ENGINEERING CHEMISTRY

LECTURE NOTE

Based on New syllabus (2018-19) circulated by SCTE&VT, Odisha for 1st and 2nd Semester Diploma Engineering courses approved by AICTE, New Delhi

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PHYSICAL CHEMISTRY

CHAPTER-1

ATOMIC STRUCTURE

Qn:-1. Define the terms (i) Electron (ii) Protons (iii) Neutrons.

(i) Electrons:- (-ve charge particle)

* Discovered by J. J. Thomson.
* charge = -1.6×10^{-19} coulombs
* Mass = 9.1×10^{-31} kg

(ii) Protons:- (+ve charge particle)

* Discovered by Goldstein.
* charge = $+1.6 \times 10^{-19}$ coulombs
* Mass = 9.1×10^{-31} kg

(iii) Neutrons:- (charge less)

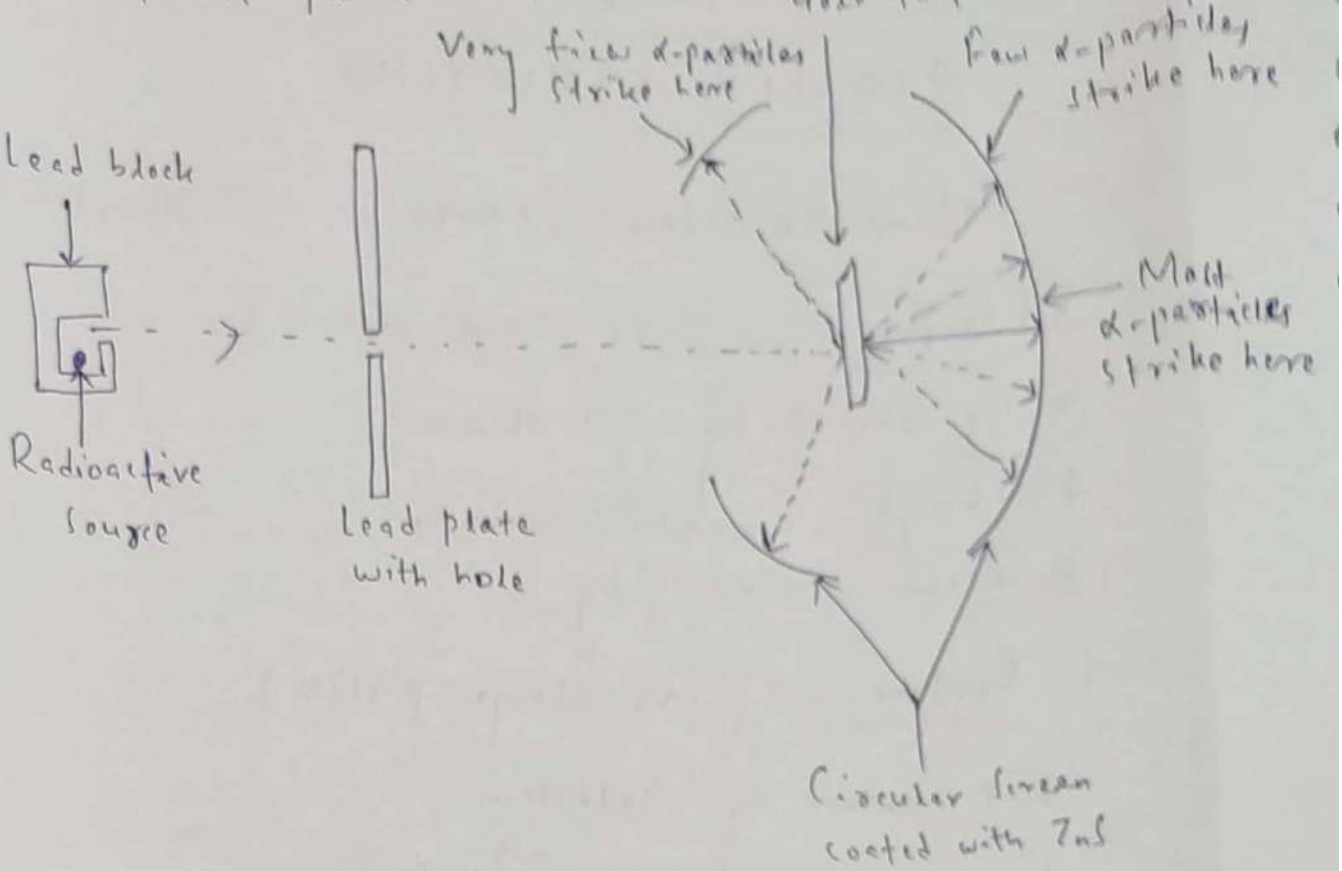
* Discovered by Chadwick.
* charge = 0
* Mass = 1.675×10^{-27} kg

Qn:-2 Briefly explain Rutherford's α-scattering experiment. Write Rutherford's atomic model. and it's limitations

Experiment:-

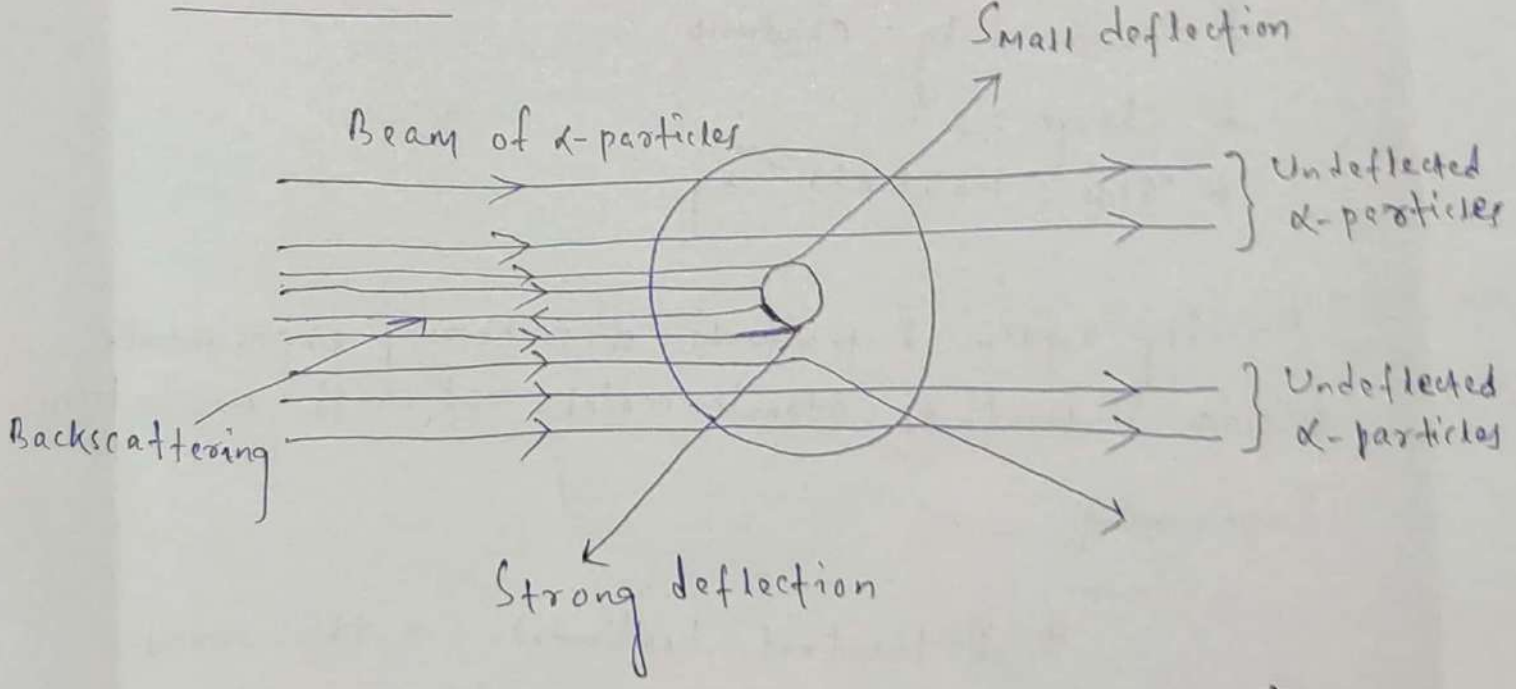
* Rutherford bombarded a thin sheet of gold foil with α-particle (He^{2+}).
* A circular screen coated with ZnS is placed on the otherside of the gold foil.

* α-particles are produced from a radioactive material placed in a lead block.



(Rutherford's α-scattering experiment)

Observation:-



(Scattering experiment for a single atom)

Rutherford's Atomic Model :-

Postulates :-

(i) According to this model, an atom consists of two parts. (1) Nuclear part.
(2) Extranuclear part.

(1) Nuclear part :-

* Nucleus is positively charged due to the presence of proton.

* As neutrons and protons are present in the nucleus, the whole mass of an atom is concentrated at the nucleus only.

* Nucleus is situated at the centre of an atom in a very small volume.

* Diameter of the nucleus is about 10^{-13} cm, which indicates that the size of ~~the~~ an atom is about 10^5 times the size of the nucleus.

(2) Extranuclear Part :-

* Extranuclear part of the atom is an empty space around the nucleus where electrons are revolving around the nucleus.

* The number of electrons and protons present in ~~a~~ an atom is equal. So, atom is neutral.

* The Rutherford's atomic model is compared to solar system, where nucleus is like sun and the ~~planets~~ electrons are like planets.

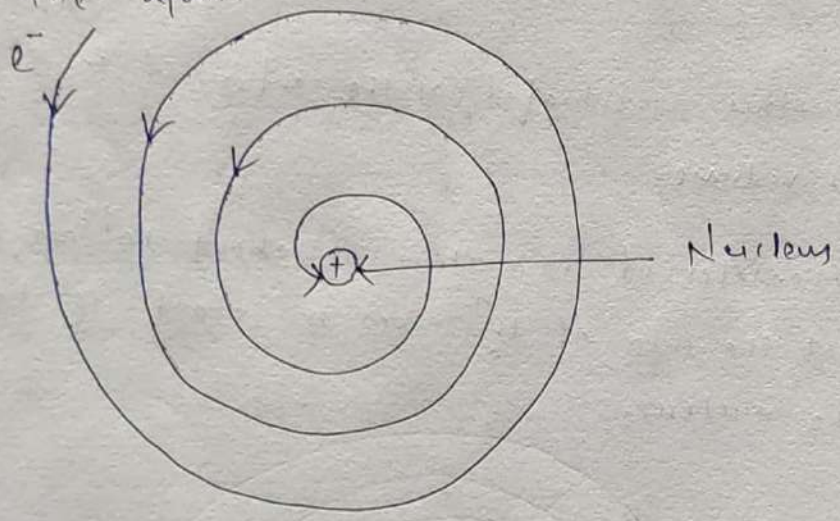
Drawbacks of Rutherford's atomic Model:—

(i) Rutherford's atomic model does not obey the law of electrodynamics.

According to Clark Maxwell, when a charged particle moves around an oppositely charged centre, it will lose energy continuously.

As e^- is revolving around the nucleus, it will loose energy continuously and come closer and closer towards the nucleus and ultimately fall into the nucleus. But it never happens.

So, this model does not explain the stability of the atom.



(Spiral path of an electron)

(ii) This theory does not explain the line spectra of atoms.

Qn:-2 Write the postulates of Bhor's atomic Model.

This theory is based on Max Planck's quantum theory. The main postulates of this theory are as follows:-

(i) Electrons moved around the nucleus in certain fixed circular orbits without losing or gaining energy.

(ii) Such orbits are called stationary states or main energy levels and numbered as 1, 2, 3, 4, etc. or alphabetically designated as K, L, M, N etc. respectively.

(iii) Energy associated with these stationary states is given by, $E_n = \frac{-1312}{n^2}$ KJ/mol for H-atom.

n = Number of energy levels.

(iv) Electrons can move only around the nucleus on those energy levels where the angular momentum is a whole number multiple of $h/2\pi$. That is,

$$mvr = \frac{nh}{2\pi}$$

where, m = Mass of e^-
v = Velocity of e^-
r = radius of orbit
n = number of orbit
h = Planck's constant

(v) Transition of electron between two stationary states can take place by absorption or emission of energy.

$$\boxed{\Delta E = E_2 - E_1} \Rightarrow \boxed{h\nu = E_2 - E_1}, \text{ where } \Delta E = h\nu$$

ΔE = change of energy

E_2 = Energy of second shell

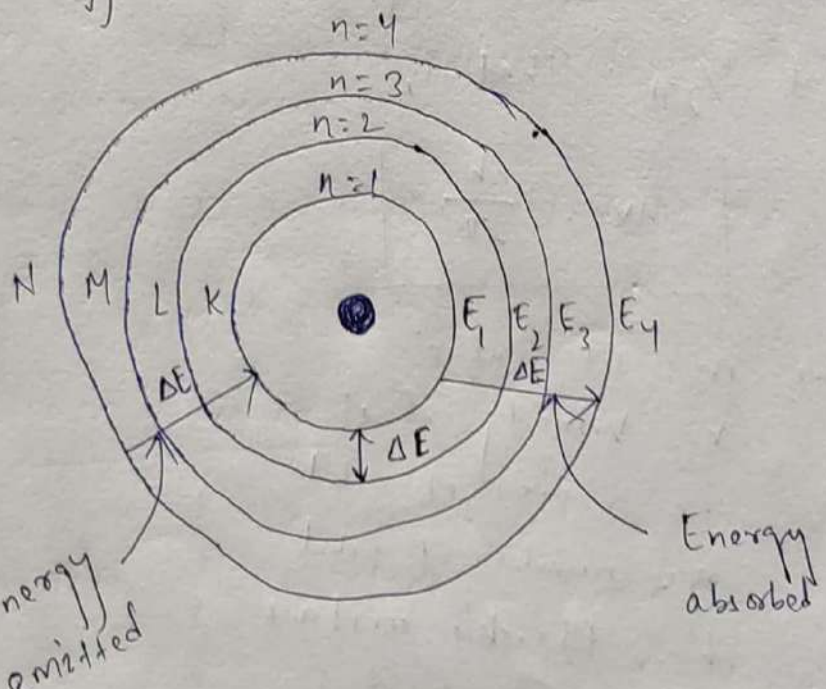
E_1 = Energy of 1st shell

h = Planck's constant

ν = frequency of energy

(vi) As long as an electron is present in a definite energy level, it does not lose or gain energy.

The electrons jump from a lower energy level to higher energy level by absorbing energy and jumps from a higher energy level to a lower energy level by emitting out energy.



(Electronic Energy)

Qn:-3

What is Bohr-Bury Scheme / Model ?

The distribution of electrons in different orbits was given by Bohr and Bury.

It includes the following rules:-

(i) The maximum number of electrons that can be accommodated in an orbit is equal to $2n^2$, where n is the number of orbits.

For 1st shell, $n=1$, number of $e^-s = 2 \times 1^2 = 2$

For 2nd shell, $n=2$, number of $e^-s = 2 \times 2^2 = 8$

For 3rd shell, $n=3$, number of $e^-s = 2 \times 3^2 = 18$

For 4th shell, $n=4$, number of $e^-s = 2 \times 4^2 = 32$

(ii) The outermost orbit of an element cannot contain more than 8 electrons and the penultimate orbit cannot contain more than 18 electrons.

(iii) It is not always necessary to complete an orbit before the next orbit starts filling.

Qn:-4 Define the following terms (i) Atomic Mass

(ii) Mass Number

(iii) Atomic Number

(iv) Isotope

(v) Isotone

(vi) Isobar

(ii) Atomic Mass :-

Atomic mass of an element is defined as the relative average mass of it's atom as compared to the mass of an atom of Carbon taken as 12 (^{12}C).

Hence the atomic mass of an element is the number which shows how many times the mass of an atom of that element is heavier than $1/12^{th}$ mass of an atom of carbon ~~taken as~~ (^{12}C) or one amu. Atomic mass is a number and it has no unit.

Ex:- Atomic mass of aluminium is 27. That means one atom of Al is 27 times heavier than $1/12^{th}$ mass of one atom of carbon (^{12}C)

(ii) Mass Number :-

The sum of the number of protons and neutrons present in the nucleus of an atom is known as the mass number.

Ex:- 'C' has 6 neutron and 6 proton.

So, mass number = 6+6 = 12

(iii) Atomic Number :-

The number of protons present in the nucleus of an atom is known as atomic number.

Ex:- 'C' has 6 proton. So, it's atomic number 6.

(iv) Isotopes :-

Atoms having same atomic number but different mass number.

Example – $^{12}_{6}C$, $^{13}_{6}C$

$^{35}_{17}Cl$, $^{37}_{17}Cl$

(v) Isotones :-

Atoms of different elements which possess the same no. of neutrons.

Example – $^{76}_{32}Ge$, $^{77}_{33}As$

(vi) Isobar :-

Atoms of different elements having the same mass number but different in their atomic numbers.

Example – $^{40}_{18}Ar$, $^{40}_{20}Ca$

Qn:-5 Define the following principles.

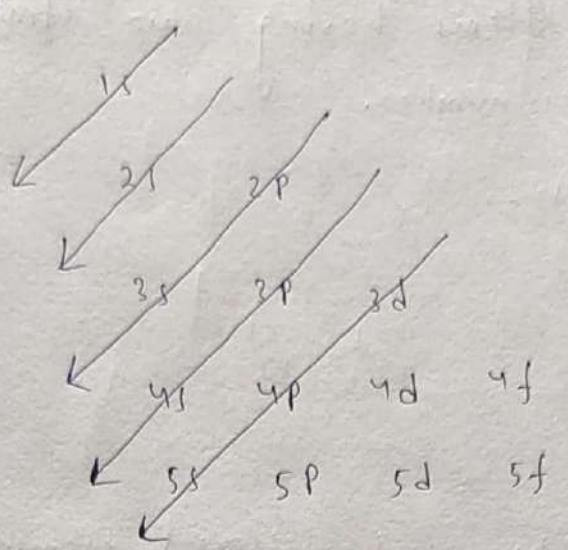
(i) Aufbau's Principle

(ii) Hund's Rule

(i) Aufbau's Principle :-

According to this principle, the electrons are filled in various orbitals in order of their increasing energies.

Thus, an orbital with lowest energy will be filled first.



(Order of filling up orbitals)

(n+l) Rule

(i) The subshell with lower (n+l) value will possess lower energy and will be filled first.

(ii) Hund's Rule :—

According to this rule

"No electron pairing takes place in p, d and f-subshells until each degenerate orbital in the given subshell contains one electron."

Qn:-6 Write the electronic configuration of elements having atomic no. 1 to atomic no. 30.

$_{1}H \rightarrow 1s^1$

$_{2}He \rightarrow 1s^2$

$_{3}Li \rightarrow 1s^2\ 2s^1$

$_{4}Be \rightarrow 1s^2\ 2s^2$

$_{5}B \rightarrow 1s^2\ 2s^2\ 2p^1$

$_{6}C \rightarrow 1s^2\ 2s^2\ 2p^2$

$_{7}N \rightarrow 1s^2\ 2s^2\ 2p^3$

$_{8}O \rightarrow 1s^2\ 2s^2\ 2p^4$

$_{9}F \rightarrow 1s^2\ 2s^2\ 2p^5$

$_{10}Ne \rightarrow 1s^2\ 2s^2\ 2p^6$

$_{11}Na \rightarrow 1s^2\ 2s^2\ 2p^6\ 3s^1$

$_{12}Mg \rightarrow 1s^2\ 2s^2\ 2p^6\ 3s^2$

$_{13}Al \rightarrow 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$

$_{14}Si \rightarrow 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^2$

$_{15}P \rightarrow 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^3$

$_{16}S \rightarrow 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^4$

$_{17}Cl \rightarrow 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$

$_{18}Ar \rightarrow 1s^2\ 2s^2 2p^6\ 3s^2 3p^6$

$_{19}K \rightarrow 1s^2\ 2s^2 2p^6\ 3s^2 3p^6\ 4s^1$

$_{20}Ca \rightarrow 1s^2\ 2s^2 2p^6\ 3s^2 3p^6\ 4s^2$

$_{21}Sc \rightarrow \underbrace{1s^2\ 2s^2 2p^6\ 3s^2 3p^6}_{[Ar]_{18}}\ 4s^2\ 3d^1$

$_{22}Ti \rightarrow [Ar]_{18}\ 4s^2\ 3d^2$

$_{23}V \rightarrow [Ar]_{18}\ 4s^2\ 3d^3$

$_{24}Cr \rightarrow [Ar]_{18}\ 4s^1\ 3d^5$

$_{25}Mn \rightarrow [Ar]_{18}\ 4s^2\ 3d^5$

$_{26}Fe \rightarrow [Ar]_{18}\ 4s^2\ 3d^6$

$_{27}Co \rightarrow [Ar]_{18}\ 4s^2\ 3d^7$

$_{28}Ni \rightarrow [Ar]_{18}\ 4s^2\ 3d^8$

$_{29}Cu \rightarrow [Ar]_{18}\ 4s^1\ 3d^{10}$

$_{30}Zn \rightarrow [Ar]_{18}\ 4s^2\ 3d^{10}$

CHAPTER-2

CHEMICAL BONDING

Qn:-1 Define and explain different types of bonds with examples. Differentiate between Ionic compounds and Covalent compounds.

Ionic Compounds	Covalent Compounds
1. These are formed by the transfer of one or more electrons from one atom to another.	1. These are formed by the sharing of one or more electrons between the bonded atoms.
2. These consists of ions.	2. These consist of individual molecules.
3. These are hard solids with high boiling and melting points	3. These exists as gases, liquids or soft solids with low melting and boiling points.
4. These are soluble in water but insoluble in organic solvents	4. These are soluble in water but soluble in organic solvents.
5. These conduct electricity in fused state as well as in aqueous solution.	5. These do not conduct electricity
6. These undergo ionic reactions which are very fast.	6. These undergo molecular reactions which are very slow.
7. These do not show isomerism	7. These show isomerism.

Chemical Bond :-

The force of attraction which holds the constituent atoms together in a molecule is known as the chemical bond.

There are three types of bonds

(I) Ionic Bond

(II) Covalent Bond

(III) Coordinate Bond

(I) Ionic Bond :-

The bond which is formed by the transfer of one or more electrons from one atom to the other is called the ionic bond.

$$A \longrightarrow A^{n+} + ne^-$$

$$B + ne^- \longrightarrow B^{n-}$$

$$A^{n+} \quad B^{n-}$$

~~Example~~

(II) Covalent Bond :-

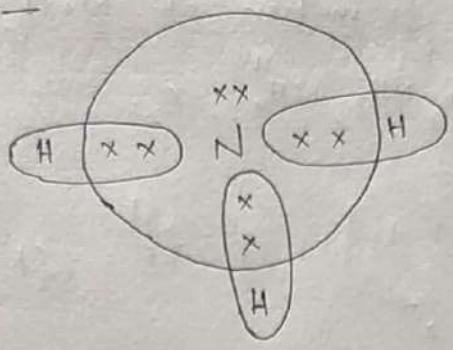
It is formed by mutual sharing of valence electrons bet^n the constituent atoms to attain the stable electronic configuration.

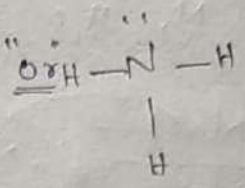
Example :-

$_7N \rightarrow 1s^2\ 2s^2\ 2p_x^1\ 2p_y^1\ 2p_z^1$

$_1H \rightarrow 1s^1$

Example :—





(iii) Co-ordinate or Dative Bond :—

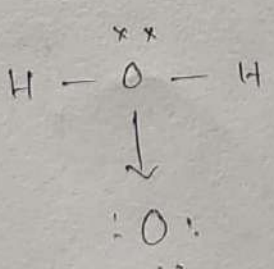
A co-ordinate bond is formed when an atom with complete octet (after mutual sharing) donates its pair of electrons to the other atom. The donated pair is counted for the stability of both the atoms.

Characteristics :—

* Formed bet^{n} two dissimilar atoms
* denoted by ($\longrightarrow$) : The head arrow towards the acceptor and tail is towards donor.
* Directional in nature.

Example :—

H_2O_2



Qn:-2 Write the formation of $NaCl$, $MgCl_2$, H_2, Cl_2, O_2, N_2, H_2O, CH_4, NH_3, NH_4^+, SO_2.

NaCl

$_{11}Na \rightarrow 1s^2 2s^2 2p^6 3s^1$ $\quad$ $_{17}Cl \rightarrow 1s^2 2s^2 2p^6 3s^2 3p^5$

$Na \rightarrow Na^+ + e^-$

$Cl + e^- \rightarrow Cl^-$

$Na^+ : Cl^-$

(NaCl)

$MgCl_2$

$_{12}Mg \rightarrow 1s^2 2s^2 2p^6 3s^2$

$_{17}Cl \rightarrow 1s^2 2s^2 2p^6 3s^2 3p^5$

$Mg \rightarrow Mg^{2+} + 2e^-$

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

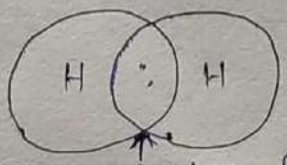
$Cl^- : Mg^{2+} : Cl^-$

($MgCl_2$)

H_2

$_1H \rightarrow 1s^1$

$_1H \rightarrow 1s^1$



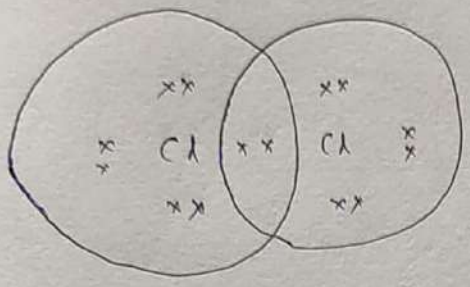
Electron Pair

(H_2)

Cl_2

$_{17}Cl \rightarrow 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$

$_{17}Cl \rightarrow 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$



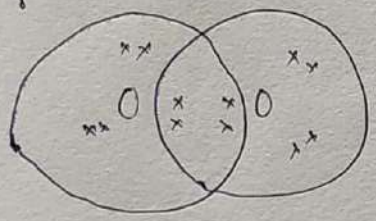
Cl – Cl

(Cl_2)

O_2

$_{8}O \rightarrow 1s^2\ 2s^2\ 2p^4$

$_{8}O \rightarrow 1s^2\ 2s^2\ 2p^4$

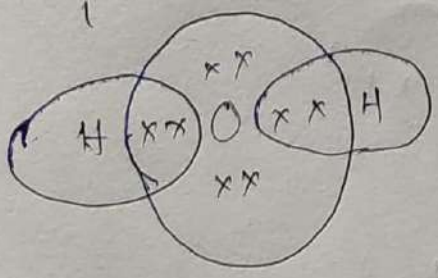


O = O

H_2O

$_{8}O \rightarrow 1s^2\ 2s^2\ 2p^4$

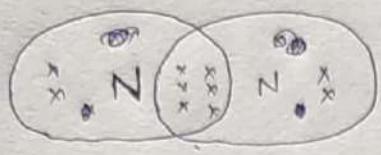
$_{1}H \rightarrow 1s^1$



H – O – H

N_2

$_7N \rightarrow 1s^2\ 2s^2\ 2p^3$

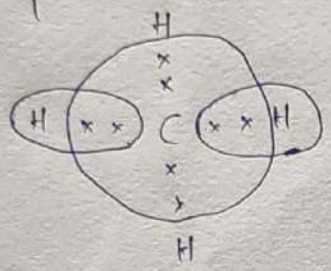


$N \equiv N$

CH_4

$_6C \rightarrow 1s^2\ 2s^2\ 2p^2$

$_1H \rightarrow 1s^1$



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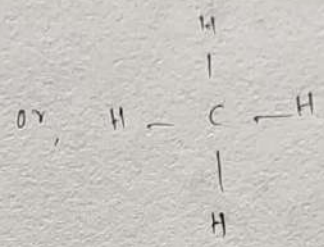
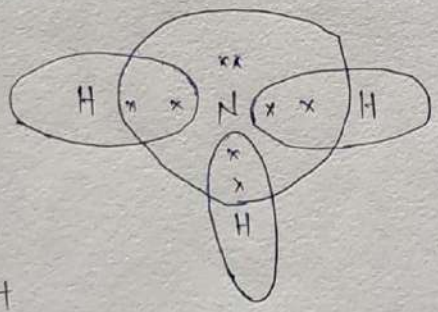


NH_3

$_7N \rightarrow 1s^2\ 2s^2\ 2p^3$

$_1H \rightarrow 1s^1$



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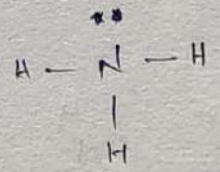
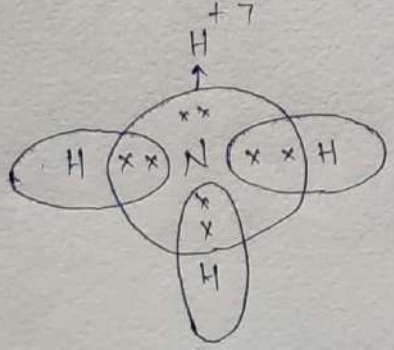


NH_4^+

$_7N \rightarrow 1s^2\ 2s^2\ 2p^3$ $\quad$ $_1H \rightarrow 1s^1$



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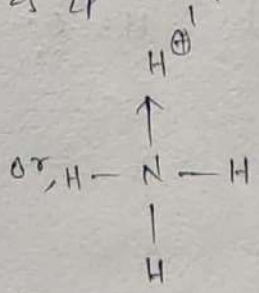
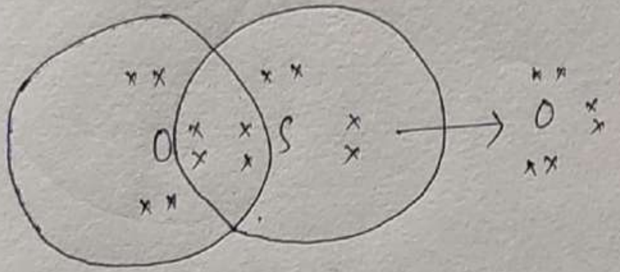


SO_2

$_{16}S \rightarrow 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^4$

$_8O \rightarrow 1s^2\ 2s^2\ 2p^4$



or, $O = S \longrightarrow O$

* We can denote electron either by '×' i.e. cross mark or '·' dot mark,

ACID BASE THEORY

CHAPTER-3

Qn:- Write the postulates and limitations of the following theories - (1) Arrhenius theory
(2) Bronsted-Lowry theory
(3) Lewis theory

(1) Arrhenius theory of Acids and bases:-

Acids are those substance which give H^+ ions in aqueous solution and bases are those substances which give OH^- ions in aqueous solution.

Example:-

$$HCl(aq) \longrightarrow H^+(aq.) + Cl^-(aq.)$$

$$HNO_3(aq) \longrightarrow H^+(aq.) + NO_3^-(aq.)$$

So, HCl and HNO_3 are acids.

$$NaOH(aq.) \longrightarrow Na^+(aq.) + OH^-(aq.)$$

$$KOH(aq.) \longrightarrow K^+(aq.) + OH^-(aq.)$$

So, NaOH and KOH are bases.

Limitations of Arrhenius Theory:-

(i) This theory is limited to aqueous medium only.

(ii) This theory does not explain the acidic and basic nature of the substances which do not contain H^+ or OH^- ions.

(2) Bronsted-lowry theory of Acids and Bases:-

According to this theory, acids are the substance which has a tendency to donate a proton(H^+) and bases are the substances which has a tendency to accept a proton(H^+).

Ex:-

$$HCl \rightleftharpoons H^+ + Cl^-$$

$$HNO_3 \rightleftharpoons H^+ + NO_3^-$$

As, HCl, HNO_3 can donate a proton, these are acids.

$$NH_3 + H^+ \rightleftharpoons NH_4^+$$

$$HS^- + H^+ \rightleftharpoons H_2S$$

As, NH_3, HS^- can accept a proton, these are bases.

Limitations:-

(i) This theory does not explain the acidic nature of $AlCl_3$, $FeCl_2$, BF_3 etc.

(ii) This theory fails to explain the reactions between acidic oxides such as CO_2, SO_2 and SO_3 and basic oxides such as MgO, CaO and BaO.

Conjugate Acid-Base Pair:-

When an acid loses a proton, the residue will act as a base and when a base accepts a proton, the residue will act as an acid.

$$\text{Acid} \longrightarrow \text{Conjugate base} + H^+$$

$$\text{Base} + H^+ \longrightarrow \text{Conjugate acid.}$$

The pair of acid and base which differs by a proton is known as the conjugate acid-base pair.

Ex:-

$$NH_3 + H^+ \longrightarrow NH_4^+$$

Conjugate acid-base pair

$$H_2O + H^+ \longrightarrow H_3O^+$$

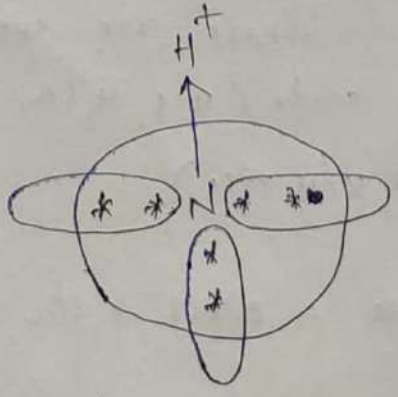
Conjugate acid-base pair.

(3) Lewis Acid-Base Theory :-

According to this theory, acid is a substance that accept a lone pair of electrons while a base is a substance which can donate a lone pair of electrons.

So acid is a lone pair acceptor and base is a lone pair donor.

Example :-



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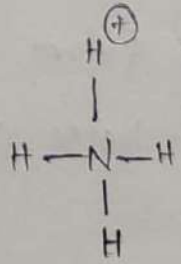


Here, H^+ is the acid as it accepts a lone pair and

NH_3 is the base as it donates a lone pair.

Limitations of Lewis theory :-

(i) This theory does not explain the behaviour of strong acids such as HCl, H_2SO_4 and HNO_3 as they do not form a dative bond with bases.

(ii) This theory fails to explain the strength of acids and bases as it does not consider ionisation.

Qn:-2 What is salt ? Explain different types of salts (i) Normal (ii) Acidic (iii) Basic (iv) Double (v) Complex (vi) Mixed salts.

A salt is defined as a crystalline compound which is formed by the complete neutralisation of aqueous strong acid with an aqueous solution of a strong base.

Acid + Base ⟶ Salt + Water

(i) Normal Salt :-

These are the salts which are formed from strong acids (HCl, H_2SO_4, HNO_3 etc.) and strong bases (NaOH, KOH etc.)

Example :- NaCl, K_2SO_4, Na_2SO_4 etc.

(ii) Acidic Salts:—

Acidic salts are formed by the incomplete neutralisation of polybasic acids. Such salts still contain one or more replaceable hydrogen atoms.

Examples:— $NaHCO_3$, $NaHSO_4$, NaH_2PO_4 etc.

(iii) Basic Salts:—

Such salts are formed by the incomplete neutralisation of poly acid bases. Such salts still contain one or more hydroxyl groups.

Examples:— $Mg(OH)Cl$, $Zn(OH)Cl$ etc.

(iv) Double salts:—

These are the addition compounds formed by the combination of two simple salts. Such salts are stable only in the solid state.

Examples:— $K_2SO_4 \cdot Al_2(SO_4)_3 \cdot 24H_2O$

(v) Complex Salts:—

These are compounds formed by the combination of simple salts or molecular compounds.

These are stable in the solid state as well as in solutions.

Example — $K_4[Fe(CN)_6]$, $[Cu(NH_3)_4]SO_4$ etc.

(vi) Mixed salts :-

These are the salts which furnish more than one cation or more than one anion when dissolved in water.

Examples :- $CaOCl_2$, $NaKSO_4$, $NaNH_4HPO_4$ etc.

Qn :-3 What is neutralisation of acid and base ?

When an aqueous solution of an acid is added to an aqueous solution of a base, a chemical reaction occurs resulting in the formation of a salt and water.

This process is called acid-base neutralisation

$$HCl(aq) + NaOH(aq) \longrightarrow NaCl(aq) + H_2O(l)$$

SOLUTIONS
CHAPTER-4

(1) Atomic Weight :—

It is defined as the relative average mass of it's atom as compared to the mass of an atom of Carbon taken as 12 (^{12}C).

Ex → Atomic mass of Aluminium is 27. That means one atom of Al is 27 times heavier than $\frac{1}{12}^{th}$ mass of one atom of carbon (^{12}C)

(2) Molecular Weight :—

The molecular mass ~~of~~ is the number which indicates how many times one molecule of a substance is heavier than $\frac{1}{12}^{th}$ mass of one atom of carbon ^{12}C.

Ex → Molecular mass of CO_2 is

$= 12 + 16 \times 2$

$= 12 + 32$

$= 44$ amu

That means one molecule of CO_2 is 44 times heavier than $\frac{1}{12}^{th}$ mass of one atom of carbon (^{12}C)

(3) Equivalent Mass :—

Equivalent mass of a substance is the number of parts by mass of it that combine with or displace directly or indirectly 1.008 parts by mass of hydrogen or 8 parts by mass of Oxygen or 35.5 parts by mass of Chlorine.

* It has no unit.

(4) Equivalent mass of Acid :-

Equivalent mass of acid = $\frac{\text{Molecular mass of acid}}{\text{Basicity}}$

Basicity : Number of replaceable H^+ ions.

Ex :- Calculate the equivalent weight of (i) HCl (ii) H_2SO_4

(i) HCl :-

Molecular mass = 1 + 35.5 = 36.5

Basicity = 1

Equivalent mass = $\frac{36.5}{1}$ = 36.5

(ii) H_2SO_4 :-

Molecular mass = 1×2 + 32 + 16×4

= 2 + 32 + 64

= 98

Basicity = 2

Equivalent mass = $\frac{98}{2}$ = 49

(5) Equivalent Mass of base :-

$$\text{Equivalent mass of base} = \frac{\text{Molecular mass of base}}{\text{Acidity}}$$

Acidity : Number of replaceable OH^- ions.

Ex :- Find the equivalent mass of NaOH, $Ca(OH)_2$ etc.

NaOH

Molecular mass : $23 + 16 + 1 = 40$

Acidity = 1

Equivalent mass : $\frac{40}{1} = 40$.

$Ca(OH)_2$

Molecular mass = $40 + (16+1) \times 2$

$= 40 + 34$

$= 74$

Acidity = 2

Equivalent mass = $\frac{74}{2} = 37$.

(6) Equivalent Mass of Salt :-

$$\text{Equivalent mass of salt} = \frac{\text{Molecular mass of salt}}{\text{Total valency of cation}}$$

Ex:- Find out the equivalent mass of $CaCl_2$, $Al_2(SO_4)_3$

$CaCl_2 \rightarrow Ca^{2+} + 2Cl^-$

Molecular mass : $40 + (35.5 \times 2)$

$= 40 + 71$

$= 111$

Valency of cation $= 2$

Equivalent mass $= \frac{111}{2} = 55.5$

$Al_2(SO_4)_3 \rightarrow 2Al^{3+} + 3SO_4^{2-}$

Molecular mass $= (27 \times 2) + (32 \times 3) + (16 \times 4)$

$= 54 + 96 + 192$

$= 342$

Equivalent mass $= \frac{342}{6} = 57$

(7) Modes of Expression of the concentrations: —

(i) **Molarity**: — It is the number of gram moles of the solute present in 1 Litre of solution.

$$\text{Molarity} = \frac{w \times 1000}{M \times V}$$

w: mass of solute

E = equivalent mass of solute

V = Volume of solution in ml.

(ii) **Normality**: — It is the number of gram equivalents of the solute present in 1 ltr. of solution.

$$\text{Normality} = \frac{w \times 1000}{E \times V}$$

w: Mass of solute

E = Equivalent Mass

V = Volume of solution in ml.

(iii) **Molality**: — It is the number of gram moles of the solute present in 1000g of the solvent.

$$\text{Molality} = \frac{w \times 1000}{M \times W}$$

w: Mass of the solute

M: Molecular mass of solute

W: Weight of solvent in gram.

(8) p^H of Solution :—

p^H of a solution is defined as the negative logarithm of the hydrogen ion concentration in moles per litre.

$$p^H = \log_{10} \frac{1}{[H^+]} = -\log [H^+]$$

So, $$\boxed{p^H = -\log [H^+]}$$

(9) Importance of p^H value Industries :—

(1) Sugar Industry :—

* The early stages of operation involves in the extraction of sugar cane juice, filtration etc.

* The p^H of this juice is carefully controlled to 7 i.e. neutral before further processing.

* If the juice becomes acidic (i.e. $p^H < 7$) sucrose in the juice is hydrolysed to glucose and fructose mixture.

* If the juice becomes alkaline ($p^H > 7$) undesirable acids and coloured substances are produced.

* p^H control is also very necessary during crystallisation of sugar.

ELECTROCHEMISTRY

CHAPTER-5

Qn:-1 Define the following terms (i) Electrolyte
(ii) Electrolytic cell
(iii) Electrolysis

(i) Electrolytes:-

The substances which conduct electricity in its aqueous state, molten state or fused state are known as electrolytes.

There are of two types:- (i) Strong Electrolytes
(ii) Weak Electrolytes

(ii) Electrolytic cell:-

It is the device in which electrolysis is carried out.

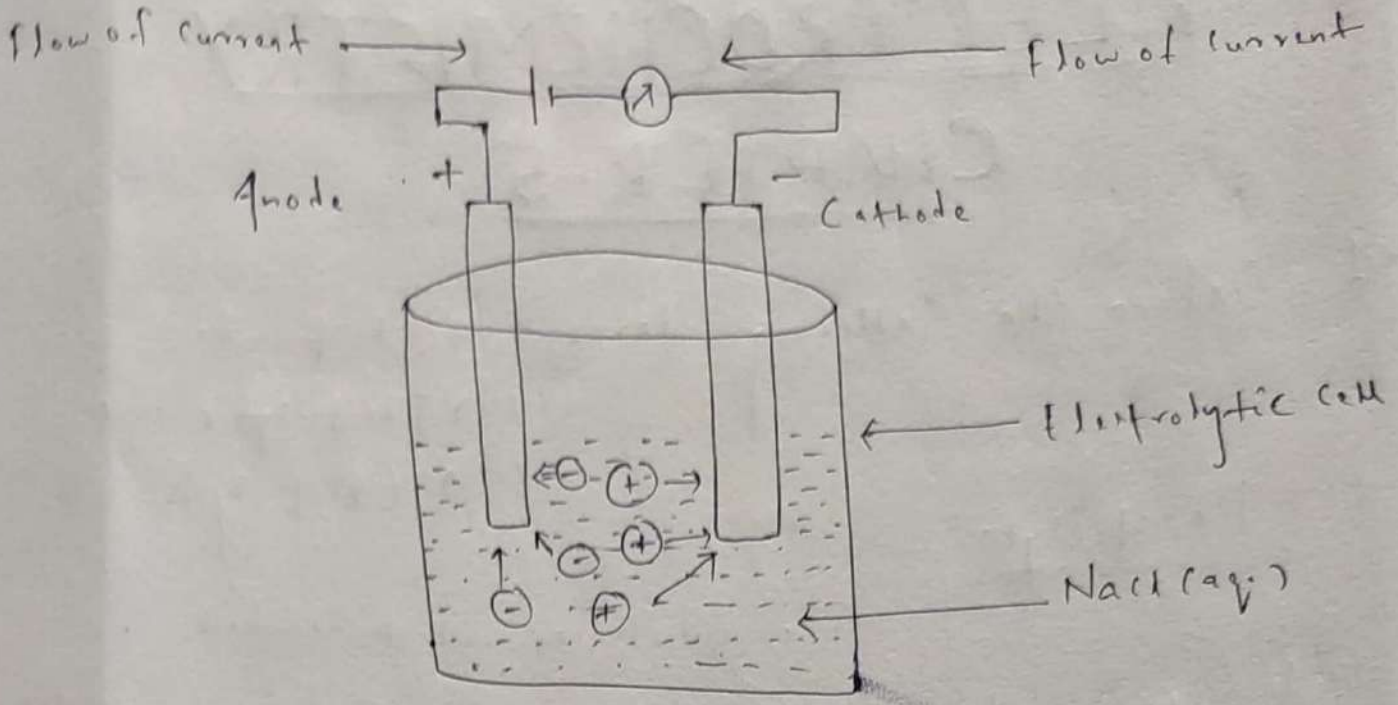
(iii) Electrolysis:-

Ex:- Electrolysis of Sodium Chloride (NaCl).

At cathode:- $Na^+ + e^- \longrightarrow Na$

At Anode:- $2Cl^- \longrightarrow Cl_2 + 2e^-$

It is the phenomenon in which the electrolytes are decomposed into their constituent ions by passage of ~~electrolysis~~ electricity.



(Electrolysis of NaCl.)

* Electrodes :—

These are the metallic rods dipped into the electrolyte through which electricity enters or leaves the electrolytes.

The -ve electrode is known as cathode

The +ve electrode is known as Anode

Qn:-2 Write and derive the expression for Faraday's 1st and 2nd laws of electrolysis.

Faraday's 1st law of electrolysis :—

The mass of the substance deposited on or liberated at any electrode during electrolysis is directly proportional to the quantity of electricity passed through the electrolyte.

$$W \propto Q$$

$$\boxed{W = Zit}$$

Since, $Q = it$

Where, W = Mass of the substance deposited

Q = Quantity of electricity in coulombs.

Z = Constant known as the electrochemical equivalent.

i = Current in amperes

t = time in seconds

* Electrochemical equivalent :—

When $i = 1$ Ampere, $t = 1$ sec $\Rightarrow W = Z$

Hence, Electrochemical equivalent equivalent (Z) of a substance is defined as the substance deposited by the passage of 1 A current for 1 sec. through the electrolyte.

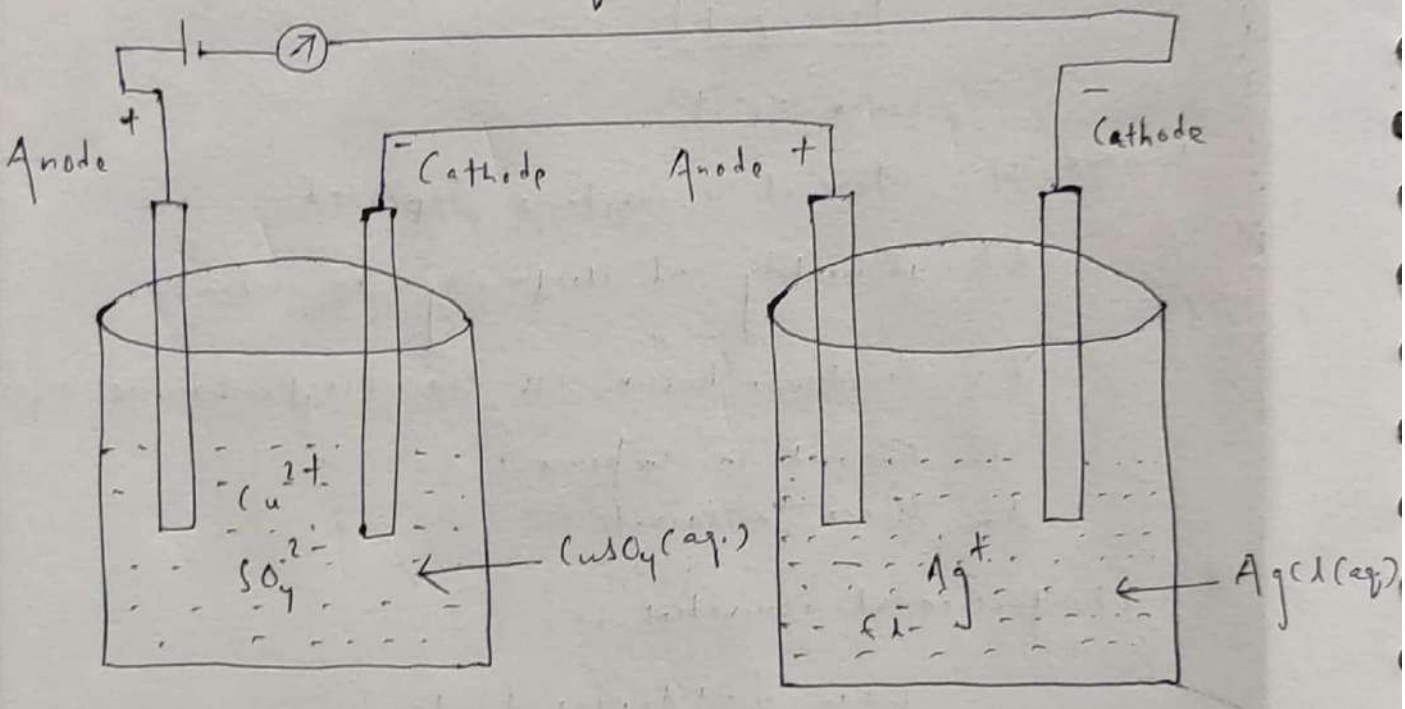
Faraday's Second Law:-

It states that, When the same quantity of electricity is passed through different electrolytic solutions connected in series, the weight of different substances deposited at the different electrodes is proportional to their equivalent weights.

i.e. $W \propto E$

Where, W: Mass of the substance deposited at an electrode

E: Equivalent mass of the substance



(Faraday's Second law of electrolysis)

Comider two electrolytic cell containing $CuSO_4$ and AgCl solutions connected in series. Applying Faraday's second law of electrolysis

$$\frac{W_{Cu}}{W_{Ag}} = \frac{E_{Cu}}{E_{Ag}}$$

Where, W_{Cu} → Weight of Copper

W_{Ag} → Weight of Silver

E_{Cu} → Equivalent weight of Copper

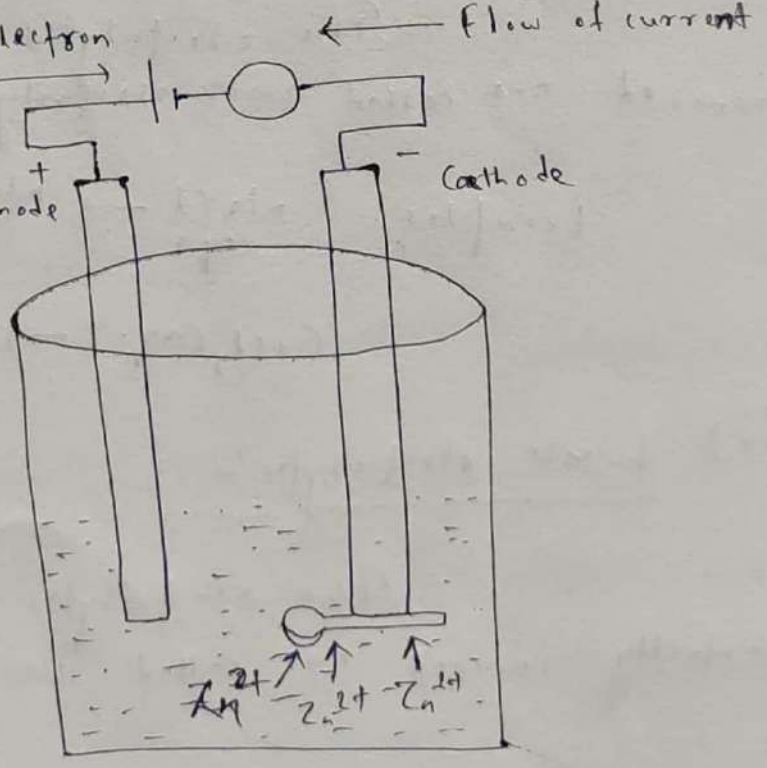
E_{Ag} → Equivalent weight of Silver

Qn:-3 What do you mean by electroplating? Explain taking Zinc as an example.

It is the procell of depositing a superior metal over the surface of an inferior metal by electrolysis.

* It is carried out for decoration, protection and repair purpose.

Zinc Plating:-



(Electroplating of Zinc)

* For deposition acid and alkali solutions are taken.

* The electrolyte consists of a solution of zinc sulphate, sodium chloride, aluminium sulphate, boric acid and dextrin.

* The alkali solution consists of zinc oxide, sodium cyanide, sodium carbonate in 1000 ml water.

* Temperature - 30-40°c

* Purpose is to avoid rusting.

Qn:- 4 What are strong and weak electrolytes?

(i) strong electrolytes:-

The electrolytes which are completely ionised are called weak electrolytes.

Examples:- $NaCl_{(aq.)} \longrightarrow Na^{+} + Cl^{-}$

$CaCl_2(aq.) \longrightarrow Ca^{2+} + 2Cl^{-}$

(ii) Weak electrolytes:-

The electrolytes which are partially ionised are called weak electrolytes.

Examples:-

$CH_3COOH\ (aq.) \rightleftharpoons H^{+} + CH_3CO^{-}$

$NH_4OH \rightleftharpoons NH_4^{+} + OH^{-}$

CORROSION
CHAPTER-6

Qn:-1 Define Corrosion. Explain different types of corrosion.

Corrosion may be defined as the conversion of metal into an undesirable compound by a chemical or electrochemical reaction with the environment.

Corrosion can be classified into two types -

(I) Atmospheric Corrosion

(II) Waterline Corrosion

(I) Atmospheric Corrosion :-

It is the deterioration and destruction of a material and its properties by the atmosphere surrounding the material.

* Different atmospheric substances cause corrosion and erosion of metal and non-metals.

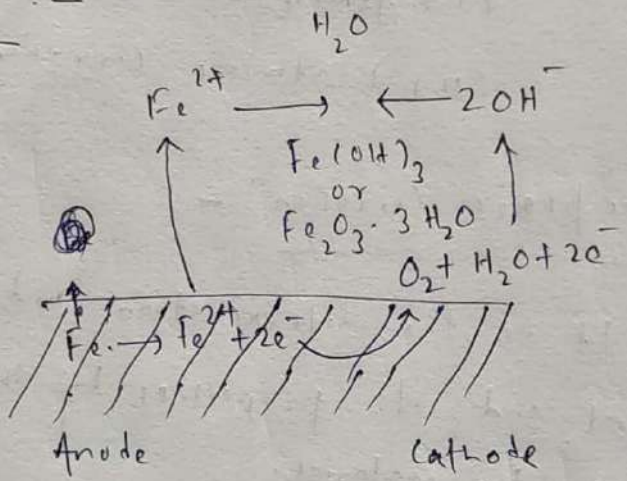
* Corrosion alters the microstructure and drastically reduces the mechanical strength of the material.

Example :- tarnishing of silver, development of green coating on copper and rusting of iron etc.

Mechanism of Atmospheric Rusting of Iron :-

* Chemical formula of rust is $Fe_2O_3 \cdot nH_2O$ (hydrated ferric oxide)
* It can be explained by electrochemical theory.
* Iron behaves as a small electric cells in presence of water.

Mechanism :-



(Rusting of Iron)

At Anode :-

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

$$Fe^{2+} + 2H_2O \rightarrow Fe(OH)_2 + 2H^+$$

At Cathode :-

$$2H_2O + O_2 + 4e^- \longrightarrow 4OH^-$$

~~$4Fe(OH)_2 + O_2 + 2H_2O \rightarrow 4Fe(OH)_3$~~

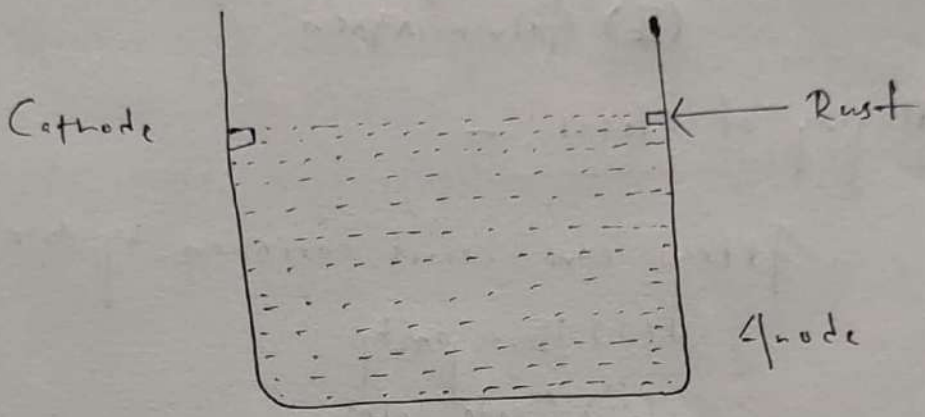
Overall reaction :- $Fe^{2+} + 2OH^- \longrightarrow Fe(OH)_2$

$$4Fe(OH)_2 + O_2 + 2H_2O \longrightarrow 4Fe(OH)_3$$

* It corresponds to $Fe_2O_3 \cdot H_2O$. (Yellow rust)

(II) Waterline Corrosion :-

* It is caused because of difference in oxygen concentrations.
* When water is stored in a steel tank, corrosion takes place along a line just below the level of the water meniscus as shown in fig.



(Waterline Corrosion)

* The area above the waterline is called the cathode as oxygen concentration is more and the area below the waterline is the anode as oxygen concentration is less.
* This type of corrosion is seen in ships, water tanks, etc.

Qn:- 2

Write different methods to protect metals from corrosion.

Metals can be protected from corrosion by following two ways:- (I) Alloying of metal

(II) Galvanisation

(I) Alloying of Metal:-

Alloys can resist corrosion by two ways:

(i) Homogenity

(ii) Oxide film

(i) Homogenity:- Alloys are the homogeneous mixture of two or more metals. Alloys ~~are~~ is done with the metals which are not active to the environment.

Ex- The rusting of iron is minimised by alloying it with chromium as alloying increase the homogenity of the metal, which decreases the rate of corrosion.

(ii) Oxide film:- Oxide film formed on the surface of the metal also decreases corrosion

(II) Galvanisation:-

* It is an electrochemical process and the metal to be protected acts as the cathode.

* In this process, more electropositive metals are used to prevent corrosion.

* Corrosion occurs only at the anode. If the whole surface of the metal is turned into a cathode, corrosion can be prevented.

* The process of covering iron with zinc is called galvanisation. Zinc is used to protect iron from rusting.

* Zinc is more electropositive metal than iron.

CHAPTER-7

METALLURGY

Qn: 1 - Define the following terms (i) Mineral (ii) Ore (iii) Flux (iv) Slag.

Mineral :-

The materials which contain metals and are found in the earth's crust are called minerals.

These compounds contain impurities

Example - Zincite (ZnO)

Horn Silver ($AgCl$)

Cuprite (Cu_2O)

Ore :-

An ore is a mineral from which metals can be conviniently, economically and profitably extracted.

Example - Copper glance (Cu_2S)

Galena (PbS)

Corundum (Al_2O_3)

Flux :-

The substance which combines with gangue to form a light and easily fusible material is called the flux.

Slag :-

The easily fusible material (not soluble in the molten metal) which is formed when the flux react with gangue is called slag.

* Flux is of two types -

(i) Acidic flux :-

When the ore contain basic impurities such as lime and FeO the acidic flux such as silica and borax is used.

Example :-

$$CaO + SiO_2 \longrightarrow CaSiO_3$$

Gangue (Basic) Flux (Acidic) (Slag)

(ii) Basic flux :-

When the ore contains impurities like SiO_2, the basic flux such as $CaCO_3$ and $MgCO_3$ is used to remove the gangue.

Example :-

$$SiO_2 + CaCO_3 \longrightarrow CaSiO_3 + CO_2$$

Gangue (Acidic) Flux (Basic) Slag

Qn: 2- Explain general methods of extraction of Metal.

It involves the following steps :—

(i) Crushing and grinding of the ore
(ii) Concentration of the ore
(iii) Extraction of the metal
(iv) Refining of the Metal

① Crushing and grinding of the ore :—

(i) Ores are found in nature a huge lumps.

(ii) First the huge lumps are broken into smaller pieces with the help of jaw crusher.

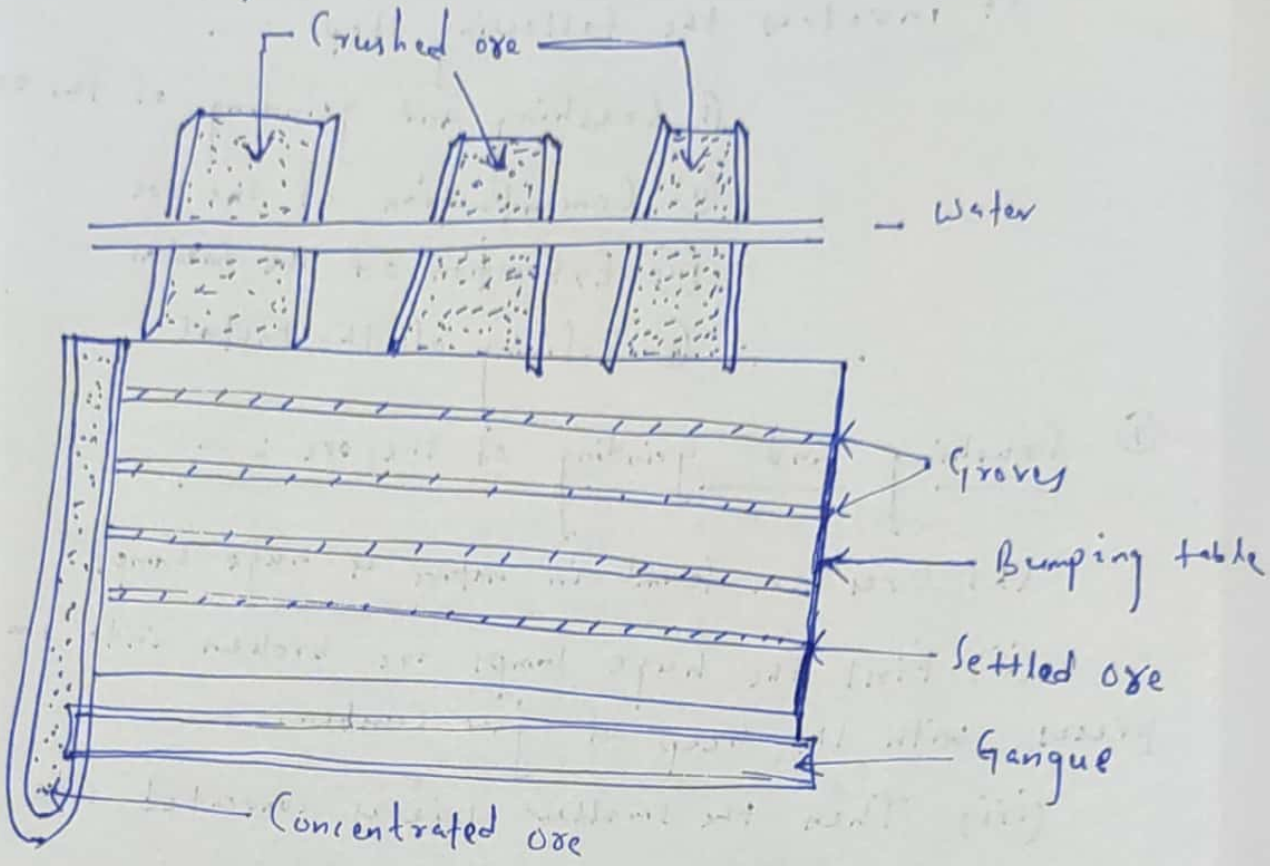
(iii) Then the smaller pieces converted into powder with the help of stamp mill.

② Concentration of Ore (Ore dressing) :—

* It is the process of removing gangue from ore.
* It involves the following methods

(i) Gravity separation
(ii) Magnetic separation
(iii) Froth floatation
(iv) Leaching

(i) Gravity Separation :-



(Gravity Separation process)

(i) In this method, less dense materials (lighter gangue) from the powdered ore are separated.

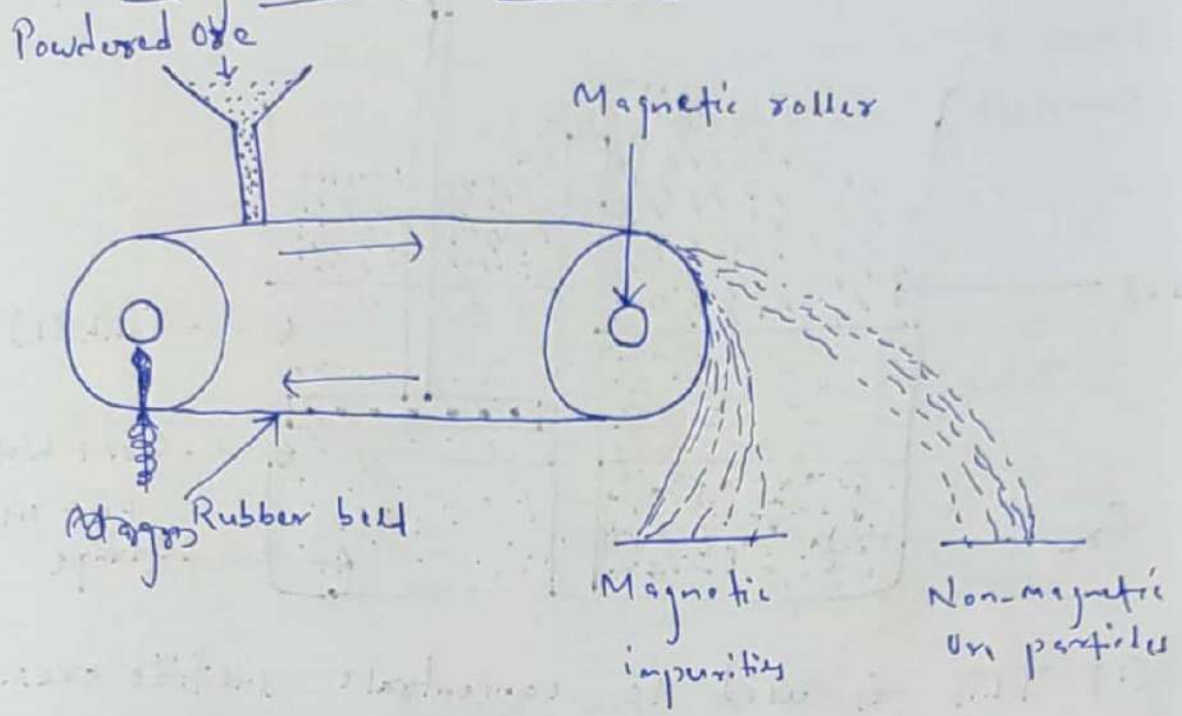
(ii) The crushed ore is spread on the table.

(iii) Then stream of water is flown over them.

(iv) As gangue is lighter than ~~or~~ metal, it is carried away by water, while ore is detained by the ridges as shown in fig.

Ex - Galena (PbS) is concentrated by this process

(ii) Magnetic Separation :-



(Magnetic separation process)

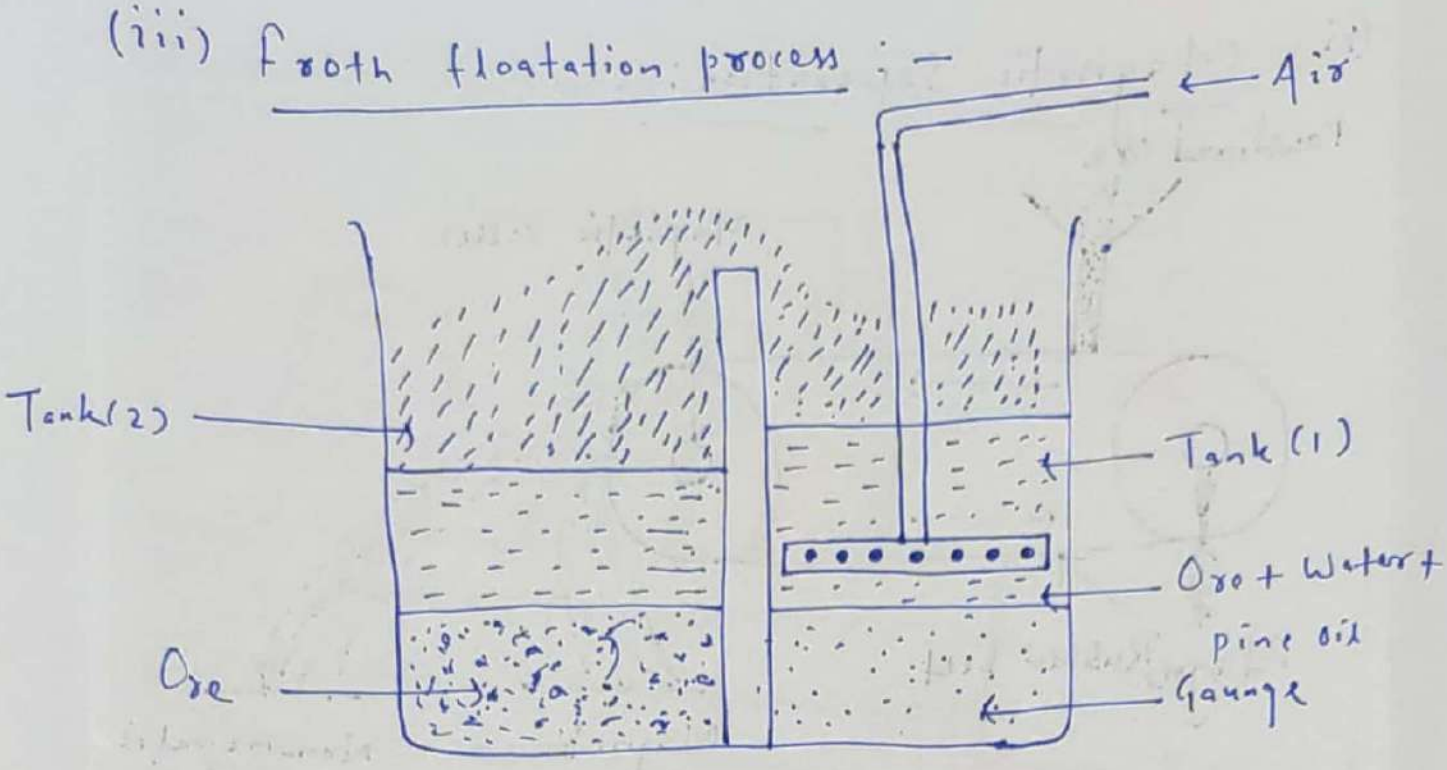
(i) Use to concentrate the ores which differ from their impurities in the magnetic character.

(ii) The powdered ore is poured on a conveyor belt which is connected by two rollers, out of which one is magnetic.

(iii) The magnetic part forms a heap near the roller, while the non-magnetic part form a separate heap a little away from it. as shown in fig.

Ex:- Tin stone

(iii) Froth floatation process :-



(i) This is used to concentrate sulfide ores.

(ii) First a suspension of powdered ore is made with water and a few drops of pine oil or fatty acid.

(iii) Suspension is vigorously mixed by ~~soapti~~ passing air

(iv) The ore particle forms a froth with and passed to another vessel, where the ore particles settle down.

⊗ Ex:- Zn S, Pb S are concentrated by this process.

(iv) Leaching :-

(i) It is a chemical method in which the powdered ore is treated with a suitable reagent which dissolves the ore and not the impurities.

Ex:- Bauxite

Bauxite usually contains SiO_2, iron oxide and TiO_2 impurities.

$$Al_2O_3 + NaOH \longrightarrow NaAlO_2 + H_2O$$

Sodium meta-aluminate

Here, Al_2O_3 is leached out as sodium aluminate, leaving the impurities behind.

(III) Extraction of the Crude metal from the Concentrated Ore:-

It involves two steps:-

1. Concentration of the concentrated ore into its oxide.
2. Conversion of metal oxide to metal by the reduction process.

1. Conversion of concentrated ore into its oxides:-

It is done by roasting or calcination process.

(i) Calcination :-

* It is the process of heating the concentrated ore in the absence of air or in the limited supply of air at a temperature - just below its melting points.

* (ii) The process helps to remove moisture and volatile impurities such as As and Sb.

$$Fe_2O_3 \cdot 3H_2O\,(s) \longrightarrow Fe_2O_3\,(s) + 3H_2O\,(g)$$

$$CuCO_3\,(s) \longrightarrow CuO\,(s) + CO_2\,(g)$$

(iii) Roasting :-

* It is the process of heating the concentrated ore in the free supply of oxygen in a reverberatory furnace to get a metal oxide.

* This process is used to convert sulphide ores into metal oxides.

$$2PbS + 3O_2 \longrightarrow 2PbO + 2SO_2$$

$$FeS + O_2 \longrightarrow FeO + SO_2$$

Calcination	Roasting
* Applicable to ores which do not require oxygen for oxide formation	* This is applicable to ores which require oxygen for oxide formation.
* Carbonates and hydrated oxide ores are usually treated by this process.	* Usually sulphide ores are treated by this process.
* The aim is to remove the volatile impurities.	* The aim of this process is to convert the ore into oxide.
* In this process thermal decomposition takes place.	* In this process oxidation reaction takes place.

2. Conversion of metal oxide into metal (reduction):-

* The metal oxide ~~[illegible]~~ formed in the process of concentration is reduced to the metal.

* Reducing agent combines with the oxygen of the metal oxided.

$$M_xO_y + yC \longrightarrow xM + yCO$$

Smelting:-

In this method, the roasted ore is mixed with a suitable quantity of coke or charcoal and heated strongly in excess of air.

Example - $PbO + C \longrightarrow Pb + CO$

(iv) Refining of the Metal:-

The metals obtained from the above process also contains some impurities. So, ~~other~~ the metals are further purified by the following processes.

(i) Distillation
(ii) Liquation
(iii) Electrolytic refining
(iv) Zone refining

CHAPTER-8

ALLOYS

Qn: 1- Define alloy. Write different types of alloy.

An alloy is a homogeneous mixture of two or more elements with metallic property.

Types – (i) Ferro alloys
(ii) Non-ferro alloys
(iii) Amalgam

(i) Ferro alloys :–

The alloys which contain iron as one of the major components are called ferro alloys.

Example – Stainless steel, cast irons, steels etc.

(ii) Non-ferro alloys :–

These alloys do not have iron as one of the major components.

Example – Bronze, brass etc.

(iii) Amalgam :–

If one of the constituent metals of an alloy is mercury, it is called amalgam.

Example – Zinc Amalgam

Qn: 2:- Write the composition and uses of the following alloy (i) Brass (ii) Bronze (iii) Alnico (iv) Duralumin.

(i) Brass

Composition — Cu = 60-80%.
Zn = 40-20%.

Uses - Utensils, condenser tube, cartridges etc.

(ii) Bronze

Composition — Cu = 75-90%.
Sn = 25-10%.

Uses - Utensils, coins, springs, electrical connectors etc.

(iii) Alnico

Composition - Steel = 50%.
Ni = 21%.
Al = 20%.
Co = 9%.

Uses - Making of permanent magnets. This is used in electric motors, microphones etc.

(iv) Duralumin

Composition - Al = 95%.
Cu = 4%
Mn = 0.5%.
Mg = 0.5%.

Uses - Aircraft constructions, automobiles, gun barrels, surgical instruments etc.

CHAPTER-9

HYDROCARBONS

Qn:-1 What are hydrocarbons. Differentiate between Saturated and Unsaturated hydrocarbon.

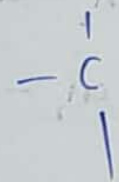
Hydrocarbons are the compounds which mainly contains carbon and hydrogen.

[* Simple fact about hydrocarbon (For Understanding Purpose)

$_6C \rightarrow 1s^2\ 2s^2\ 2p^2$ (Ground State)

$\rightarrow 1s^2\ 2s^1\ 2p_x^1\ 2p_y^1\ 2p_z^1$ (Excited state)

So, 'C' forms four bonds.



* Carbon has the property to form long chain. It is called catenation property.

* Homologous Series :-

Series of compounds in which each member differ from it's adjacent member by $-CH_2-$ unit.

Types of Hydrocarbons :-

(i) Alkane , — (Single bond b/t C atoms)

(ii) Alkene , = (Double bond " ")

(iii) Alkyne , ≡ (Triple " ")

(i) Alkane :-

C_nH_{2n+2} , where n = no. of 'C' atom

When n = 1 , CH_4 (Methane)

n = 2 , $CH_3 - CH_3$ (Ethane)

n = 3 , $CH_3 - CH_2 - CH_3$ (Propane)

n = 4 , $CH_3 - CH_2 - CH_2 - CH_3$ (Butane)

n = 5 , $CH_3 - CH_2 - CH_2 - CH_2 - CH_3$ (Pentane)

n = 6 , $CH_3 - CH_2 - CH_2 - CH_2 - CH_2 - CH_3$ (Hexane)

(ii) Alkene :-

C_nH_{2n} , where n = no. of 'C' atom

n = 2 , $H_2C = CH_2$ (Ethene)

n = 3 , $H_2C = CH - CH_3$ (Propene)

n = 4 , $H_2C = CH - CH_2 - CH_3$ (Butene)

n = 5 , $CH_2 = CH - CH_2 - CH_2 - CH_3$ (Pentene)

n = 6, $CH_2 = CH - CH_2 - CH_2 - CH_2 - CH_3$

(Hexene)

Alkyne C_nH_{2n-2}

n = 2, $HC \equiv CH$
(Ethyne)

n = 3, $HC \equiv C - CH_3$
(Propyne)

n = 4, $HC \equiv C - CH_2 - CH_3$
(Butyne)

n = 5, $HC \equiv C - CH_2 - CH_2 - CH_3$
(Pentyne)

n = 6, $HC \equiv C - CH_2 - CH_2 - CH_3$
(Hexyne)

Difference bet^n saturated and Unsaturated hydrocarbons.

Saturated Hydrocarbon

(i) These are the hydrocarbons having (C-C) single bond

Ex - Alkane

$CH_3 - CH_2 - CH_2 - CH_3$
(Butane)

$CH_3 - CH_2 - CH_3$
(Propane)

Unsaturated Hydrocarbon

(i) These are the hydrocarbons having carbon-carbon multiple bond. i.e. C=C, C≡C

Ex - Alkene and Alkyne

$CH_3 - CH = CH - CH_3$
(Pentene)

$HC \equiv C - CH_2 - CH_2 - CH_2 - CH_3$
(Hexyne)

2. Qn:- What is aliphatic and aromatic hydrocarbon?

Aliphatic hydrocarbons

These are open chain hydrocarbons, where the two ends of the chain remain free or open.

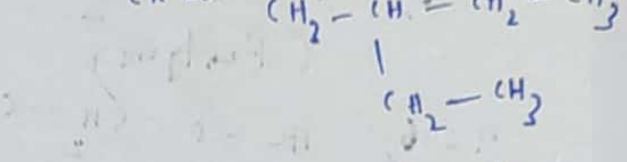
It is of two types (i) Straight chain

Ex → $CH_3 - CH_2 - CH_2 - CH_3$

(Butane)

(ii) Branched chain

Ex →



(3-Methyl pentene)

Aromatic Hydrocarbons :—

These are the hydrocarbons which obey Huckel's rule.

Huckel's Rule

The cyclic hydrocarbons having conjugated $(4n+2)\ \pi$ electrons are aromatic in nature.

Here, $n = 1, 2, 3, 4$ and so on.

If $n = 1$, $(4 \times 1 + 2)\ \pi = 6\pi$ electrons

$n = 2$, $(4 \times 2 + 2)\ \pi = 10\pi$ electrons

$n = 3$, $(4 \times 3 + 2)\ \pi = 14\pi$ electrons

Hence, the cyclic hydrocarbons having 6π, 10π, 14π, 18π .... and so on electrons are aromatic in nature

Example :-

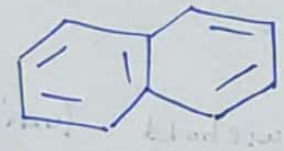
(i) 

(Benzene)

(C_6H_6)

No. of π electrons = 6 [2×3]

No. of π bonds = 3

(ii) 

(Naphthalene)

($C_{10}H_8$)

No. of π electrons = 10 [2×5]

No. of π bonds = 5

3. Qn :- Write some uses of following compounds.

(i) Benzene (ii) Toluene (iii) BHC (iv) Phenol (v) Naphthalene (vi) Anthracene (vii) Benzoic acid

(i) BENZENE :-

(i) It is used as a solvent in many reactions

(ii) Used in manufacture of ethylbenzene, cumene and cyclohexane etc.

(ii) TOLUENE :-

(i) Toluene is used to prepare benzene

(ii) Preparation of TNT explosive

(iii) Toluene is a common solvent.

(iii) BHC (Gammexene) :-

(i) Used as pesticides in agriculture

(ii) Benzene hexa chloride (BHC) also used to kill ants.

(iv) PHENOL :-

(i) Plastic preparation

(ii) Preparation of herbicides

(v) Naphthalene :-

(i) Used as household fumigant

(ii) Ingredient of mothballs

(iii) Precursor to other chemicals

(vi) Anthracene :-

(i) Wood preservatives

(ii) Insecticides

(iii) Coating material

(vii) Benzoic Acid :-

(i) Food preservative

(ii) Medicine

(iii) Preparation of phenol

NOMENCLATURE OF ORGANIC COMPOUNDS

Rules:-

① Select the longest continuous chain of carbon atoms in the compound and number them, which will form the main chain.

② The other groups attached to the main chain are called substituents.

③ Assign the name for each substituent and write their positions.

④ Use comma(,) between two numbers and hyphen(-) between numbers and names.

⑤ The numbering of the ~~substituents are~~ parent hydrocarbon chain is done in such a way that the position of the substituent gets the lowest number.

⑥ If many substituents are there, then the substituents are arranged in the alphabetical order and the sum of the number of substituents should be less.

⑦ If double or triple bonds are present, then they should get the minimum number.

⑧ The longest chain should contain double or triple bond.

⑨ In between double and triple bond, double bond should get the minimum number.

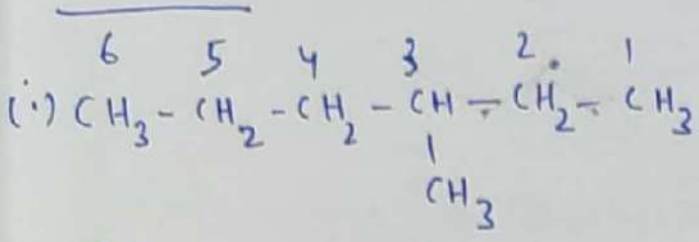
Prefix + Name + Suffix

Name :→

No. of 'c' atoms	Name
1	Meth
2	Eth
3	Prop
4	But
5	Pent
6	Hex

Substituents	Prefix	Suffix
$-CH_3$	Methyl	
$-C_2H_5$	Ethyl	
$-C_3H_7$	Propyl	
$-F$	Fluoro	
$-Cl$	Chloro	
$-Br$	Bromo	
$-I$	Iodo	
$-OH$	Hydroxy	'ol'

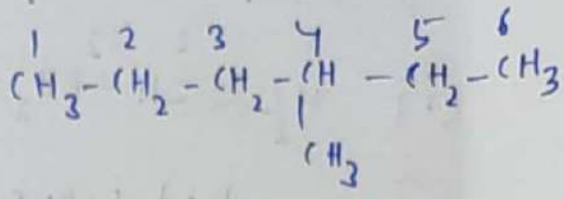
Alkane (-ane)

(i) 

(3-Methyl hexane)

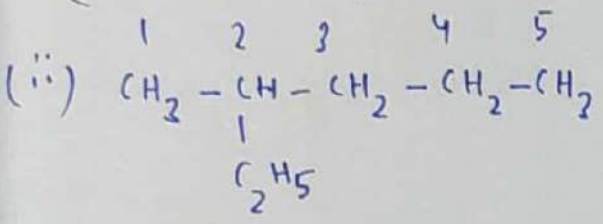
(Correct ✓)

(Bond Line notation)

or 

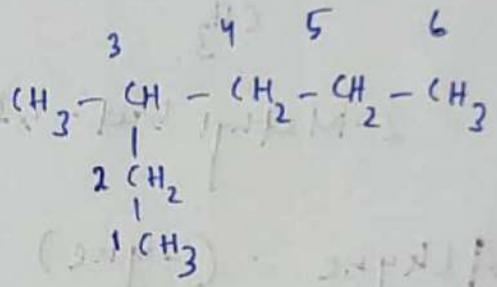
(4-Methyl hexane)

(Wrong) ✗

(ii) 

(2-Ethyl pentane)

(Wrong ✗)



~~3-Ethyl~~

(3-Methyl pentane)

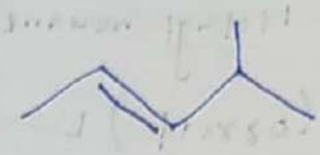
(Correct ✓)

Alkene (-ene)

(i) $H_2C^{1} = CH^{2} - CH_2^{3} - CH_3^{4}$

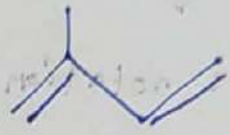
But-1-ene

(ii) $CH_3^{1} - CH^{2} = CH^{3} - CH^{4}(CH_3) - CH_3^{5}$



4-Methyl pent-2-ene

(iii) $H_2C^{1} = C^{2}(CH_3) - CH^{3} = CH_2^{4}$



2-Methyl but-1,3-diene

Alkyne (-yne)

(i) $HC^{1} \equiv C^{2} - CH_2^{3} - CH_3^{4}$

But-1-yne

(ii) $HC^{1} \equiv C^{2} - CH^{3}(CH_3) - C^{4} \equiv CH^{5}$

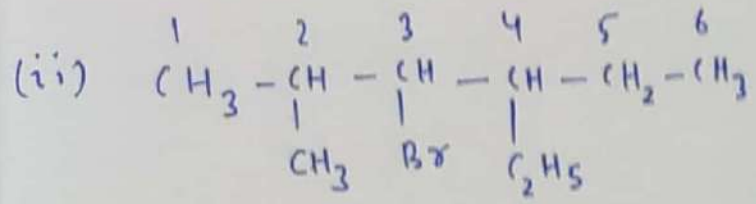
3-Methyl penta-1,4-diyne

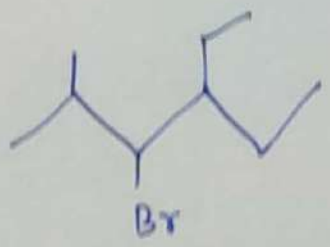
Alkylhalide

(i) $H_2C^{1}(Cl) - CH_2^{2}(Cl)$

1,2-Dichloroethane

(ii)

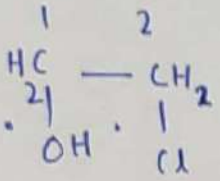


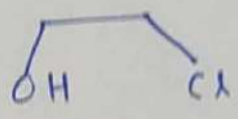


3-Bromo-4-ethylhexane

Alcohol (-ol)

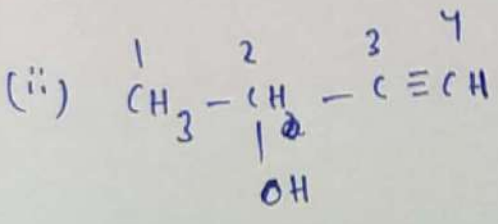
(i)

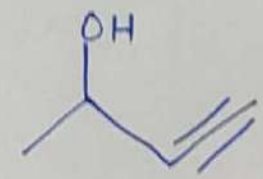




2-Chloro ethan-1-ol

(ii)

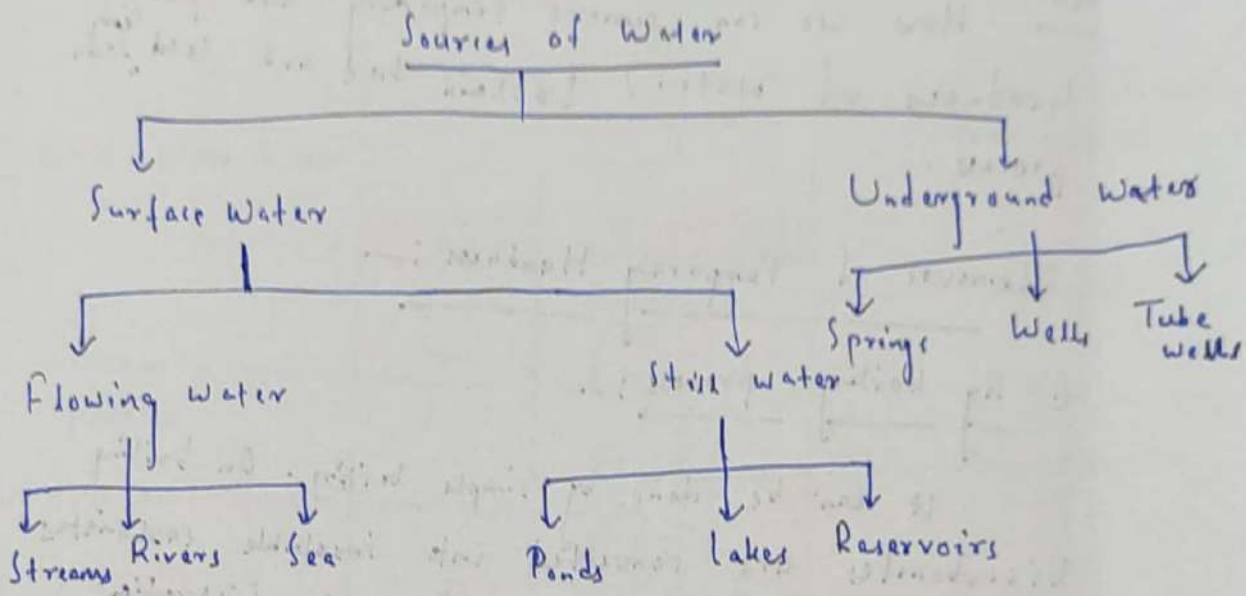




But-3-yn-2-ol

CHAPTER-10
WATER TREATMENT

1. Qn:- What are the sources of water? Explain soft water, hard water. Explain types of hardness.



Soft Water:-

Water which forms lather with soap solution is termed as soft water.

Example - Rain water, distilled water etc.

Hard Water:-

Water which does not form lather with soap and detergent is termed as hard water.

Example - Sea water, river water etc.

Types of hardness

There are two types of hardness

① Temporary hardness :- If water contains bicarbonates of Ca^{2+} and Mg^{2+} ions, then it is called a temporary hardness.

② Permanent hardness :- If water contains chloride and sulfates of Ca^{2+} and Mg^{2+} ions, then it is called permanent hardness.

2. Qn:- How we can remove temporary and permanent hardness of water? Explain hot and cold lime soda process.

Removal of Temporary Hardness :-

① By boiling process :-

It can be done by simple boiling. On boiling bicarbonates are converted into insoluble carbonates or hydroxides and can be removed by filtration.

$$\underset{\text{(Soluble)}}{Ca(HCO_3)} \longrightarrow \underset{\text{(Insoluble)}}{CaCO_3\downarrow} + H_2O + CO_2\uparrow$$

② Removal of Permanent Hardness :-

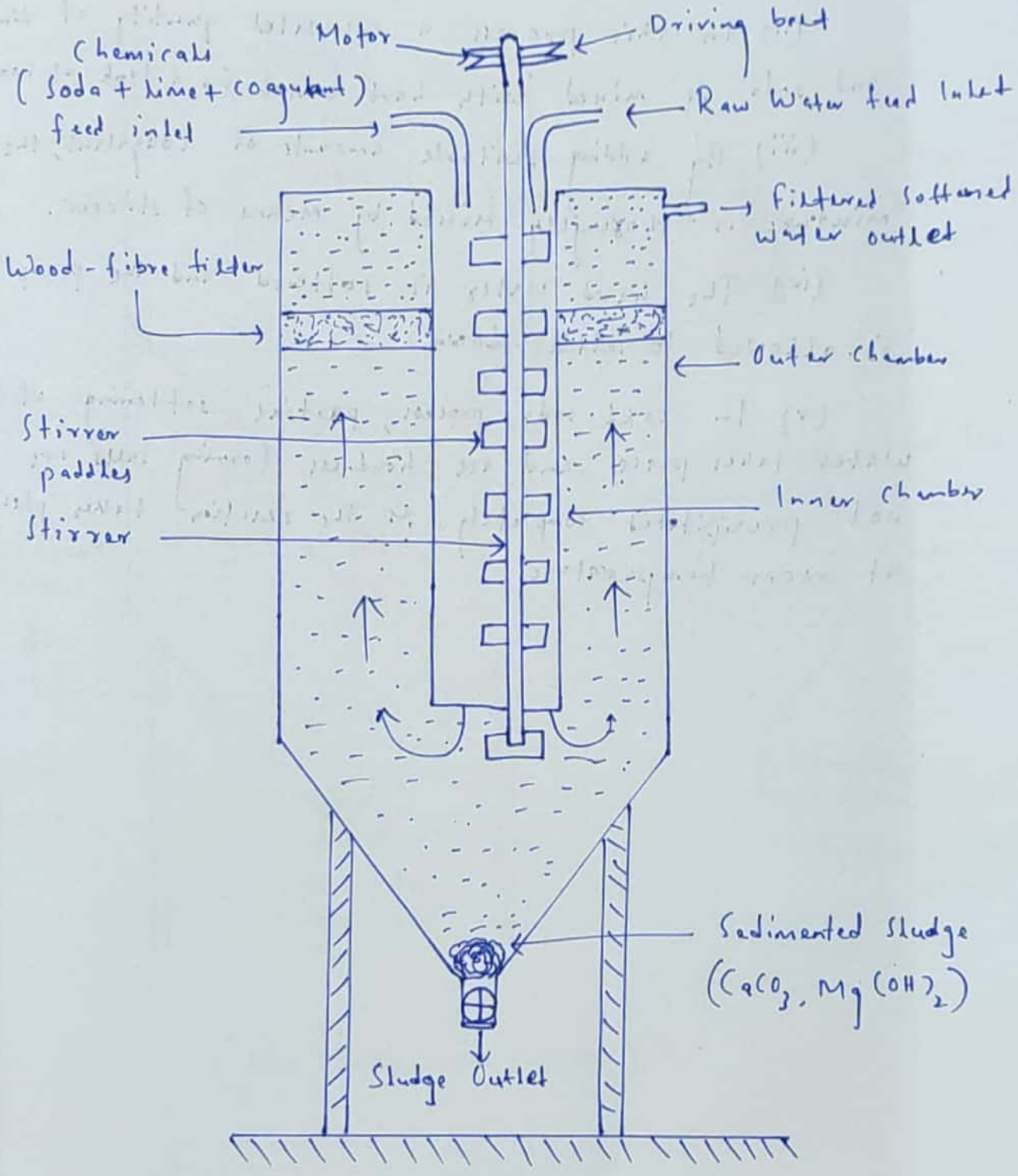
Lime Soda Process

* It is the most suitable process to remove the hardness.

* Calculated quantity of lime ($Ca(OH)_2$) and soda (Na_2CO_3) is treated with hard water. The Calcium and Magnesium salts are converted into insoluble carbonates.

* It is carried out in two ways (i) Cold lime soda process (ii) Hot lime soda process

① Cold lime Soda Process —



(Cold lime Soda process)

Process :-

(i) It is carried out at room temperature.

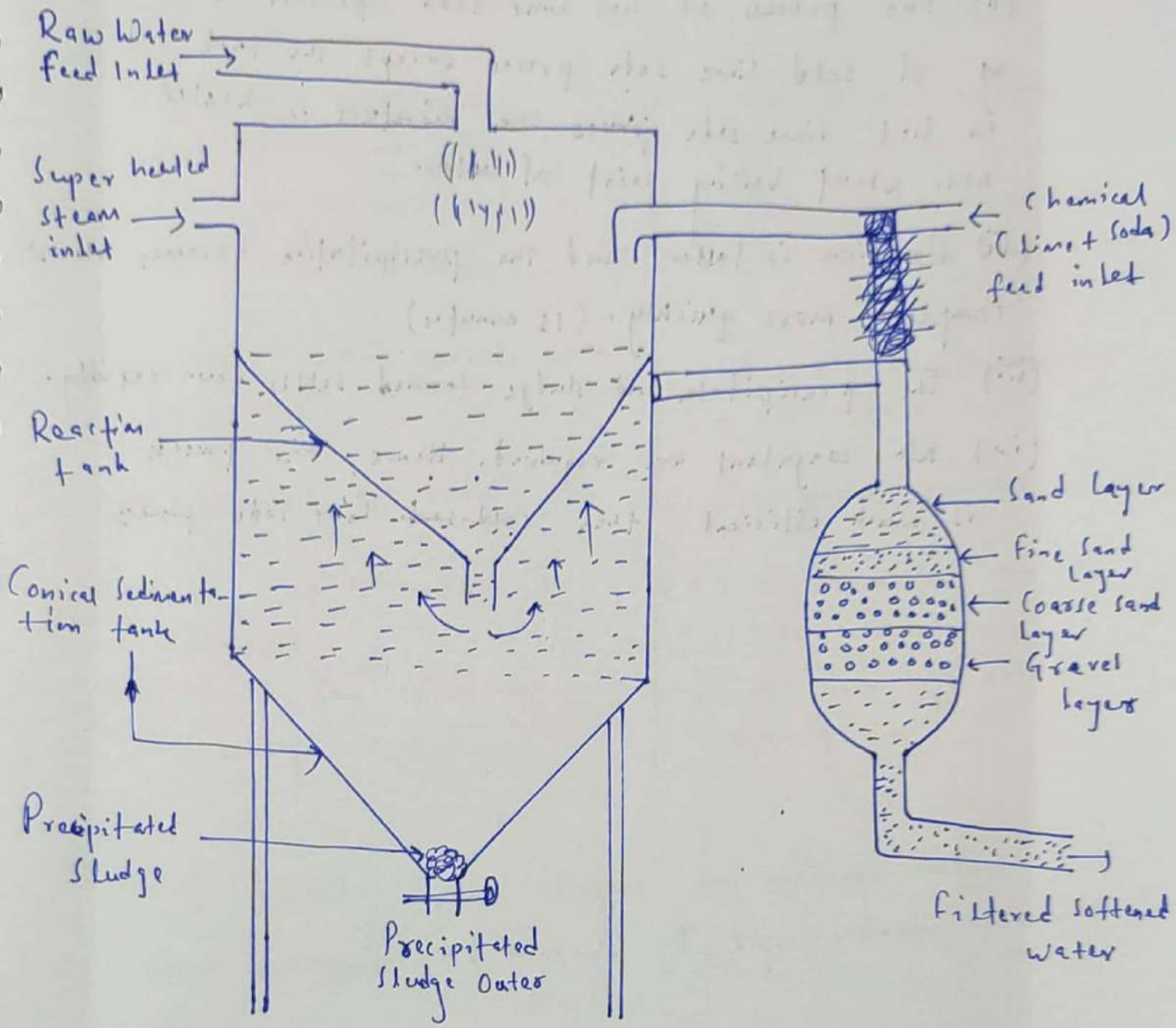
(ii) In this process, a calculated quantity of lime and soda is mixed with hard water in a tank at room temp.

(iii) By adding suitable amounts of coagulant, the mixture is thoroughly mixed by means of stirrer.

(iv) The hard water is softened and the precipitate is allowed to settle down

(v) In cold soda process, partial softening of water takes place and all hardness forming salts are not precipitated completely as the reaction takes place at room temperature.

② Hot Lime Soda Process :-



(Hot Lime Soda Process)

Process :- (i) Hard water is treated with lime and soda at 80 - 150°c.

(ii) The process of hot lime soda process is same as of cold lime soda process except the fact that in hot lime soda process the mixture is heated near about boiling point of water.

(iii) Reaction is faster and the precipitation becomes almost complete more quickly. (15 minutes)

(iv) The precipitate and sludge formed settle down rapidly.

(v) No coagulant are required. Hence, this process is much efficient then cold ~~soda~~ lime soda process.

3. Qn:- Differentiate between Cold Lime Soda process and Hot lime soda process.

Cold lime Soda process	Hot Lime Soda process
(i) This is carried out in room temperature.	(i) This process is carried out in the higher temperature. (80-150°C)
(ii) The reaction proceeds at a slower rate.	(ii) The reaction proceeds at a faster rate.
(iii) Coagulants are added.	(iii) Coagulants are not added
(iv) It takes some hours to complete.	(iv) It takes some minutes to complete.
(v) It has low softening capacity.	(v) It has high softening capacity.

4. Qn:- Briefly explain Organic Ion exchange method. Also explain the method of regeneration of exhausted resins.

Organic Ion exchange method is the most advance method for removing the hardness.

It involves two steps -

(i) Cation exchange resin

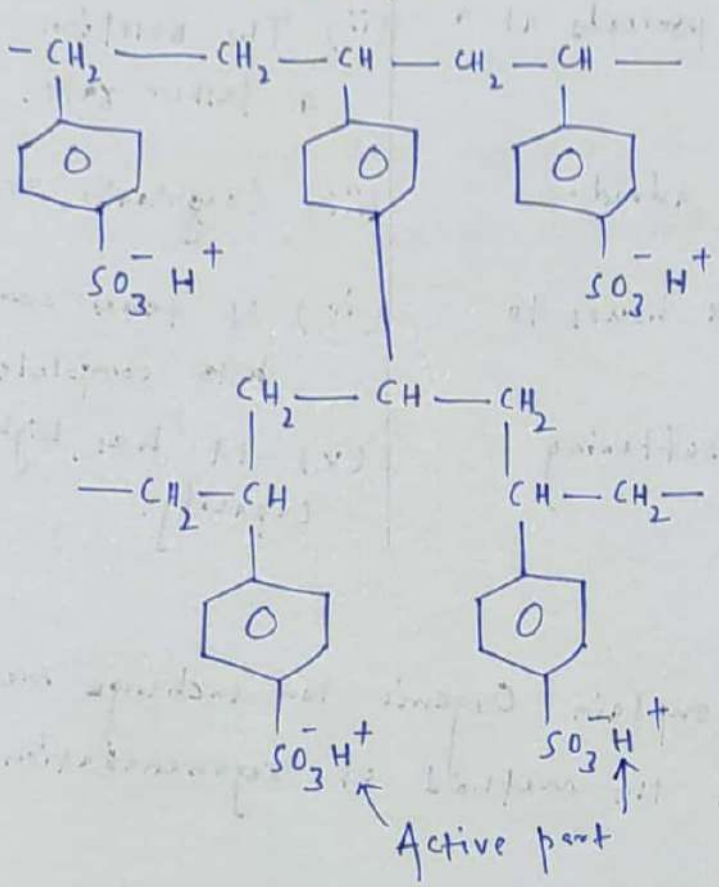
(ii) Anion exchange resin

① Cation Exchange resin :-

* Resins containing acidic groups like $-COOH$ or $-SO_3H$ group are called cation exchange resin.

* The active part ~~of~~ in cation exchange resin is a cation.

Example :- H^+ resin



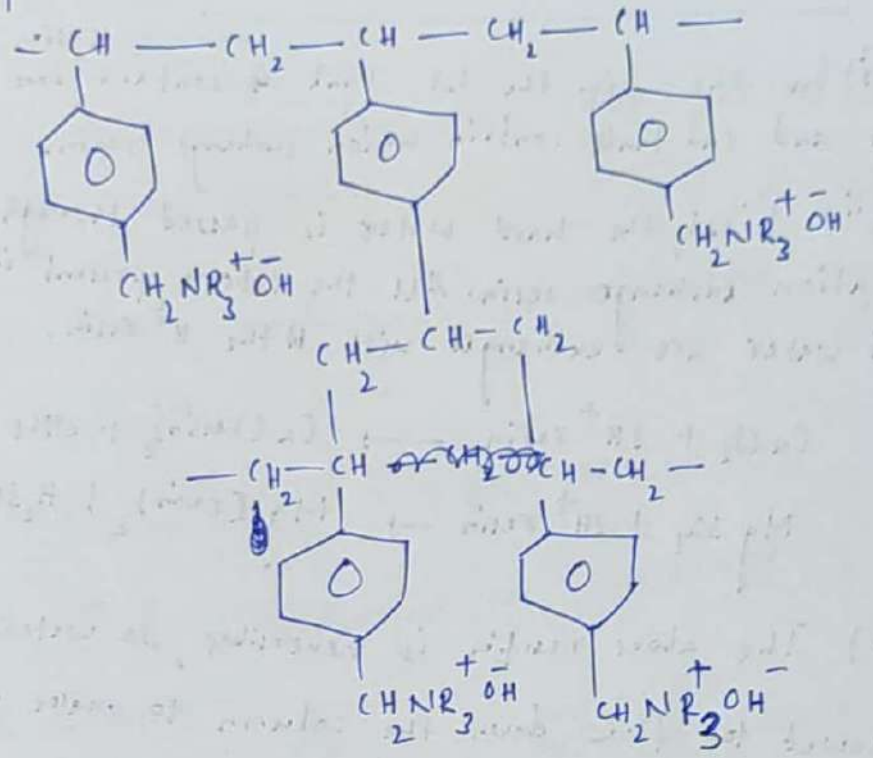
② Anion Exchange resin :-

* Resins containing basic groups such as amines or substituted amines are called anion exchange resin.

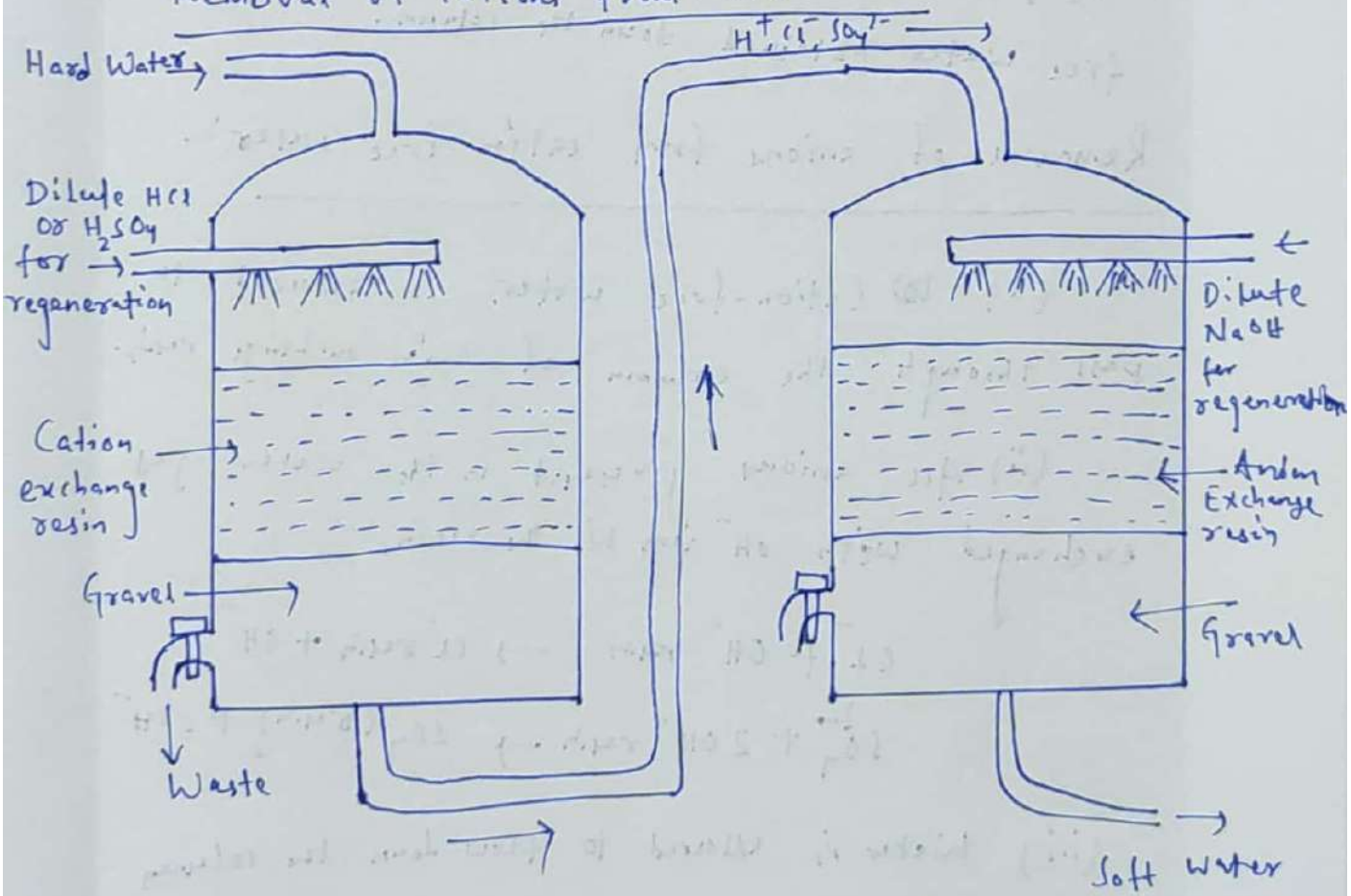
* The active part in the anion exchange resin is an anion.

Example :- OH^- resin

Example:—



Removal of cations from hard water :—



(Organic Ion-exchanger)

Removal of cations from hard water:—

(i) In the fig. the 1st tank contain cation exchange resin and 2nd tank contain anion exchange resin.

(ii) First, the hard water is passed through the column of cation exchange resin. All the cations present in the hard water are exchanged with the H^+ resin.

$$CaCl_2 + 2H^+ \text{ resin} \longrightarrow Ca(\text{resin})_2 + 2HCl$$

$$MgSO_4 + 2H^+ \text{ resin} \longrightarrow Mg(\text{resin})_2 + H_2SO_4$$

(iii) The above reaction is reversible, so water is allowed to flow down the column to make it irreversible.

(iv) The Cl^- and SO_4^{2-} ions remain in the cation free water obtained down the column.

Removal of anions from cation-free water:—

(i) Cation-free water is allowed to pass through the column of anion exchange resin.

(ii) All anions present in the water get exchanged with OH^- ions of the resin.

$$Cl^- + OH^- \text{ resin} \longrightarrow Cl^- \text{resin} + OH^-$$

$$SO_4^{2-} + 2OH^- \text{ resin} \longrightarrow SO_4(\text{resin})_2 + 2OH^-$$

(iii) Water is allowed to flow down the column to make it irreversible.

(iv) This water became ion free and is called deionised or demineralised water.

Regeneration :-

(i) After some time the cation and the anion exchangers stop working.

(ii) Cation exchanger is regenerated by treatment with 2% H_2SO_4.

$$Ca(resin)_2 + 2HCl \longrightarrow 2H^+ resin + CaCl_2$$

(iii) Anion exchanger is regenerated by treatment with NaOH.

$$Cl^- resin + NaOH \longrightarrow OH^- resin + NaCl$$

CHAPTER - 11

LUBRICANTS

1. Qn - What are lubricants ? Explain all types of lubricants ? with example ?

There are the substances which are introduced between two moving or sliding surfaces to reduce the frictional resistance.

Types :-

It is classified into three types according to its physical state.

1. Solid lubricants
2. Semisolid lubricants
3. Liquid lubricants

(1) Solid lubricants :-

It is used in powder form or mixed with water or oil where the operating temp. is high.

Ex - Graphite.

(2) Semisolid lubricants :- ~~Used~~ Exists in semisolid form.

Ex - Greases

(3) Liquid lubricants :-

It is the common type of lubricant.

ex - lubricating oils

2. Qn :- What are the purpose of lubrication.?

The followings are the ~~purpose~~ reasons for lubrication -

(i) It reduces frictional resistance bet^n moving parts.

(ii) It reduces the surface deformation

(iii) It helps in transfer of heat and cool engine parts

(iv) It provides protection against corrosion

(v) It act as a seal

(vi) It improves the efficiency of the machine

(vii) It cleans the inside of the engine.

3. Qn :- Write notes on Graphite, Oils and Grease.

Graphite -

(i) It is used in IC engine (Internal combustion engine)

(ii) It is used as a lubricant between uneven surfaces.

(iii) It is used in railway tracks joining, open gears, chains and cast iron bearings.

(iv) It is also used in making lead pencil

(v) It is used heavy machinery.

Greases :-

Greases are a semisolid combination of lubricating oil and soap.

Uses -

(i) It is used when a machine is working at low speed and high pressure.

(ii) It is used in bearings and gears that work at high temperature.

(iii) It is used in machine employed in the manufacture of paper, textiles, etc.

Lubricating oils :-

(*) It is used to reduce the friction bet^n two sliding metallic surfaces.

(ii) It also act as a cooling medium

(iii) It is used at high operating temperatures

(iv) Olive oil is used as a lubricant for bearing and machine parts.

CHAPTER - 12

FUEL

Qn. 1. What is fuel? Classify fuel? Define calorific value? How we can choose good fuel?

Fuel

Any substance which on combustion gives large amount of heat energy that can be used for domestic or industrial purpose is called fuel

$$\text{Fuel} + O_2 \longrightarrow \text{Product} + \text{Heat}$$

Calorific Value

It is the amount of heat energy released by the complete combustion of 1 gm of the fuel.

Unit → Cal/gm

Classification of fuels :—

It is classified into three catagories

(i) Solid fuel
(ii) Liquid fuel
(iii) Gaseous fuel

① Solid Fuel :—

Solid fuels that occur naturally are called primary fuels and that are processed are called secondary fuels. These are mainly used for domestic and industrial purposes.

Ex - Wood, Coal, Coke etc.

(ii) Liquid Fuels :—

These are extensively used in industrial and domestic fields.

Ex - Petroleum

(iii) Gaseous Fuels :—

These are used in gaseous form.

Ex - Liquified petroleum gas (LPG), Compressed natural gas (CNG)

Characteristics of a good fuel :—

(i) It should have high calorific value
(ii) The ignition temperature should be moderate
(iii) It should leave only small amount of residue or ash when burnt.
(iv) Should contain minimum quantity of moisture
(v) Should have controllable combustion rate.
(vi) It should be cheap and easy to transport.

2. Qn:- Write the composition and uses of Diesel, Petrol and Kerosene?

Diesel :-

Composition

C = 85%

H = 12 %

Rest = 3%

Uses

It is used as fuel in diesel engine

Petrol :-

Composition

C = 84%

H = 15 %

N + S + O = 1%

Uses

Used as fuel for internal combustion engines of automobiles and aeroplanes.

Kerosene Oil :-

Composition

C = 84%

H = 16%

S ≤ 1%

Uses Domestic fuels in stoves, jet engines etc.

3. Qn :- Write the composition and uses of Water Gas and Producer Gas.

Water Gas

Composition

H_2 : 51%.

CO = 41%.

N_2 = 4%.

CO_2 = 4%.

Uses

(i) A source of Hydrogen gas for synthesis of (Ammonia) NH_3.

(ii) Fuel gas as its flame is very hot.

(iii) Uses for welding purposes.

Producer Gas

Composition

CO = 22-30%.

H_2 = 8.12%

N_2 = 52-55%.

CO_2 = 3%.

Uses

It is cheap

(i) For heating upon hearth furnaces

(ii) As a reducing agent in metallurgical operation

4. Qn :- Write notes on LPG, CNG and coal Gas.

Liquified Petroleum Gas (LPG) :-

Composition

n-Butane = 27%,

Iso-butane = 25%.

Butane = 43%,

Propane = 2.5%.

Propene = 2.5%,

Uses

(i) Mainly used as domestic fuel and industrial fuel

(ii) It is also used as a motor fuel.

Compressed Natural Gas (CNG) :-

Composition

Methane - 70-90%.

Ethane - 4-9%.

Uses

(i) It is used as a fuel for vehicles

(ii) It is also used as a domestic and industrial fuel.

Coal Gas

Composition

$H_2 = 40\%$

$CH_4 = 32\%$

$C_2H_2 = 2\%$

$C_2H_4 = 3\%$

$N_2 = 4\%$

$CO = 7\%$

$CO_2 = 1\%$

Uses

(i) It is used as a fuel

(ii) It is used as an illuminant

(iii) It is used as a reducing agent in metallurgical operations

(iv) It is used in smelting of metals and alloys.

CHAPTER-13

POLYMER

1. Qn:- Define the term Polymer, Monomer. Write notes on homopolymer and copolymer.

Polymer :-

"Poly" means "many" and "mers" means "parts". Hence polymer means many single units. When large number of monomer units are joined together, polymers is formed.

Ex- Polyethene $-[CH_2-CH_2]-[CH_2-CH_2]-[CH_2-CH_2]-$

Monomer :-

Monomers are the repeating units which combine with each other to form polymers.

Ex - Ethene $CH_2 = CH_2$

Homopolymer :-

These are the polymers having identical monomers.

$-A-A-A-A-A-A-$

Where A = Monomer

Ex- $-[CH_2-CH_2]-[CH_2-CH_2]-[CH_2-CH_2]-$

Polyethene

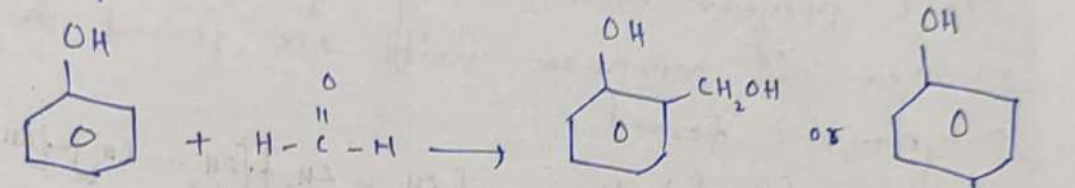
Copolymer :-

These are the polymers having different monomers.

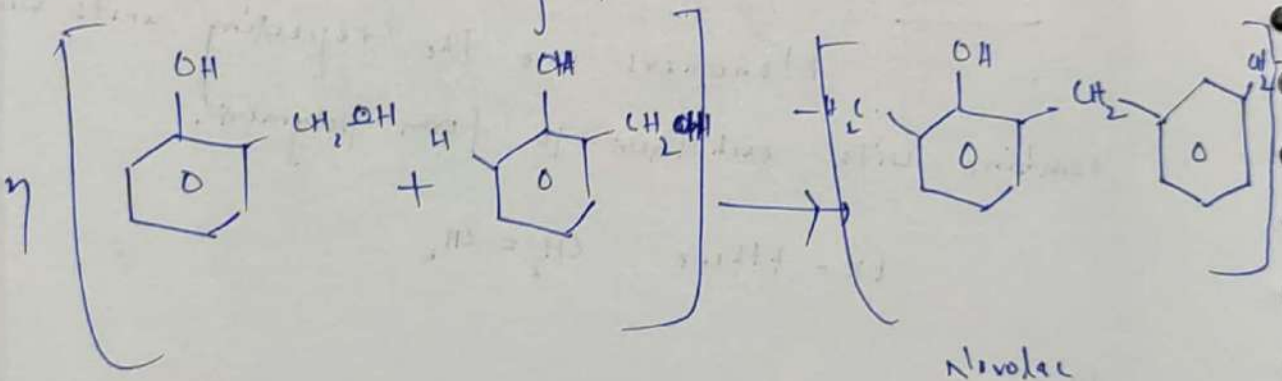
:: $-A-B-A-B-A-B-A-B-$

A and B ware different monomers.

Example - (1)

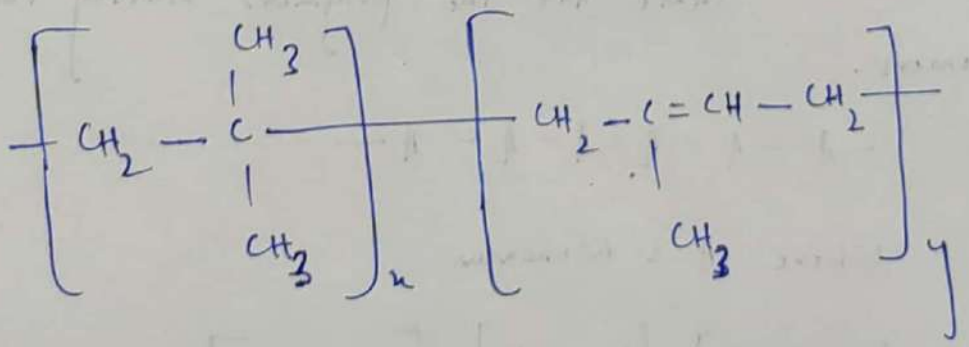


(Phenol) (Formaldehyde)



Novolac

Example - (2)



Poly (isobutene - co - isoprene)

2. Qn:- What is degree of polymerization (DP)?

The number of monomers present in a polymer is known as degree of polymerization.

$$DP = \frac{\text{Molecular mass of polymer}}{\text{Molecular mass of monomer}}$$

3. Qn:- Differentiate between thermoplastics and thermosetting plastics.

Thermoplastics	Thermosetting Plastics
(i) These are linear polymers	(i) These are three dimensional cross-linked polymers
(ii) They are soft and less brittle	(ii) They are hard and more brittle
(iii) They can be reshaped and reused	(iii) They can not be reshaped and reused
(iv) They soften on heating	(iv) They do not soften on heating
Examples - PVC, polystyrene, polyethylene	Examples - Bakelite, urea formaldehyde resin

4. Qn:- Write notes on Polyethylene, Polyvinyl chloride (PVC) and Bakelite.

Polyethylene (Polythene) :-

Monomer - Ethylene ($CH_2 = CH_2$)

$$n\left[CH_2 = CH_2\right] \longrightarrow \left\{CH_2 - CH_2\right\}_n$$

(Ethylene)

Uses :-

(i) Making of toys, tube, pipes etc.

(ii) Packing materials, carry bag etc.

(iii) Flexible bottle, domestic appliances.

Polyvinyl chloride (PVC) :-

Monomer :- $CH_2 = \underset{\underset{Cl}{|}}{CH}$

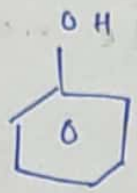
(Vinyl chloride)

$$n\left[CH_2 = \underset{\underset{Cl}{|}}{CH}\right] \xrightarrow{\text{Polymerisation}} \left\{CH_2 - \underset{\underset{Cl}{|}}{CH}\right\}_n$$

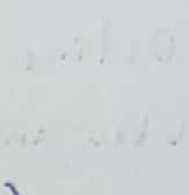
(Vinyl chloride) (Polyvinyl chloride)

Bakelite :-

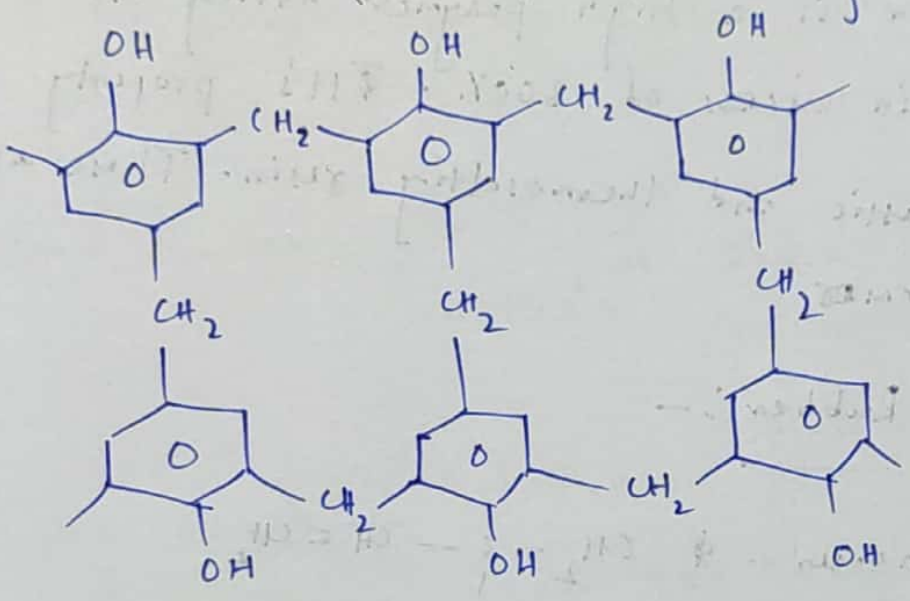
Monomer -



(Phenol)



(Formaldehyde)



(Bakelite)

Uses :-

(i) Electrical insulation parts, switch, plugs etc.

(ii) Articles such as telephone parts, radio and TV cabinets.

(iii) As a binder for grinding wheels

(iv) As an ion exchange resin in the softening of waters etc.

5. Qn:-

Define Elastomer. Write notes on natural rubber and its drawbacks.

Rubber is a high polymer having the elastic property in excess of 300%. It's property lies between thermoplastic and thermosetting resin. These are called the elastomer.

Natural Rubber:-

Monomer - $CH_2 = \underset{\underset{CH_3}{|}}{C} - CH = CH_2$

(Isoprene)

$$n\left[CH_2 = \underset{\underset{CH_3}{|}}{C} - CH = CH_2\right] \longrightarrow \left[CH_2 - \underset{\underset{CH_3}{|}}{C} = CH - CH_2\right]_n$$

(Isoprene) (Polyisoprene)

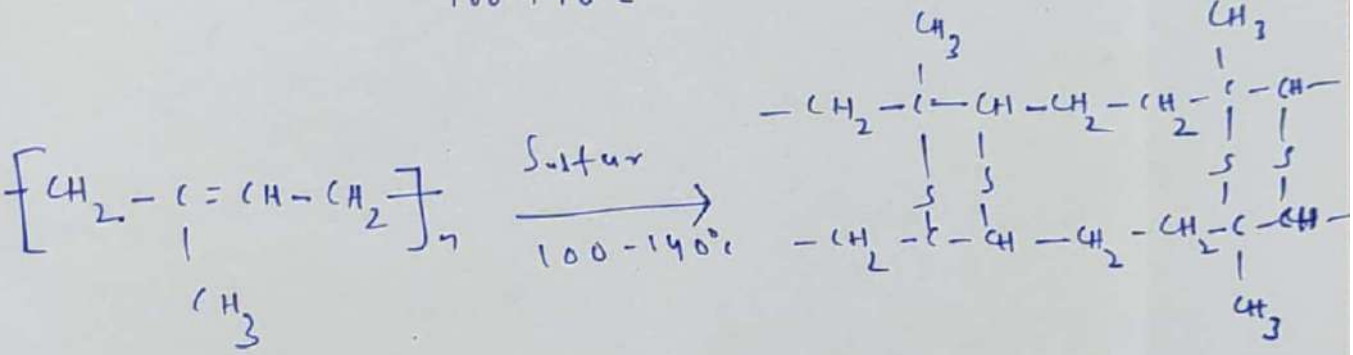
Drawbacks:-

It has inferior property than vulcanised rubber. like resistant to solvent, tensile strength etc.

6. Qn:- What is vulcanisation of rubber? What are the advantages of vulcanised rubber?

Vulcanisation is the heating of raw rubber with compounding agents like sulphur or H_2S at 100-140°C.

Natural Rubber $\xrightarrow[100-140^\circ C]{\text{Sulfur}}$ Vulcanised rubber



(Cis-Polyisoprene) (Vulcanised rubber)

Properties:-

Compared to unvulcanised rubber the vulcanised rubber has the following advantages:-

(i) It possesses higher resistance to oxygen and oxidising agents.

(ii) It is resistant to organic solvents such as petrol, benzene, fats and oils.

(iii) It has good tensile strength

(iv) It is a better electrical insulator

(v) It absorbs less water

(vi) It returns to its original shape when the determining load is removed.