radiation and some is absorbed by atmospheric carbon dioxide and water vapours but can't pass through them and once again radiated back to the surface of the earth. In this way, additional heat is kept in the lower atmosphere resulting in the warming of the earth which is called green house effect.

16. 2061 Q.No. 10 **What is an ozone layer?** [2]

The layer above the earth surface which protects the harmful gases coming from sun is called ozone layer. It lies in the stratosphere between 12 to 24 Km from the earth surface. The concentration of ozone layer in the stratosphere is about 10 ppm but near the earth surface it is found only about 0.04 ppm.

17. 2061 Q.No.20 2059 Q.No. 22 **What is Wurtz reaction? Give an example.** [2]

When alkyl halides are treated with sodium metal in the presence of dry ether, then two molecules of alkyl halides combine to form higher member of alkane. This reaction is known as **Wurtz reaction.**

$$\underset{\text{Chloroethane}}{H_3C-CH_2-Cl} + 2Na + \underset{\text{Chloroethane}}{Cl-CH_2-CH_3} \xrightarrow{\text{Dry Ether}} \underset{\text{n-Butane}}{H_3C-CH_2-CH_2-CH_3} + 2NaCl$$

18. 2060 Q.No. 21 **What happens when aluminum carbide is treated with cold water?** [2]

When aluminium carbide is treated with cold water, methane gas is formed.

$$\underset{\text{Aluminium carbide}}{Al_4C_3} + 12H_2O \longrightarrow \underset{\text{Methane}}{3CH_4} + 4Al(OH)_3$$

19. 2056 Q.No. 13 **Name any one gas responsible for the depletion of ozone layer of upper part of our atmosphere. Why is it harmful to living beings, if ozone layer get depleted?** [2]

One of the gas which is responsible for the depletion of ozone layer on the upper part of atmosphere is chlorofluorocarbon i.e CFC.

If the ozone layer is depleted, following are the effect cause by ultraviolet radiation coming from sun:

a. Human beings will suffer from many cancer disease.
b. Eyes of animals will be affected.
c. The production and reproduction of plants will be decreased.
d. There will increase in Global warming effect.

20. 2056 Q.No. 22 **What is green house effect?** [2]

Green house effect: Please refer to 2063 Q.No.20

Effect of green house effect

a. It causes global warming.
b. It also affects the monsoon during crop cultivation and growth of plants.
c. It causes excessive melting of polar ice and thus increases the water level.
d. It may increase the incidence of communicable disease like cholera, malaria, dengue fever, etc. which cause death of living beings.

21. 2058 Q.No.20 **Show our acquaintance with Wurtz reaction.** [2]

Please refer to 2069 Set A Q. No. 22a

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22. 2055 Q.No. 14 **Why do you think depletion of ozone layer from the atmosphere will be harmful to plant and animal life?** [2]

If the ozone layer in stratosphere is depleted, the ultraviolet radiation comes from the sun will direct reach on the earth surface and cause damage to plants and animals. Following are effect caused by ultraviolet radiations:

a. Human beings will suffer from many cancer diseases.
b. Eyes of animals will be affected.
c. The production and reproduction of plants will be decreased.
d. There will increase in Global warming effect.

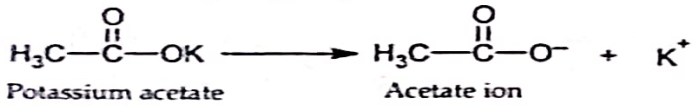
23. 2053 Q.No. 17 **How does ozone protect plant and animal life on earth?** [1.5]

Ozone layer protects the plants and animals life on earth by absorbing the solar ultraviolet radiations comes from the sun. If the ultraviolet rays of the sun are not absorbed by the ozone layer in the stratosphere they can reach on the earth surface and damage to plants and animals including human beins.

SHORT ANSWER QUESTIONS

24. 2064 Q.No. 29 **Describe the preparation of ethane in laboratory.** [5]

Laboratory preparation of Ethane: Ethane is prepared in the laboratory by the electrolysis of concentrated solution of Potassium acetate between platinum electrodes. Ethane gas is formed at anode and hydrogen gas is formed at cathode.

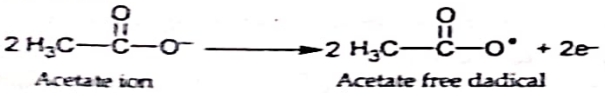


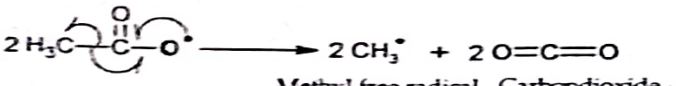
At cathode:

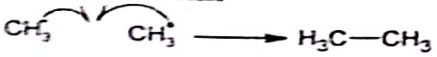
$[K^+ + e^- \longrightarrow K] \times 2$

$2K + 2H_2O \longrightarrow 2KOH + H_2$

At anode:







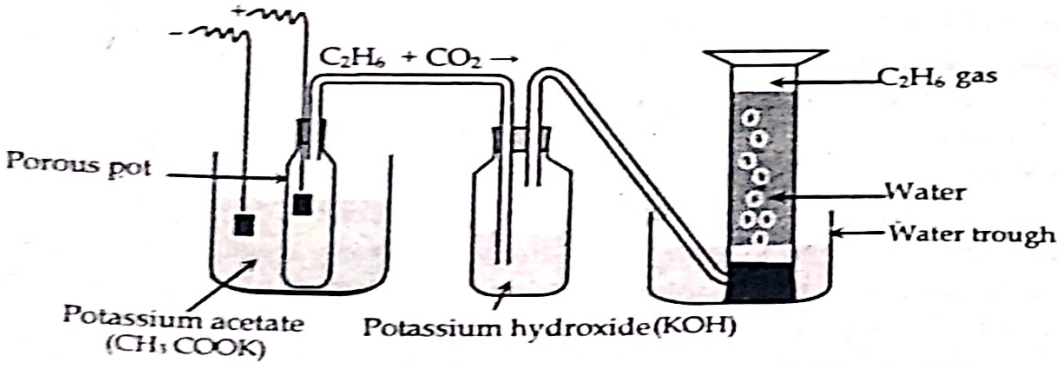


Fig: Lab preparation of ethane

Procedure: A concentrated solution of potassium acetate is taken in electrolytic cell as electrolyte and two platinum electrodes are dipped in electrolytic solution. The anode is enclosed in a porous pot fitted with a delivery tube. When electricity current is passed through electrolytic solution, ethane and CO_2 gas are produced at anode and delivered through a tube containing potassium hydroxide solution which absorbs CO_2 gas and ethane gas is collected by the downward displacement of water.

WRITE SHORT NOTE ON

25. 2065 Q.No. 33b **Laboratory preparation of ethane gas**

Ans Please refer to 2064 Q No. 29 [5]

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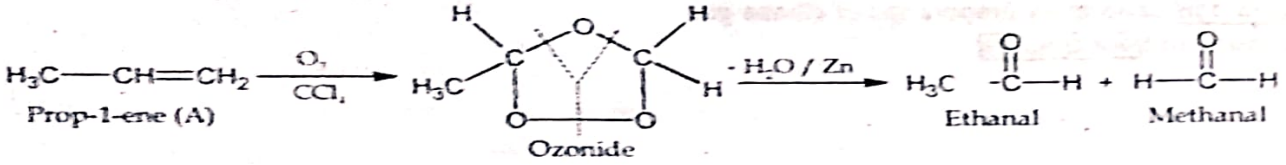
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15.3 Alkenes

VERY SHORT ANSWER QUESTIONS: [2 MARKS]

1. 2076 Set B Q.No. 21 An alkene (A) undergoes ozonolysis to give ethanal and methanal as the major products identify (A) and write its IUPAC name. [1+1]

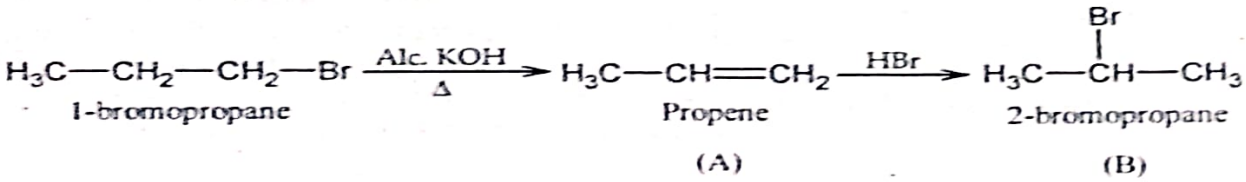
The reaction sequence is given as:



2. 2075 GIE Q.No. 20 Identify the major products A and B and write their IUPAC name [1+1]

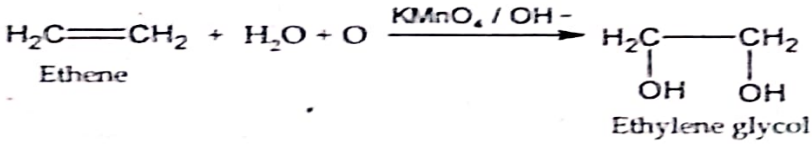
$CH_3 - CH_2 - CH_2 - Br \xrightarrow[\Delta]{\text{alc. KOH}} A \xrightarrow{HBr} B$

The reaction sequence is

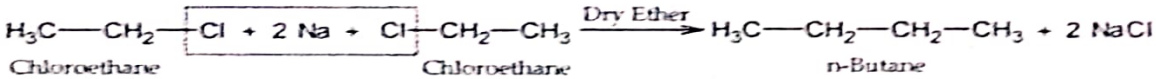


3. 2075 Set A Q.No. 20 Write an example of [1+1]
   i. Baeyer's test
   ii. Wurtz reaction

i. **Bayer's test:** When ethylene gas is bubbled in an alkaline 1 % solution of $KMnO_4$ the pink colour of $KMnO_4$ is discharged, two OH groups gets added to each molecule of ethylene and colourless ethylene glycol is formed.

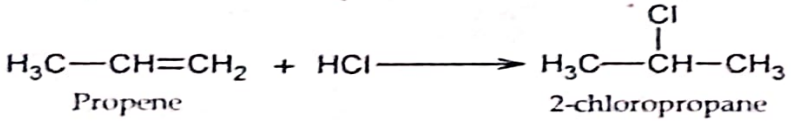


ii. **Wurtz reaction:** Two molecules of chloroethane react with sodium metal in the presence of dry ether, n-butane is formed.



4. 2075 Set B Q.No. 20 Write an example of each of the following. [1+1]
   i. Markovnikov's rule
   ii. Wurtz reaction

i. **Markovnikov's rule:** Propene on addition with HCl, 2-chloropropane is formed.



ii. Wurtz reaction: Please refer to 2075 Set A Q No. 20

5. 2074 Supp Q.No. 20(i) Write an example of each of the followings: Baeyer's test [1]

Please refer to 2075 Set A Q No. 20

6. 2074 Set B Q.No. 20i Write an example of Peroxide effect [1]

Peroxide effect:

$$\underset{\text{prop-1-ene}}{H_3C-CH=CH_2} \xrightarrow[H-Br]{\text{Organic peroxide}} \underset{\text{1-bromopropane}}{H_3C-CH_2-CH_2-Br}$$

7. 2073 Set D Q. No. 21 Identify the major products A and B in the following reaction sequence and give their IUPAC name. [1+1]

$$H_3C-CH_2-Br \xrightarrow[\Delta]{\text{Alc. KOH}} A \xrightarrow[\Delta]{\text{Ozonolysis}} B$$

The reaction sequence is given as;

$$\underset{\text{Bromoethane}}{H_3C-CH_2-Br} \xrightarrow[\Delta]{\text{Alc. KOH}} \underset{\substack{\text{Ethene}\\ A}}{H_2C=CH_2} \xrightarrow[\Delta]{\text{Ozonolysis}} \underset{\substack{\text{Methanal}\\ B}}{2\,H-\overset{\overset{O}{\|}}{C}-H}$$

The major products are
A = Ethene
B = Methanal

8. 2072 Supp Q. No. 22 Write an example of each of:
i. Kolbe's reaction [1]
ii. Dhydrohalogenation [1]

i. **Kolbe's reaction:** When aqueous solution of sodium salt of succinic acid is electrolysed, ethene gas and CO_2 gas are liberated at anode and H_2 gas is liberated at cathode.

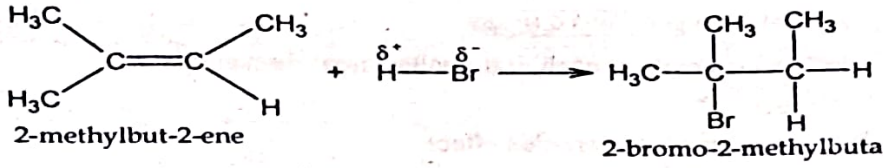
$$\underset{\text{Sodium succinate}}{H_2C(\overset{\overset{O}{\|}}{C}-ONa)-H_2C(\overset{\overset{O}{\|}}{C}-ONa)} \underset{\text{Pt electrode}}{\overset{\text{Electrolysis}}{\rightleftharpoons}} \underset{\text{Ethene}}{H_2C=CH_2} + CO_2$$

ii. **Dehydrohalogenation:** The chemical reaction in which there is the removal of hydrogen and halogen from a molecule resulting into the formation of multiple bond is known as dehydrohalogenation reaction.

$$\underset{\text{Chloroethane}}{H-\overset{H}{\overset{|}{C}}-\overset{Cl}{\overset{|}{C}}-H} \xrightarrow[\Delta]{\text{Alcoholic KOH}} \underset{\text{Ethene}}{H_2C=CH_2} + H_2O + KCl$$

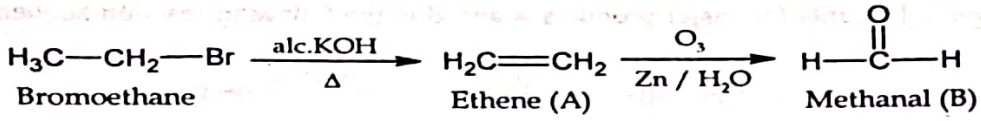
9. 2072 Set C Q.No. 20ii 2069 (Set A) Q. No. 22b Write one example of each of Markovnikov's rule. [1]

"When unsymmetrical reagent adds to the unsymmetrical alkene, the positive part of reagent goes to that double bonded carbon which have maximum number of hydrogen and negative part of reagent goes to that double bonded carbon which having minimum number of hydrogen." Example:



10. 2072 Set D Q.No. 20 **Identify the major products A and B giving their IUPAC names.** [1+1]

$CH_3 - CH_2 - Br \xrightarrow[\Delta]{\text{alc. KOH}} A \xrightarrow[Zn/H_2O]{O_3} B$

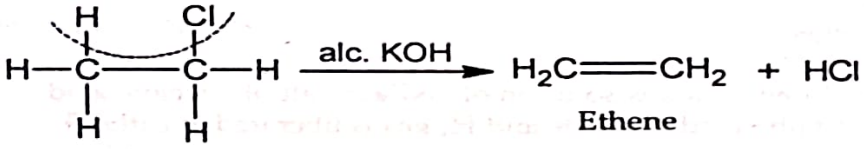


The compounds are
A = Ethene
B = Methanal

11. 2071 (Set C) Q.No. 20 **Give a suitable reaction for each:** [1+1]
a. Baeyer's test b. Dehydrohalogenation

a. **Baeyer's test:** Please refer to 2075 Set A Q.No. 20

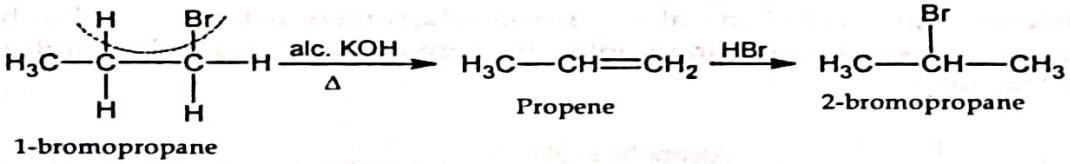
b. **Dehydrohalogenation:** When ethyl halide is heated with alcoholic KOH solution, a molecule of hyrdrogen halide is eliminated with the formation of alkene. This reaction is known as dehydrohalogenation.



12. 2071 (Set D) Q.No. 20 **Identify the major product A and B of the following and write their IUPAC name.**

$CH_3—CH_2—CH_2—Br \xrightarrow[\Delta]{\text{alc. KOH}} A \xrightarrow{HBr} B$

When 1-bromopropane is heated with alcoholic solution of KOH, propene is obtained which on addition of HBr according to Markovnikov's rule, 2-bromopropane is formed.



The compounds are
A = Propene
B = 2-boromopropane

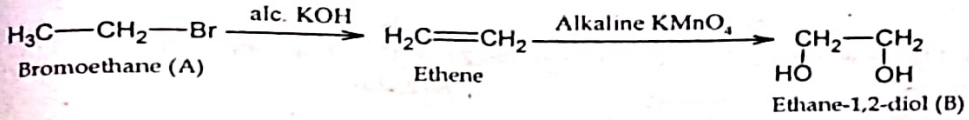
13. 2069 (Set A) Q. No. 20 **Identify A and B in the following reaction and give IUPAC name:**

$A \xrightarrow[\Delta]{\text{alc. KOH}} CH_2 = CH_2 \xrightarrow{\text{alkaline } KMnO_4} B.$ [1+1]

When bromoethane is heated with alcoholic solution of KOH, ethene is obtained which on hydrolysis in alkaline solution of $KMnO_4$, ethane-1,2-diol is obtained.

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The compounds are
A = Bromoethane
B = Ethane-1, 2-diol

14. 2069 (Set B) Q. No. 22 **Identify the compounds A and B. Give their IUPAC name.** [1+1]

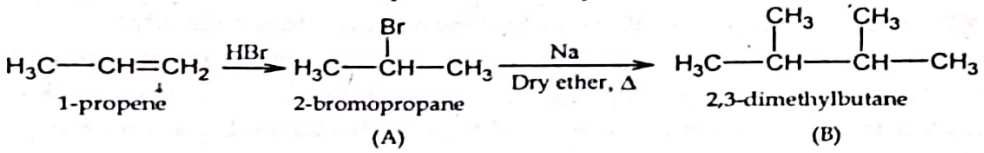
$$A \xrightarrow[\Delta]{\text{alc. KOH}} CH_2 = CH_2 \xrightarrow{\text{alkaline } KMnO_4} B.$$

Please refer to 2069 (Set A) Q. No. 20

15. 2068 Q.No. 21 **Identify the major product A and B and give their IUPAC name.** [1+1=2]

$$CH_3 - CH{=}CH_2 \xrightarrow{HBr} A \xrightarrow[\Delta\ /\ \text{dry ether}]{Na} B$$

1-propene on addition with HBr according to Markovnikov's rule, 2-bromopropane is obtained which on heating sodium metal in the presence of dry ether, 2,3-dimethylbutane is obtained.



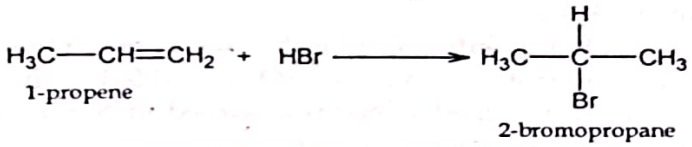
The compounds are
A = 2-bromopropane
B = 2,3-dimethylbutane

16. 2065 Q. No. 19 **Write an example of each of the following reaction:** [2]
a. Wurtz reation **b. Markovnikov's rule**

a. **Wurtz reaction:** Please refer to 2075 Set A Q No. 20
b. **Markovnikov's rule:** Please refer to 2075 Set B Q No. 20

17. 2063 Q.No. 21 **State Markovnikov's Rule. Give an example of it.** [2]

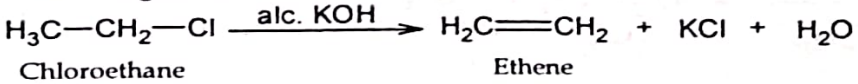
Markovnikov's Rule: "The addition of halo acid or other unsymmetrical reagent to unsymmetrical alkene occurs in such a way that the positive part of reagent goes to the carbon atom having greater number of hydrogen atom and negative part of reagent goes to the carbon atom having lesser number of carbon atom." Example:

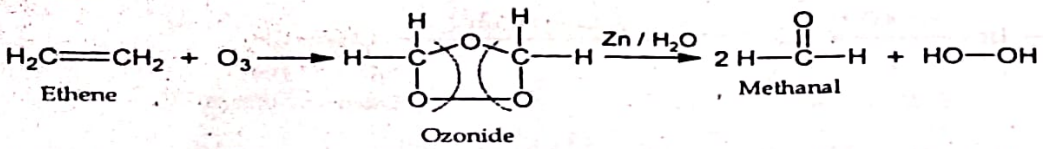


18. 2060 Q.No. 22 **Identify the unknown organic compounds 'A' and 'B' in the following reaction:** [2]

$$CH_3CH_2Cl \xrightarrow[\Delta]{\text{Alc. KOH}} A \xrightarrow[2.\ H_2O/\ Zn]{1.\ O_3} B$$

When chloroethane is heated with alcoholic solution of KOH, ethene is obtained. Ethene is treated with ozone then ethene ozonide is formed which on hydrolysis in the presence of zinc dust, two molecules of methanal is obtained.
The sequence reaction is given as:

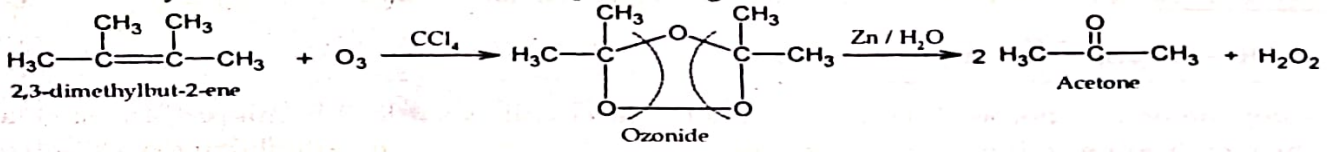




The compounds are
A = Ethene
B = Methanal

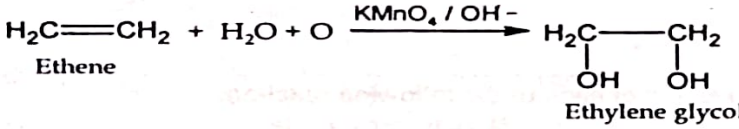
19. 2058 Q.No. 21 **The ozonolysis of a compound gave acetone as the only product. Identify the compound.** [2]

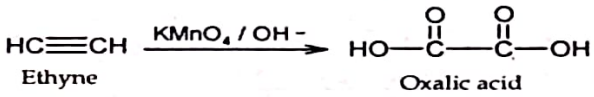
When 2,3-dimethylbut-2-ene is treated with ozone, addition product ozonide is formed which on hydrolysis with Zn/H_2O then only acetone as the product is formed. So, that compound is 2, 3- dimethylbut-2-ene. The reaction sequence is given as,



20. 2058 Q.No. 19 **Describe the Baeyer test. What is observed and what does it identify?** [2]

Alkaline solution of potassium permanganate is called Baeyer's reagent. About 1 mL of organic compound is taken in clean and dry test tube and about 2 – 3 drops of alkaline solution of $KMnO_4$ is added to it. If the pink colour of $KMnO_4$ is discharged, the given organic compound contains double or triples covalent bond between two carbon atoms.





This test identify the given organic compound is unsaturated hydrocarbon.

SHORT ANSWER QUESTIONS [5 MARKS]

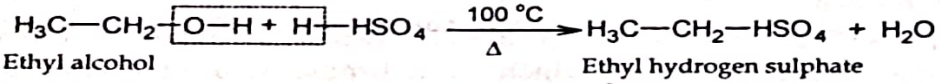
21. 2076 Set B Q.No. 25 **Describe laboratory method of preparation of ethene. Suggest a chemical test to distinguish ethene from ethane.** [4+1]

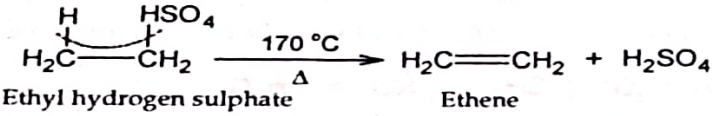
Laboratory preparation of ethene:

Principle: When ethyl alcohol or ethanol is heated with conc. H_2SO_4, at 170°C, ethylene or ethene gas is formed. To stop frothing some $Al_2(SO_4)_3$ is added to the mixture of C_2H_5OH and conc. H_2SO_4. Some CO_2 is also formed which is absorbed in NaOH solution and C_2H_4 gas is collected by the downward displacement of water.

Reactants: Ethanol and conc. H_2SO_4

Reaction:





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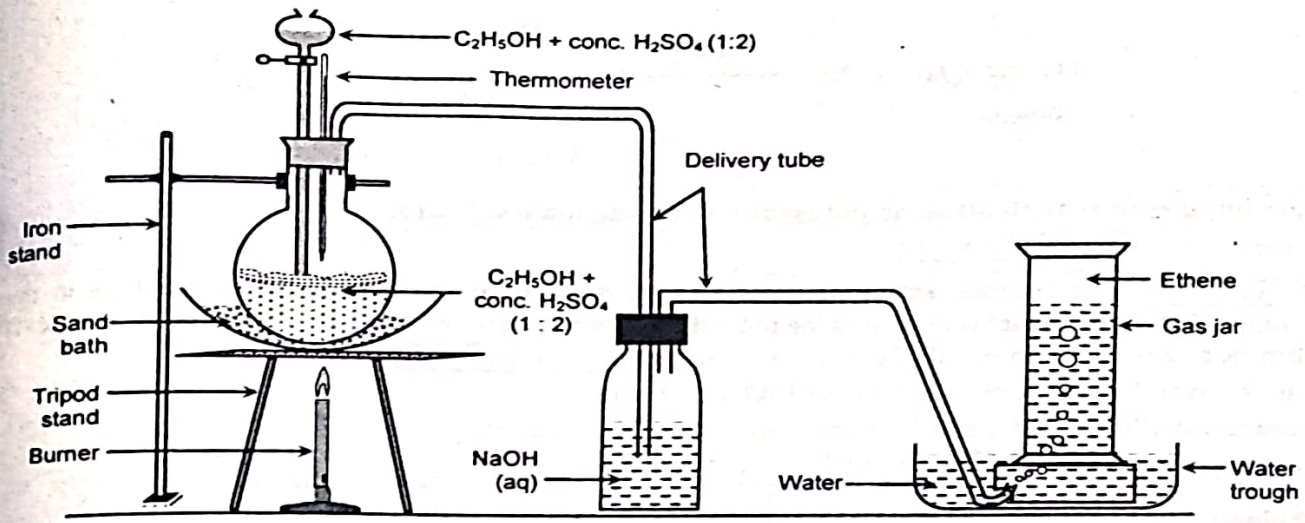


Fig: Laboratory preparation of ethene

Procedure: Mixture of ethyl alcohol (50 mL) and conc. H_2SO_4 (100 mL) is taken in Round Bottom flask, fitted with dropping funnel, thermometer and delivery tube. Some sand and anhydrous $Al_2(SO_4)_3$ is added as catalyst and heated in sand bath at 170°C, ethene gas is passed through bottle containing NaOH solution, which absorbs CO_2 and SO_2 only and undissolved pure ethene gas collected in gas jar by downward displacement of water.

Bromine solution test distinguish ethene from ethane: Ethene reacts with bromine (Br_2) dissolved in CCl_4, the reddish brown colour of of bromine is decolourized. This indicates the presence of ethane whereas ethane does not react with bromine.

$$\underset{\text{Ethene}}{H_2C{=}CH_2} + \underset{\text{Reddish brown}}{Br_2} \xrightarrow{CCl_4} \underset{\text{1,2-dibromoethane (Colourless)}}{H_2C(Br){-}CH_2(Br)}$$

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22. 2073 Set C Q. No. 25 2073 Set D Q. No. 25 **How is ethene prepared in the laboratory? What happens when ethene is passed through Baeyer's reagent?** **[4+1]**

Laboratory preparation of ethene: Please refer to 2076 Set B Q.No. 25

What happens:

When ethene gas is passed through alkaline solution of potassium permanganate, pink colour of $KMnO_4$ is discharged into colourless ethylene glycol.

$$\underset{\text{Ethene}}{H_2C{=}CH_2} + H_2O + O \xrightarrow{KMnO_4 / OH^-} \underset{\text{Ethylene glycol}}{H_2C(OH){-}CH_2(OH)}$$

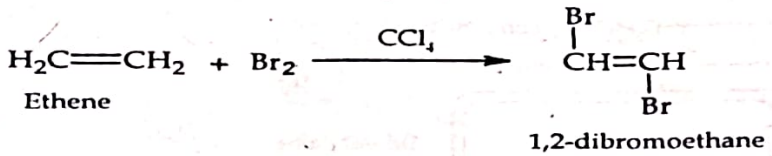
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23. 2072 Supp Q. No. 29 **How is ethene obtained in the laboratory? How does it react with bromine and alkaline potassium permanganate solution?** **[3+2]**

Laboratory preparation of ethene: Please refer to 2076 Set B Q.No. 25

Reaction of ethene with bromine: Ethene reacts with bromine, the brown colour of bromine is decolorized.

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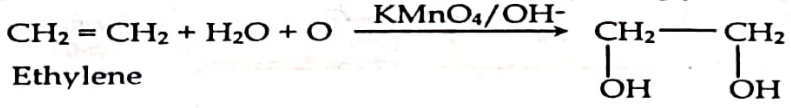
Reaction of ethene with alkaline potassium permanganate solution:
Please refer to 2073 Set C Q. No. 25

24. 2071 Supp Q. No. 29 **Describe with a neat and labelled diagram for the preparation of ethylene in the laboratory. How does it react with aq. alkaline potassium permanganate solution?** [4+1]

Laboratory preparation of ethylene: Please refer to 2076 Set B Q.No. 25

Reaction of ethylene with alkaline $KMnO_4$ solution

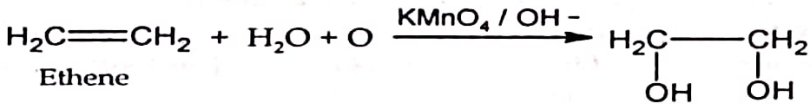
It reacts alkaline $KMnO_4$ solution, ethylene glycol is obtained.



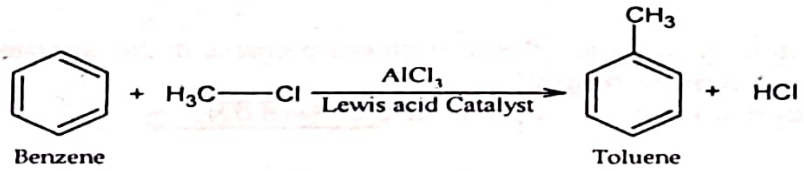
25. 2060 Q.No. 29(I) 2059 Q.No. 29(a) **What happens when:** [5]

a. ethene is passed through alkaline potassium permanganate solution
b. benzene is allowed to react with methyl chloride in presence of anhydrous aluminium chloride.

a. When ethene gas is passed through alkaline solution of potassium permanganate, pink colour of $KMnO_4$ is discharged into colourless ethylene glycol.



b. When benzene is allowed to react with methyl chloride in the presence of anhydrous aluminium chloride then toluene is obtained. This reaction is known as **Friedel Craft alkylation reaction.**



WRITE SHORT NOTES ON

26. 2070 Set D Q.No. 33a 2068 Q.No. 33 a **Laboratory preparation of ethene.** [5]

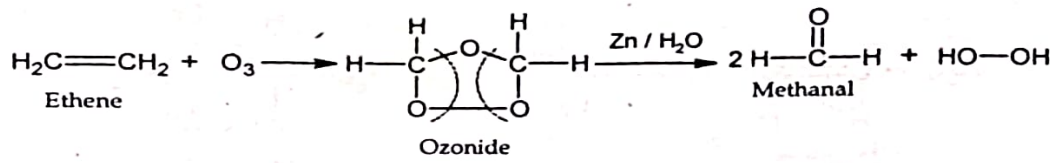
Please refer to 2076 Set B Q.No. 25

27. 2066 Q.No. 28 **Ozonolysis** [2.5]

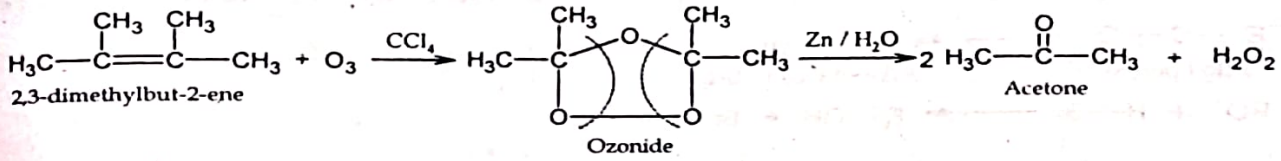
The process of conversion of alkene into unstable product ozonide which on hydrolysis in the presence of zinc dust to give carbonyl compound i.e. aldehyde and ketone is known as ozonolysis.

The product i.e. aldehyde and ketone formed during ozonolysis depends upon the nature of alkene.

Example: When ethene is treated with ozone then unstable ethene ozonide is formed which on hydrolysis in the presence of zinc dust gives two molecules of methanal.

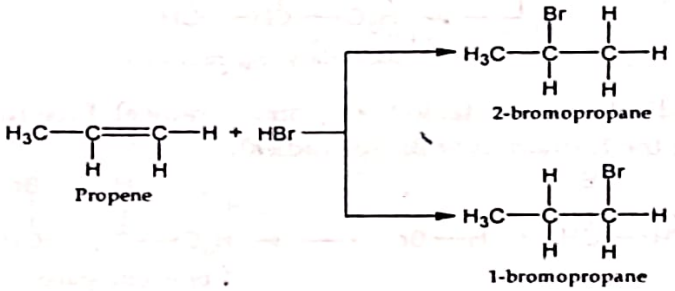


When 2,3-dimethyl but-2-ene is treated with ozone, addition product ozonide is formed which on hydrolysis with Zn/H_2O then only acetone as the product is formed. The sequence reaction is



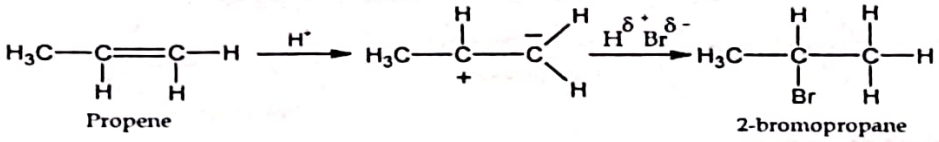
28. 2066 Q.No. 28ii Markovnikov's rule **[2.5]**

"The addition of halo acid or other unsymmetrical reagent to unsymmetrical alkene occurs in such a way that the positive part of reagent goes to the carbon atom having greater number of hydrogen atom and negative part of reagent goes to the carbon atom having lesser number of carbon atom." Example:



The major product is 2-bromopropane.

Mechanism: It involves the formation of carbocation and carboanion. The carbocation and carboanion are formed by the displacement of bonding pair of electrons toward more electronegative carbon atom. The positive part of reagent i.e. H^+ of HBr adds to the negative part i.e. carboanion and negative part of reagent i.e. Br^- of HBr adds to the positive part i.e. carbocation.



29. 2064 Q.No. 33(c) Markovnikov's rule and peroxide effect. **[5]**

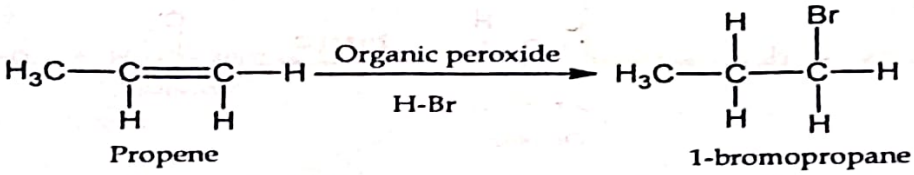
Markovnikov's rule: Please refer to 2066 Q.No. 28

Anti-Markovnikov's Rule or Peroxide effect or Kharasch effect:

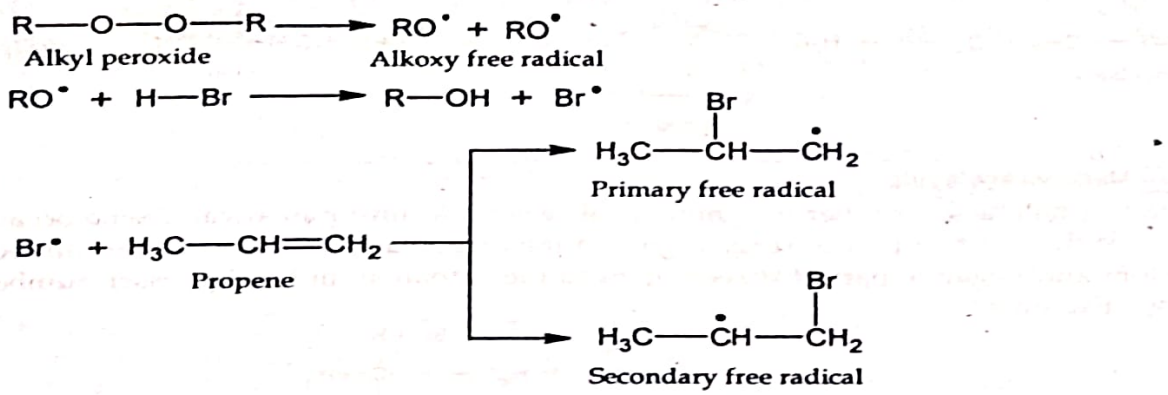
It is opposite of Markovnikov's rule and followed in the presence of organic peroxide i.e. benzoyl peroxide or alkyl peroxide. In the presence of a trace of organic peroxide catalyst, Markovnikov's rule is disobeyed and H of the HBr adds to that unsaturated carbon atom of the unsymmetrical alkene which contains less number of hydrogen atoms already attached to it and Br gets attached to the other unsaturated carbon.

Example:

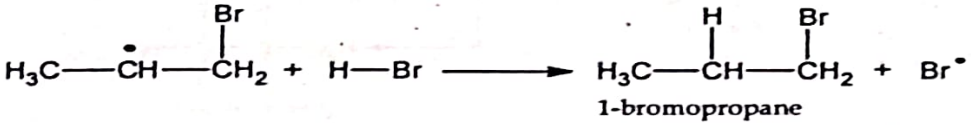
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Mechanism: It involves the formation of free radicals. The alkyl peroxide gives alkoxy free radical which abstracts hydrogen from HBr to form bromide free radical. The bromide free radical abstracts proton from alkene to form primary and secondary free radical.



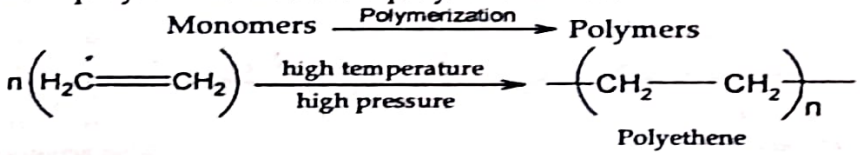
The secondary free radical is more stable than primary radical. Free radical attacks HBr to form addition product with the formation of Br free radical.



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30. 2061 Q.No. 33(b) 2059 Q.No. 3(c) **Polymerization** [5]

Polymerization: Polymer is the high molecular weight compounds whose structures are composed of a large number of simple repeating units. The repeating units are usually obtained from low molecular weight simple compound referred to as monomers. The conversion process, monomer to polymer is known as polymerization.



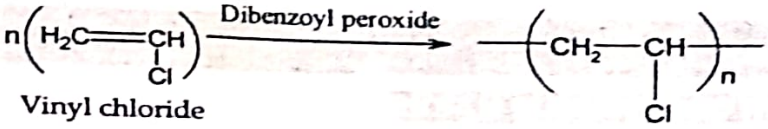
Classification of polymers:

On the basis of origin or source, polymers are classified into two types: (a) Natural polymers (b) Synthetic polymers

a. **Naturalpolymers:** The polymer that is found in nature i.e. in animals or plants , are called natural polymers.
   Examples: Protein, nucleic acid, natural rubber etc.

b. **Synthetic polymers:** The polymer which is prepared in the laboratory, are called synthetic polymers. **Examples:** Polyethene, Polystyrene, rubber, nylon, PVC, Bakelite, Teflon etc.
   Examples:
   Polyvinyl chloride (PVC): It is prepared by heating vinyl chloride in an inert solvent dibenzoyl peroxide.

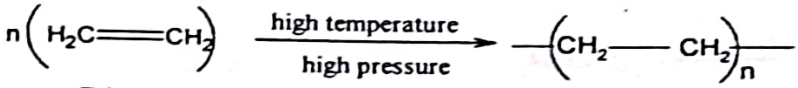
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Vinyl chloride — Polyvinyl chloride

Uses: It is used for making rain coats, hand bags, toys, housepipes, gramophone records, electrical insulations and floor covering.

Polyethylene or polyethene: It is prepared by heating ethylene at 465 – 485K under pressure in the presence of oxygen.



Ethene — Polyethene

Uses: It is used in coats, milk cartons, bread wrappers, carry bags, toys etc.

31. 2058 Q.No. 33c 2056 Q.No. 32a **Markovnikov's rule** [5]

Please refer to 2066 Q.No. 28

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15.4 Alkynes

VERY SHORT ANSWER QUESTIONS [2 MARKS]

1. 2076 Set C Q.No. 22 **Write down chemical reaction to prepare ethene from:** [1+1]
   i. Ethyne
   ii. Chloroethane.

i. **Ethene from ethyne:** When hydrogen is added to ethyne in the presence of Nickel metal as catalyst, ethene is obtained.

$$\underset{\text{Ethyne}}{HC\equiv CH} + H_2 \xrightarrow[\Delta]{Ni} \underset{\text{Ethene}}{H_2C=CH_2}$$

ii. **Ethene form chloroethane:** When chloroethane is treated with alcoholic solution of KOH or NaOH, ethene is obtained.

$$\underset{\text{Chloroethane}}{H_3C-CH_2-Cl} + KOH\,(alc) \xrightarrow{\Delta} \underset{\text{Ethene}}{H_2C=CH_2} + KCl + H_2O$$

2. 2075 Set A Q.No. 21 | 2075 Set B Q.No. 22 | 2074 Supp Q.No. 21 | 2074 Set A Q.No. 21 | 2074 Set B Q.No. 21 **Identify the major products Ⓐ and Ⓑ in the following.** [2]

$$CaC_2 \xrightarrow{H_2O} Ⓐ \xrightarrow{\text{ammonical } AgNO_3} Ⓑ.$$

The reaction sequence is given as

$$\underset{\text{Calcium carbide}}{CaC_2} \xrightarrow{H_2O} \underset{\substack{\text{Ethyne}\\(A)}}{HC\equiv CH} \xrightarrow{\text{Ammonical } AgNO_3} \underset{\substack{\text{Silver acetylide}\\(B)}}{AgC\equiv CAg}$$

3. 2073 Supp Q.No. 21 **Identify the major products Ⓐ and Ⓑ in the following reaction sequence and give their IUPAC name.**

$$CaC_2 \xrightarrow{H_2O} Ⓐ \xrightarrow[60°C]{\text{Conc. } H_2SO_4/HgSO_4} Ⓑ$$

The reaction sequence is given as:

$$\underset{\text{Calcium carbide}}{Ca(C\equiv C)} + 2H_2O \longrightarrow \underset{\substack{\text{Ethyne}\\(A)}}{HC\equiv CH} \xrightarrow[60\ °C]{\text{Conc. } H_2SO_4,\ HgSO_4} \underset{\substack{\text{Ethane-1,2-diol}\\(B)}}{H_2C(OH)-CH_2(OH)}$$

4. 2073 Set C Q. No. 21 | 2070 Supp. Q.No. 22 **Identify the major products (A) and (B) in the following reaction sequence. And give their names.** [1+1]

$$CaC_2 \xrightarrow{H_2O} A \xrightarrow[\Delta]{\text{Fe - tube}} B$$

When calcium carbide is treated with water, ethyne gas is formed. Ethyne gas is passed through red hot iron tube, benzene is formed.

$$\underset{\text{Calcium carbide}}{Ca(C\equiv C)} + 2H_2O \longrightarrow \underset{\text{Ethyne}}{H-C\equiv C-H} + \underset{\text{Calcium hydroxide}}{Ca(OH)_2}$$

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$$3\,HC{\equiv}CH \xrightarrow[400\,^\circ C,\ \text{Polymerization}]{\text{Red hot iron tube}} \text{Benzene}$$

Ethyne

The compounds are
A = Ethyne
B = Benzene

5. 2072 Set C Q. No. 22 2072 Set E Q.No. 22 **Identify the major product (A) and (B) in the following:** **[1+1]**

$$CHCl_3 \xrightarrow[\Delta]{\text{Ag powder}} A \xrightarrow[Pd/BaSO_4]{H_2} B$$

The major product of given reaction is as

$$H{-}\overset{\overset{Cl}{|}}{\underset{\underset{Cl}{|}}{C}}{-}Cl \xrightarrow[\Delta]{\text{Ag powder}} HC{\equiv}CH \xrightarrow[Pd\ /\ BaSO_4]{H_2} H_3C{-}CH_3$$

Trichloromethane — Ethyne (A) — Ethane (B)

The compounds are
A = Ethyne
B = Ethane

6. 2072 Set D Q.No. 22 **What happens when ethyne is reacted with hydrogen in presence of $Pd/BaSO_4$?** **[1]**

When ethyne is treated with hydrogen in the presence of $Pd/BaSO_4$, ethane is obtained.

$$HC{\equiv}CH + 2\,H_2 \xrightarrow{Pd\ /\ BaSO_4} H_3C{-}CH_3$$

Ethyne — Ethane

7. 2071 Supp Q. No. 21 **Identify A and B in the following reaction and give their IUPAC name:** **[1+1]**

$$CaC_2 \xrightarrow{H_2O} A \xrightarrow[450\text{ - }500\,^\circ C]{\text{red hot Fe tube}} B$$

The complete reaction is

$$CaC_2 + H_2O \longrightarrow HC{\equiv}CH \xrightarrow[450\text{ - }500\,^\circ C]{\text{red hot Fe tube}} \text{Benzene}$$

Calcium carbide — Ethyne (A) — Benzene (B)

8. 2070 Supp. Q.No. 20 **Write a chemical test to distinguish ethyne from ethene.** **[2]**

Ethyne and ethane are distinguished by passing the gases through the ammoniacal solution of cuprous chloride. Ethyne gives a red ppt of copper acetylide whereas ethene does not give red ppt with cuprous chloride.

$$HC{\equiv}CH + Cu_2Cl_2 \xrightarrow{NH_4OH} CuC{\equiv}CCu + HCl$$

Acetylene — Copper acetylide, Red ppt

$$H_2C{=}CH_2 + Cu_2Cl_2 \xrightarrow{NH_4OH} \text{No reaction}$$

Ethene

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9. **2067 Q.No. 20** **How would you convert ethyne into:**
i. Ethene ii. Benzene **[1 + 1]**

i. **Ethyne to ethane:** When ethyne is mixed with hydrogen and the mixture is passed over heated nickel catalyst at 250 to 300°C, two atom of hydrogen get added to each molecule of ethyne and ethene is formed which on further addition of hydrogen to give ethane.

$$\underset{\text{Ethyne}}{HC{\equiv}CH} + H_2 \xrightarrow[250 - 300\ ^\circ C]{\text{Ni Catalyst}} \underset{\text{Ethane}}{H_3C{-}CH_3}$$

ii. **Ethyne to Benzene :** When ethyne is passed through heated iron tube at 400°C , three molecules of ethyne trimerizes to form benzene.

$$3\,\underset{\text{Ethyne}}{HC{\equiv}CH} \xrightarrow[400\ ^\circ C]{\text{Red hot iron tube}} \underset{\text{Benzene}}{C_6H_6}$$
(Polymerization)

10. **2066 Q.No. 19 b** **Write the Chemical reactions when: Ethyne is catalytically hydrated.** **[1]**

When ethyne is hydrated in the presence of 42% H_2SO_4 and 1% $HgSO_4$ at 60 – 80°C , then vinyl alcohol is obtained which on rearrangement to give acetaldehyde.

$$\underset{\text{Ethyne}}{HC{\equiv}CH} + H_2O \xrightarrow[60 - 80\ ^\circ C]{42\%\ H_2SO_4,\ 1\%HgSO_4} \underset{\text{Vinyl alcohol}}{H_2C{=}C(OH){-}H} \xrightarrow{\text{Rearrangement}} \underset{\text{Acetaldehyde}}{H_3C{-}C(=O){-}H}$$

11. **2063 Q.No. 19** **Identify the compounds A and B in the given reaction.** **[2]**

$$A \xrightarrow{H_2O} C_2H_2 \xrightarrow[HgSO_4/H^+]{H_2O} B$$

Calcium carbide is treated with water, ethyne gas is formed which on hydrolysis followed by tautomerization gives ethanal.

$$\underset{\text{Calcium carbide(A)}}{CaC_2} \xrightarrow{H_2O} HC{\equiv}CH \xrightarrow[HgSO_4/H^+]{H_2O} \underset{\text{Ethanal(B)}}{H_3C{-}C(=O){-}H}$$

The compounds are
A = Calcium carbide
B = Ethanal

12. **2058 Q.No. 22** **What gas is obtained when calcium carbide is treated with water? Show equation for this reaction.** **[2]**

When calcium carbide is treated with water then acetylene gas is formed.

$$\underset{\text{Calcium carbide}}{Ca(C{\equiv}C)} + 2\,H_2O \longrightarrow \underset{\text{Acetylene}}{H{-}C{\equiv}C{-}H} + \underset{\text{Calcium hydroxide}}{Ca(OH)_2}$$

13. **2057 Q.No.20** **You are supplied two similar gas jars. One of the jar is filled with ethene while the other with ethyne. Suggest any one suitable chemical test to identify them.** **[2]**

Ammoniacal solution of $AgNO_3$: The ammoniacal solution of silver nitrate is added to the two gas jar containing ethene and ethyne separately. White ppt of silver acetylide is formed in the jar containing ethyne gas. Ethene gas does not react with ammoniacal solution of $AgNO_3$.

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$$\underset{\text{Acetylene}}{HC\equiv CH} + \underset{\text{Silver nitrate}}{AgNO_3} \xrightarrow{NH_4OH} \underset{\substack{\text{Silver acetylide}\\ \text{White ppt}}}{Ag-C\equiv C-Ag} + HNO_3$$

$$\underset{\text{Ethene}}{H_2C = CH_2} + NH_4OH + AgNO_3 \longrightarrow \text{No reaction}$$

14. **2056 Q.No. 21** **Give a chemical reaction to show acidic nature of ethyne.** **[2]**

When ethyne gas is treated with sodium metal then hydrogen gas is formed. This evolution of hydrogen gas shows the acidic nature of hydrogen.

$$\underset{\text{Acetylene}}{2\,HC\equiv CH} + 2\,Na \longrightarrow \underset{\text{Mono sodium acetylide}}{2\,HC\equiv CNa} + H_2$$

$$\underset{\text{Mono sodium acetylide}}{2\,HC\equiv CNa} + 2\,Na \longrightarrow \underset{\text{Di sodium acetylide}}{2\,NaC\equiv CNa} + H_2$$

SHORT ANSWER QUESTIONS

15. **2076 Set C Q.No. 25** **Describe laboratory method of preparation of ethyne. How is ethyne converted into ethanal?** **[4+1]**

Laboratory method of preparation of ethyne:

When calcium carbide is treated with water then acetylene or ethyne gas is formed which is collected in gas jar by downward displacement of water.

$$\underset{\text{Calcium carbide}}{Ca(C\equiv C)} + 2\,H_2O \longrightarrow \underset{\text{Acetylene}}{H-C\equiv C-H} + \underset{\text{Calcium hydroxide}}{Ca(OH)_2}$$

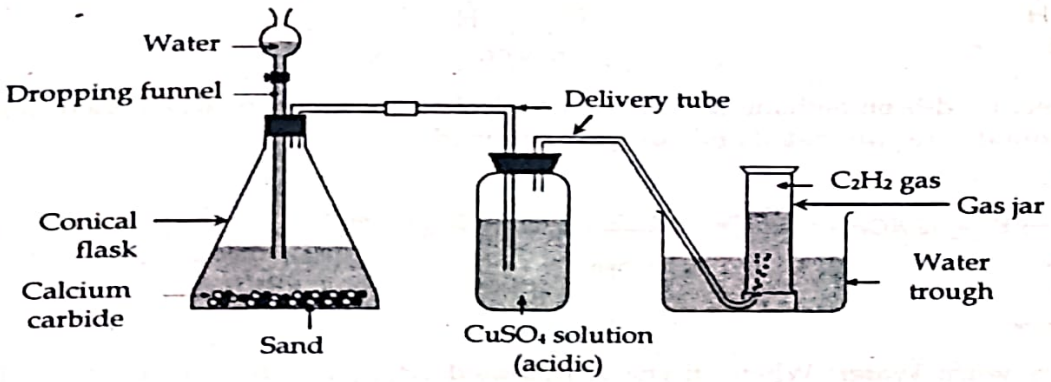


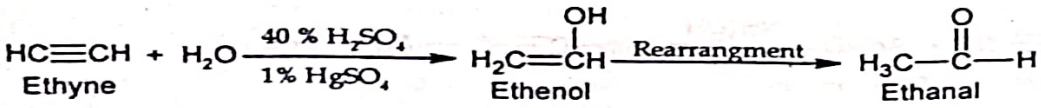
Fig: Laboratory method of preparation of ethyne

Procedure: Few grams of calcium carbide is taken in a conical flask containing a layer of sand. The flask is fitted with a dropping funnel. Few mL of water is dropped from the dropping funnel over calcium carbide. Ethyne gas is liberated, which is passed through acidified solution of copper sulphate, which removes the impurities like H_2S,PH_3,NH_3 etc. the pure ethyne gas is collected in gas jar by the downward displacement of water.

$$CuSO_4 + H_2S \longrightarrow \underset{\text{Black ppt}}{CuS\downarrow} + H_2SO_4$$

$$3CuSO_4 + 2PH_3 \longrightarrow \underset{\text{Black ppt}}{Cu_3P_2\downarrow} + 3H_2SO_4$$

Conversion: Ethyne to ethanol



16. 2075 GIE Q.No. 26 **How is ethyne gas prepared in the laboratory?** [5]

➢ Please refer to 2076 Set C Q.No. 25

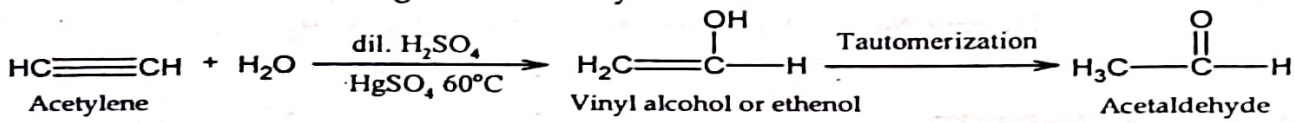
17. 2073 Supp Q.No. 25 **How is ethyne prepared in laboratory? Give a test reaction of ethyne.** [4+1]

➢ Please refer to 2076 Set C Q.No. 25

18. 2071 (Set C) Q.No. 26 **How is acetylene gas prepared in the laboratory. What happens when acetylene is passed through $HgSO_4$ and H_2SO_4 at 60°C?** [4 + 1]

➢ **Laboratory preparation of acetylene:** Please refer to 2076 Set C Q.No. 25

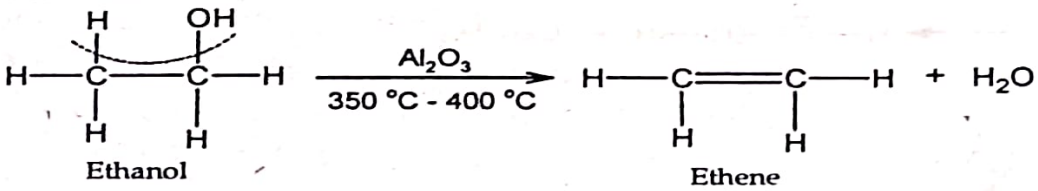
When acetylene gas is passed through $HgSO_4$ and H_2SO_4 at 60°C, vinyl alcohol is obtained which on tautomerization gives acetaldehyde.



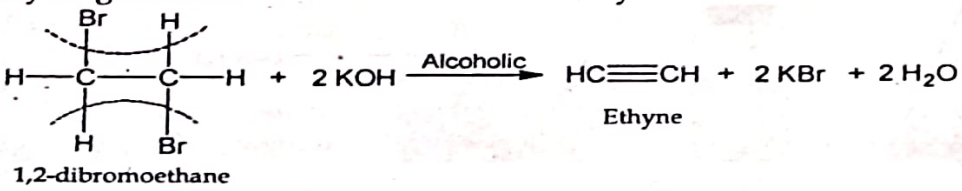
19. 2071 (Set D) Q.No. 26 **Give a suitable reaction for the preparation of each of:**
a. ethene **b. ethyne**
How does ethyne react with (i) water and (ii) cuprous chloride. How would convert ethyne into ethane? [1+1+1+

➢ **Preparation of:**

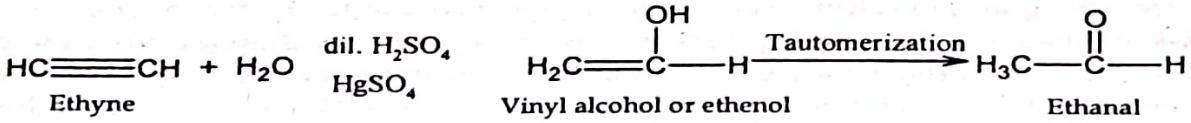
a. **Ethene:** When ethanol vapour is passed over heated alumina at 350°c – 400°c, ethene is obtained.



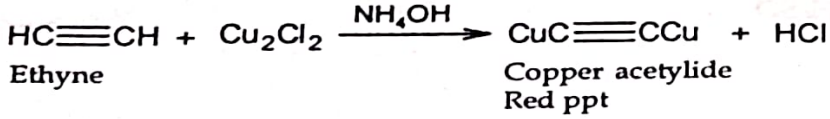
b. **Ethyne:** When 1,2-dibromoethane is boiled with alcoholic solution of KOH, two molecule of hydrogen bromide are eliminated and ethyne is obtained.



i. **Ethyne reacts with: Water:** When ethyne is hydrated (H_2O) i.e. treated with dil. H_2SO_4 in presence of $HgSO_4$ then vinyl alcohol i.e. ethenol is formed which on tautomerization to form ethanol.



ii. **Cuprous chloride:** When ethyne on treatment with ammoniacal solution of cuprous chloride then red ppt. of copper acetylide is formed.



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Conversion ethyne to ethane: Ethyne reacts with hydrogen in the presence of finely divided nickel as catalyst at 150 – 250°C, ethene then ethane is obtained.

$$\underset{\text{Ethyne}}{HC{\equiv}CH} + H_2 \xrightarrow[250\,^\circ C]{Ni} \underset{\text{Ethene}}{H_2C{=}CH_2}$$

$$\underset{\text{Ethene}}{H_2C{=}CH_2} + H_2 \xrightarrow[250\,^\circ C]{Ni} \underset{\text{Ethane}}{H_3C{-}CH_3}$$

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20. 2069 (Set A) Q. No. 29 **How is ethyne prepared in the laboratory? What is Baeyer's test?** **[4+1]**

Laboratory Preparation of Ethyne: Please refer to 2076 Set C Q.No. 25

Baeyer's Test: Alkaline solution of pot. permanganate is called Baeyer's reagent. This reagent is used for the identification of unsaturated hydrocarbon. The test which is performed by using Baeyer's reagent is called Baeyer's test. When alkyne is treated with Baeyer's reagent then pink colour of reagent is discharged.

$$\underset{\text{Ethyne}}{HC{\equiv}CH} \xrightarrow{KMnO_4 / OH^-} \underset{\text{Oxalic acid}}{HO{-}\overset{O}{\overset{\|}{C}}{-}\overset{O}{\overset{\|}{C}}{-}OH}$$

This test identify the given organic compound is unsaturated hydrocarbon.

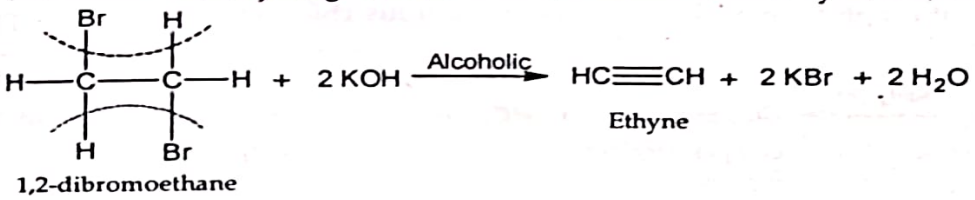
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21. 2069 (Set B) Q. No. 26 **Write any two method of preparation of ethyne. What happens when ethyne is**

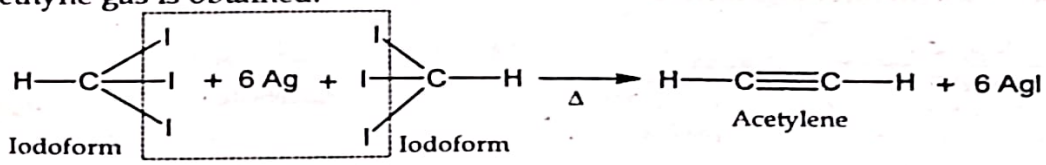
i. **Catalytically hydrated.**
ii. **Heated in a red hot iron tube**
iii. **Treated with hydrogen in presence of Pd / $BaSO_4$** **[2+3]**

Preparation of ethyne:

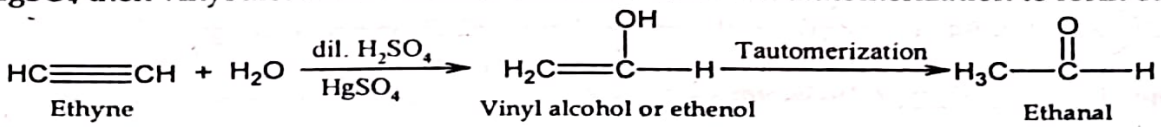
a. **From 1,2-dibromoethane:** When 1,2-dibromoethane is boiled with alcoholic solution of KOH, two molecule of hydrogen bromide are eliminated and ethyne is obtained.



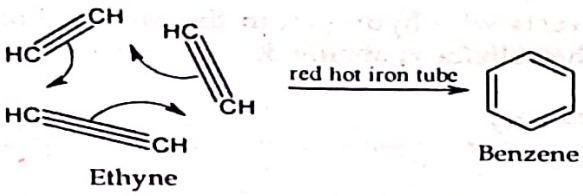
b. **By heating iodoform with silver powder:** When iodoform is heated with silver powder then ethyne gas is obtained.



i. **Catalytically hydrated:** When ethyne is hydrated (H_2O) i.e. treated with dil. H_2SO_4 in presence of $HgSO_4$ then vinyl alcohol i.e. ethenol is formed which on tautomerization to form ethanol.



ii. **Heated in a red hot iron tube:** When ethyne gas is passed through red hot iron tube, benzene is formed. This reaction is known as polymerization reaction.



iii. Treated with hydrogen in presence of Pd / $BaSO_4$: When ethyne is treated with hydrogen in presence of Pd/$BaSO_4$, ethene is formed which on further addition then ethane is formed.

$$\underset{\text{Ethyne}}{HC{\equiv}CH} + H_2 \xrightarrow{Pd\,/\,BaSO_4} \underset{\text{Ethene}}{H_2C{=}CH_2} \xrightarrow[H_2]{Pd\,/\,BaSO_4} \underset{\text{Ethane}}{H_3C{-}CH_3}$$

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22. 2062 Q.No. 29 **How is acetylene prepared in laboratory? What happens when acetylene gas is passed through ammoniacal solution of Silver nitrate?** [4+1]

Laboratory Preparation Acetylene: Please refer to 2076 Set C Q.No. 25

When acetylene gas is passed through ammoniacal solution of silver nitrate i.e. $AgNO_3$ then white ppt of silver acetylide is formed. This indicates the presence of triple covalent bond between two carbon atom.

$$\underset{\text{Acetylene}}{HC{\equiv}CH} + 2AgNO_3 \xrightarrow{NH_4OH} \underset{\substack{\text{Silver acetylide}\\ \text{White ppt}}}{Ag{-}C{\equiv}C{-}Ag} + 2HNO_3$$

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23. 2061 Q.No. 29(b) 2060 Q.No. 29(ii) 2059 Q.No. 29(b) **What happens when:** [2]

a. ethyne is passed through ammonical solution of cuprous chloride.
b. ethyne is hydrated catalytically.
c. iodoform is heated with silver powder.

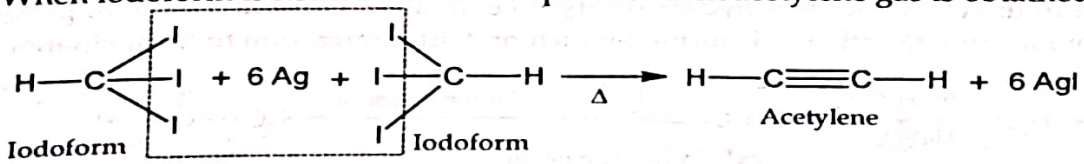
a. When ethyne is passed through ammoniacal solution of cuprous chloride, red ppt. of copper acetylide is formed.

$$\underset{\text{Ethyne}}{HC{\equiv}CH} + Cu_2Cl_2 \xrightarrow{NH_4OH} \underset{\substack{\text{Copper acetylide}\\ \text{Red ppt}}}{CuC{\equiv}CCu} + HCl$$

b. When ethyne is hydrated in the presence of 42% H_2SO_4 and 1% $HgSO_4$ at 60 – 80°C , then vinyl alcohol is obtained which on rearrangement to give acetaldehyde.

$$\underset{\text{Ethyne}}{HC{\equiv}CH} + H_2O \xrightarrow[\substack{1\%HgSO_4\\ 60-80\,^\circ C}]{42\%\,H_2SO_4} \underset{\text{Vinyl alcohol}}{\begin{matrix} H & & OH \\ & C{=}C & \\ H & & H \end{matrix}} \xrightarrow{\text{Rearrangement}} \underset{\text{Acetaldehyde}}{H_3C{-}\overset{O}{\overset{\|}{C}}{-}H}$$

c. When iodoform is heated with silver powder then acetylene gas is obtained.

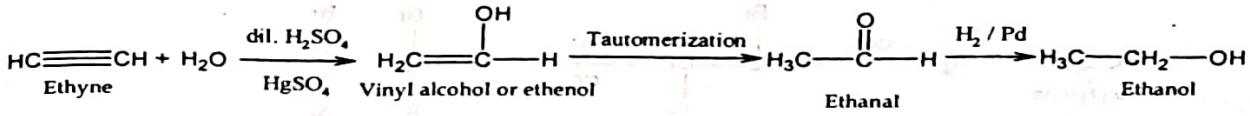


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24. 2061 Q.No. 29(b) **Conversion: Ethyne to ethanol** [2.5]

When ethyne is treated with water in the presence of H_2SO_4 and $HgSO_4$, vinyl alcohol is obtained which on tautomerization to give ethanal. Ethanal on reduction with H_2 / Pd, ethanol is obtained.

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25. 2058 Q.No. 33(c)/ 2056 Q.No. 32 b **Write notes on Acidic nature of ethyne** **[5]**

The polarity of the bond between H atom and triple bonded carbon atom can be explained on the basis of hybridization. In acetylene the carbon atoms are sp-hybridization and they possess 50% s-character and 50% p-character. So, the sp-hybridized carbon atom is more electronegative than hydrogen and the bonding pair of electrons are displaced towards the carbon atom and bearing partial negative charge and hydrogen atom bears partial positive charge. Due to this polarity generated, H- atoms are easily donated as their proton indicating the acidic property of acetylene.

The acidic nature of acetylene or ethyne is proved by the following reaction:

$$H-C\equiv C-H + 2Na \longrightarrow \underset{\text{Sod. acetylide}}{NaC\equiv CNa} + H_2\uparrow$$

$$H-C\equiv C-H + 2Li \longrightarrow \underset{\text{Lithium acetylide}}{LiC\equiv CLi} + H_2\uparrow$$

$$H-C\equiv C-H + 2NaNH_2 \longrightarrow NaC\equiv CNa + NH_3\uparrow$$

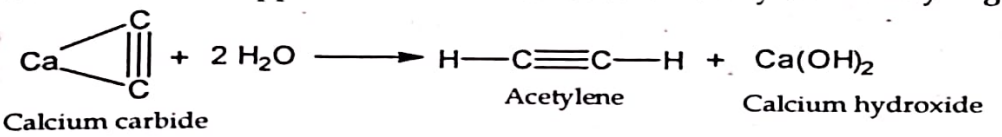
$$H-C\equiv CNa + H_2O \longrightarrow H-C\equiv C-H + NaOH$$

26. 2057 Q.No. 29

a. What gaseous product would you expect when water is dropped over calcium carbide? Give reaction. [2]

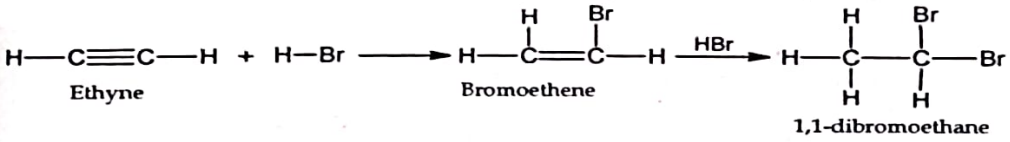
b. What action takes place when the gas obtained from the above reaction is allowed to react with (i) HBr and (ii) dil. H_2SO_4 in presence of $HgSO_4$? [3]

a. When water is dropped over calcium carbide then acetylene or ethyne gas is formed.

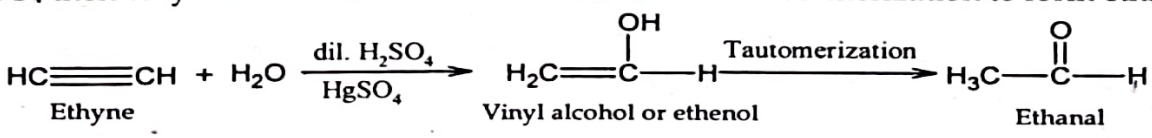


b. Acetylene gas is allowed to react with

i. **HBr:** When acetylene gas is treated with HBr then bromoethene is formed which on further treatment with HBr to form 1,1-dibromoethane according to Markovnikov's rule.



ii. **With dil. H_2SO_4 in presence of $HgSO_4$:** When ethyne is treated with dil. H_2SO_4 in presence of $HgSO_4$ then vinyl alcohol i.e. ethenol is formed which on tautomerization to form ethanal.

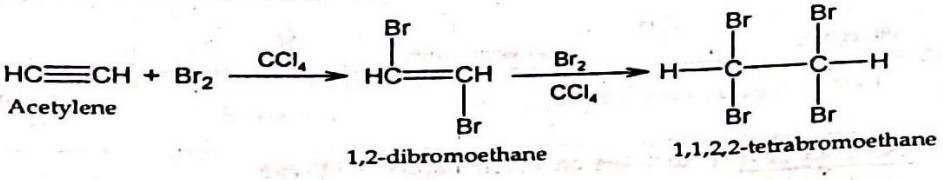


27. 2056 Q.No. 29 **How is acetylene prepared in the laboratory from calcium carbide? Give a reaction to detect unsturation in acetylene.** **[5]**

Laboratory method of preparation of acetylene: Please refer to 2076 Set C Q.No. 25

Test of acetylene: When acetylene gas is treated with 5% bromine in the presence of carbon tetrachloride. If the brown colour is discharged, then organic compound is unsaturated. This is due to the formation of 1,1,2,2-tetrabromoethane.

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Acetylene

1,2-dibromoethane

1,1,2,2-tetrabromoethane

WRITE SHORT NOTES ON

28. 2075 Set A Q.No. 33iii 2075 Set B Q.No. 33iii 2074 Supp Q.No. 33(ii) 2074 Set A Q.No. 33ii 2074 Set B Q.No. 33iii 2072 Set E Q.No. 33iv 2070 Supp. Q.No. 33 (a) 2065 Q. No. 33 b **Laboratory preparation of ethyne.** [5]

Please refer to 2076 Set C Q.No. 25

29. 2072 Set C Q.No. 33c 2072 Set D Q.No. 33c 2067 Q.No. 33c **Laboratory preparation of acetylene.** [5]

Please refer to 2076 Set C Q.No. 25

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