CHEMISTRY

NOTES

(1st Semester)

Unit- I

Atomic Structure, Periodic Table and Chemical Bonding

Bhor's Model of atom:-

The postulates of this model is as under:-

1. An atom consists of a small, heavy, positively charged nucleus in the centre and the electrons revolve round it in some well-defined paths called as **orbits**.
2. The orbits are associated with definite amount of energy and are also called as **Energy Levels**. They are numbered as 1, 2, 3, 4……or K, L, M, N etc.
3. As long as an electron remains in a particular orbit it does not lose or gain energy meaning thereby the energy of an electron in particular energy level remains the same . Such energy levels/ orbits are called as **STATIONERY ORBITS.**
4. Only those orbits are allowed in which the electrons have angular momentum of an integral multiple of h/2π

   Therefore mvr= n h/2π

   where m= Mass

   v= Velocity

   r= Radius of orbit

   n= Whole number

   h= Plank's constant
5. If an electron continues to move in particular energy level without losing energy, then atom is said to be in **GROUND STATE**.
6. Energy is emitted or absorbed only when an electron jumps from one orbit to other.

Application/Success of Bohr's Model of Atom:-

1. It explains the stability of an atom.
2. It helps in calculation of energy of an electron in a particular orbit.
3. It explains the **line spectrum** of Hydrogen atom.

Limitation / Drawbacks

1. It failed to explain the line spectra of multi electron atom.
2. It even failed to explain the splitting of line spectra of hydrogen in presence of electric field **(Stark Effect)** and magnetic field **(Zeeman's effect).**
3. It failed to explain three dimensional model of an atom.

4. It failed to explain the cause of Chemical Combination and shapes of molecules.

de-Broglie's Equation

The wave and particle dualism for material particles in motion lead de-Broglie to put forward a relationship that embraces both these aspects. The de-Broglie's relation may be derived as under:-

Consider a photon of mass m, moving with a velocity c,

According to Plank's theory of radiation

$$E = h\nu \text{----------1}$$

Where h= Plank's constant,

v= frequency of wave.

However $c = \nu \lambda$

$$\nu = c/\lambda$$

By substituting the value of v in equation 1

$$E = hc/\lambda \text{ ----------2}$$

According to Einstein Equation

$$E = mc^2\text{----------3}$$

Combination of relations 2 & 3 gives

$$hc/\lambda = mc^2$$

$$hc = \lambda.mc^2$$

$$\lambda = hc/mc^2$$

$$\lambda = h/mc\text{----------4}$$

For other material particles moving with velocity v, the above equation reduces to

$\lambda = h/m\ v$ [mv = p (momentum)]

$\lambda = h/p$ [however h is a constant]

$\lambda \propto 1/p\text{---------5}$

Thus wave length of a particle is inversely proportional to its momentum and the equation is called **de- Broglie equation**

Heisenberg's Uncertainty Principle

This Principle states that **it is not possible to determine simultaneously both the position and momentum of a moving microscopic particle with absolute accuracy or certainty**.

Mathematically

$\Delta x \times \Delta p \geq h/4\pi$

Where Δx= Uncertainty in position

Δp= Uncertainty in momentum

Since both h and π are Constant meaning thereby if Δx is large then Δp will be small and vice a versa.

Concept of Atomic orbitals

In light of Heisenberg's Uncertainty principle, the exact **Position and Path** of an electron can't be described. So the best way to describe this is in terms of probability.

The three-dimensional space around the nucleus of an atom when the probability of finding the electron is maximum is called **Orbital.**

It is commonly represented by an **Electron Cloud.**

Difference between an orbit and orbital

Sr. No.	Orbit	Orbital
1	It refers to a **circular path** in which the electrons revolves around the nucleus.	It represents a **three dimensional space** around the nucleus, where the probability of finding the electron is maximum.
2	It has **two dimensional** representation.	It has **three dimensional** representations.
3	They are **circular.**	They have **different shapes.**
4	They are denoted as K, L, M, N etc. or 1, 2, 3……..	They are denoted as s, p, d & f.
5	The maximum number of electrons in an orbit is given by the formula $\mathbf{2n^2}$	Each orbital can have maximum **two electrons.**

Quantum Numbers:-

These may be defined as a set of four numbers which describes completely the state of an electron i.e. its position, energy, spin etc.

1. **Principal or Primary Quantum number**:-

It is represented by the letter n and gives the following information:-

i. It tells us about the main energy level which the electron occupies i.e. approximate distance from the nucleus.

ii. It tells about the number of shells present in an atom.

If n= 1 then K shell

n= 2 then L shell

n= 3 then M shell

----------and so on.

iii. The maximum number of electron in a shell is given by the formulae $2n^2$ where n is the Principal Quantum Number eg.

N	Shell	No. of Electrons
1	K	2
2	L	8
3	M	18
4	N	32

Significance:- It tells up about the size of **electron cloud.**

2. **Azimuthal or Secondary Quantum number**:-

It is denoted by the symbol 'l'

i. It tells the number of subshells in a shell for a given value of n, the value of l= o to (n-1)

eg.

N	l= o to (n-1)	No. subshells
1	O	1 (s)
2	O, 1	2 (s, p)
3	O, 1, 2	3 (s, p, d)
4	O, 1, 2, 3	4 (s, p, d & f)

ii. It tells us about the shape of the orbitals

eg.

L	Subshell	Shape
0	s	**Spherical**
1	p	**Dumble shape**
2	d	**Double dumble shape**
3	f	**Complex**

iii. It tells about the energy of the subshell.

The energy of the various subshells in a particular shell varies as

s<p<d<f

⟶ increasing energy

3. **Magnetic quantum number**:-

It is denoted by m

i. It tells us the number of orbitals present in the same subshell.

ii. It also gives the number of orientations of the orbitals in space.

For a given volume of l, the value of m various from + l to –l through zero.

l	M	Subshell	Orientation	Orbital
O	O	S	1	s
1	-l, o, +1	P	3	px, py, pz
2	-2,-1,o,+1,+2	D	5	dxy,dyz,dzx, dx^2-y^2, dz^2
3	-3, -2, -1, o, +1, +2, +3	F	7	

4. Spin Quantum number (s)

It is represented by S. It gives information about the spinning of an electron. An electron can spin either clockwise or anticlockwise depending on which there are two values of spin quantum numbers.

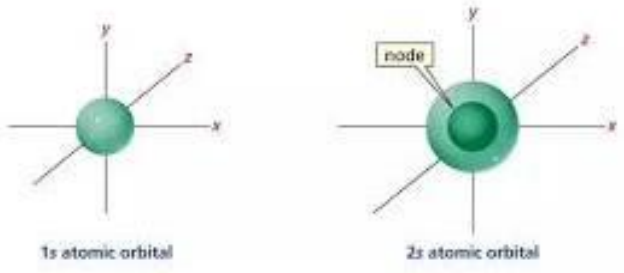
i.e. +1/2 and -1/2

Spin	S
Clockwise	+1/2
Anticlockwise	-1/2

Shapes of Orbitals

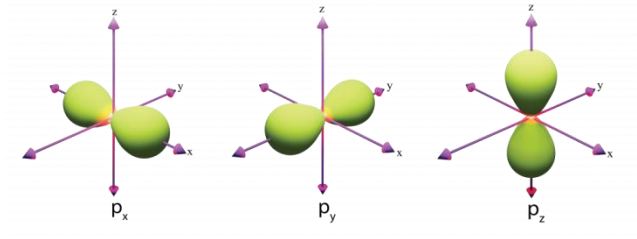
1. **Shapes of s orbital**:-

When l=0 then m=0, only one value meaning thereby only one possible orientation. The only shape that has only one orientation is **sphere**. Thus all s orbitals are **spherical** and non-directional.



The size of the s orbital increases as the principal quantum number (n) increases. Therefore, the size of 2s orbital is larger than the size of 1s orbital.

2. **Shapes of p orbital**:-



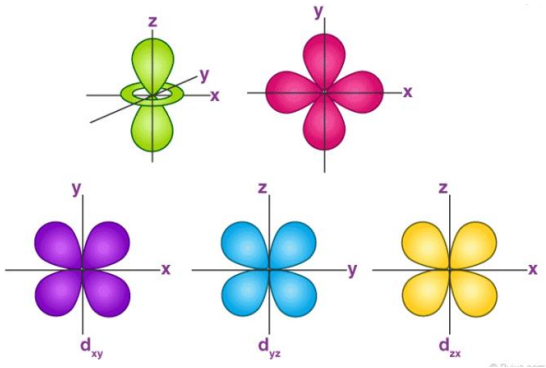
When l=1 then m= -1, 0, +1, three values ,meaning thereby three possible orientations.

There are **dumbled shaped** having two lobes, symmetrical about each axis. They are directional in nature.

3. **Shape of d orbital**:-

When l=2, then m=-2,-1, 0, +1, +2 i.e. five values meaning thereby five possible orientations. They are known as dxy, dxz, dyz, dx^2-y^2, dz^2 respectively.

i) dxy, dxz and dyz orbitals have four lobes in xy, yz and zx plane.



ii) dz^2 has two lobes laying along z axes with ring of high electron density around the nucleus in xy plane.

iii) The dx^2-y^2 has four lobes of high electron density of xy plane along x and y axis.

Electronic configuration of atoms

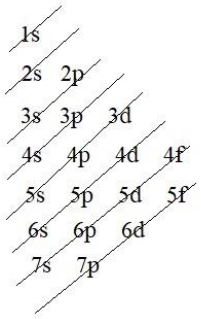
1. **Aufbau's Principle**:-

In the ground state of atoms, the orbitals are filed in order of their increasing energies.

The increasing order of energy is:-

1s, 2s, 2p, 3s, 3p, 4s ,3d, 4p, 5s, 4d, 5p, 6s.

This order can be explained on the basis of **Bohr's rule** as per this rule lower the value of (n+l) lower is the energy of the orbital and such an orbital will be filled up first.



3d = (3+2) = 5 Higher Energy

4s = (4+0) = 4 Lower Energy

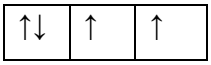
Pauli's Exclusion Principle

No two electrons in an atom can have all the four quantum numbers same.

Hund's Rule of Maximum Multiplicity

The pairing of electrons belonging to the same subshell (p, d or f) does not take place until each orbital belonging to that subshell has got one electron each i.e. singly occupied.

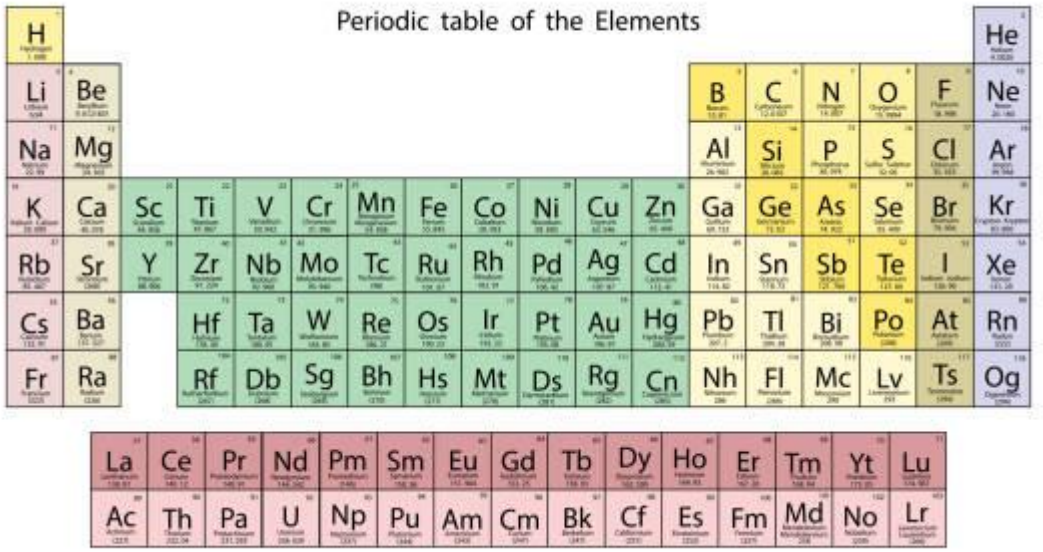
For Example if a p orbital has 4 electrons then the same can be filled as under



Electronic configuration of first 30 elements

Att. No.	Element	Symbol	Electronic Configuration
1	Hydrogen	H	$1s^1$
2	Helium	He	$1s^2$
3	Lithium	Li	$1s^2, 2s^1$
4	Beryllium	Be	$1s^2, 2s^2$
5	Boron	B	$1s^2, 2s^2, 2p^1$
6	Carbon	C	$1s^2, 2s^2, 2p^2$
7	Nitrogen	N	$1s^2, 2s^2, 2p^3$
8	Oxygen	O	$1s^2, 2s^2, 2p^4$
9	Fluorine	F	$1s^2, 2s^2, 2p^5$

10	Neon	Ne	$1s^2, 2s^2, 2p^6$
11	Sodium	Na	$1s^2, 2s^2, 2p^6, 3s^1$
12	Magnesium	Mg	$1s^2, 2s^2, 2p^6, 3s^2$
13	Aluminum	Al	$1s^2, 2s^2, 2p^6, 3s^2, 3p^1$
14	Silicon	Si	$1s^2, 2s^2, 2p^6, 3s^2, 3p^2$
15	Phosphorus	K	$1s^2, 2s^2, 2p^6, 3s^2, 3p^3$
16	Sulphur	S	$1s^2, 2s^2, 2p^6, 3s^2, 3p^4$
17	Chlorine	Cl	$1s^2, 2s^2, 2p^6, 3s^2, 3p^5$
18	Argon	Ar	$1s^2, 2s^2, 2p^6, 3s^2, 3p^6$
19	Potassium	K	$1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^1$
20	Calcium	Ca	$1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^2$
21	Scandium	Sc	$1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^2, 3d^1$
22	Titanium	Ti	$1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^2, 3d^2$
23	Vanadium	V	$1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^2, 3d^3$
24	Chromium	Cr	$1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^1, 3d^5$
25	Manganese	Mn	$1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^2, 3d^5$
26	Iron	Fe	$1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^2, 3d^6$
27	Cobalt	Co	$1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^2, 3d^7$
28	Nickel	Ni	$1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^2, 3d^8$
29	Copper	Cu	$1s^1, 2s^2, 2p^6, 3s^2, 3p^6, 4s^1, 3d^{10}$
30	Zinc	Zn	$1s^1, 2s^2, 2p^6, 3s^2, 3p^6, 4s^2, 3d^{10}$



Modern Periodic Law

The physical and chemical properties of the elements are the **periodic function** of their **Atomic numbers**.

Periodicity:-

Periodicity is the repetition of similar properties of elements placed in a group and reported by certain definite gaps of atomic numbers.

Cause of Periodicity:-

The properties of an element depend upon the number of electrons present in the valence shell. This periodic repetition of properties of the element is due to the repetition of similar outer electronic configuration.

Modern Periodic Table:-

The Modern Periodic Table is also called as **Long Form of Periodic Table**. It is based on the **Modern Periodic Law**. In this the elements are arranged in order of their increasing atomic number.

Structural features of Periodic Table

Groups

The vertical columns in the table are called as **GROUPS**. There are **18** groups in the Periodic Table. They are numbered from 1 to 18.

Characteristics of Group:-

1 Each group has same electronic configuration of outermost shell e.g. 1st group has **ns^1** configuration of outermost shell and the 18th group has **ns^2 np^6.**

2 The elements in a Group are separated by definite gap of atomic numbers (2, 8, 8, 18, 18, 32).

3 The atomic size of the element in a group increases as we move from top to bottom. This is due to increase in number of shell.

4 The elements in a **group** generally have **similar** chemical properties.

Periods

The **horizontal rows** in a periodic table are known as **Periods**. They are **seven** in numbers.

Characteristics:-

1. In all the elements in a period, the electrons are filled in the **same** valance shell.
2. The **atomic size decreases** as we move from **left to right** in a period.

Classification of elements

The elements can be classified into s, p, d and f block elements.

s-block element

The element in which last electron enters in s-orbital of outermost shell is called as **s-block** electrons. The general electronic configuration is **ns^{1-2}.**

Characteristics:-

1. All the elements are soft metals having low melting point and boiling point.
2. They are **highly reactive.**
3. They impart **colour** to flame.
4. They form generally **ionic** compound.
5. They are **good conductors** of **heat and electricity.**

p-block elements

The elements in which last electron enters in **p-orbital** of outermost shell is called as p-block elements. The general electronic configuration **ns^2 np^{1-6}.**

Characteristics:-

1. They are generally **non-metals**.
2. They from mostly **covalent** compound.
3. The ionization energies are relatively **high** as compared to s block element.

4. They show **variable** oxidation states.
5. The reactivity of the element in a Group generally **decreases down the group**.

d-block elements

The elements in which the last electron enters in **d-orbitals.** The general electronic configuration **$(n-1)d^{1-10}$ ns^{1-2}**. They are also known as transition elements.

Characteristics:-

1. They are **hard** metals with **high** melting point and boiling point.
2. They show **variable** oxidation state.
3. They from **coloured** ions.
4. They compounds of these elements exhibits **paramagnetic** in nature.

f-block elements

The elements in which the last electron enters in **(n-2) f subshell**. They have general electronic configuration **$(n-2)f^{0-14}$ $(n-1)d^{0-10}$ ns^2.** They are also called as **inner transition elements.**

Characteristics:-

1. They are **heavy** metals.
2. They show **variable** oxidation states.
3. They form complexes.
4. They for **coloured** ions.
5. Actinoids are **radioactive** in nature.

The elements can also be classified as metals, non-metals and metalloids.

Metals

The metals are those materials which passes the following characteristics:-

i. They are **solid** at room temperature and passes **high** melting point and boiling point.
ii. They are **good** conductor of heat and electricity.
iii. They are **malleable** and **ductile.**
iv. They have shining surface and produces sound on striking.

Non-metals

The non-metals are those materials which passes the following characteristics:-

i. They can be **solid**, **liquid** and **gas** at room temperature.

ii. They have **low** melting point and boiling point.

iii. They are **poor** conductor of electricity and heat.

iv. They are non-malleable and non-ductile.

v. They usually have dull appearance.

Metalloids

The elements like **silicon, germanium, arsenic, antimony** show the characteristics of both metal as well as non-metal are called metalloids.

Chemical Bonding

Chemical Bond

It can be defined as the attractive force which holds the atoms together within a molecule.

Caurse of Chemical Combination

1 **Tendency to acquire noble gas configuration**:-

The noble gases have stable electronic configuration and every atom has the tendency to acquire this stable electronic configuration i.e. 8 electrons in their outermost orbit. In order to acquire this configuration an atom may lose/gain/share electron and thus combine with other atoms by forming a bond.

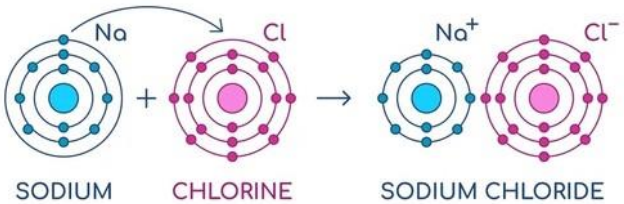
2 **Tendency to acquire minimum energy**

When two atoms approaches each other, two new force of attraction or repulsion comes into play. The force of attraction lead to decrease in energy and the force of repulsion increases the energy. Thus if the attractive forces overpower the repulsive forces, the energy of the system decreases and thus a chemical bond is formed.

Types of Chemical Bond

1. **Ionic or Electrovalent Bond**:-

A chemical bond is formed by complete transfer of electron from one atom to another atom is termed as ionic or electrovalent bond e.g. NaCl.



$Na \longrightarrow Na^+ + le^-$

2,8,1 2,8

$Cl + le^- \longrightarrow Cl^-$

2,8,7 2,8,8

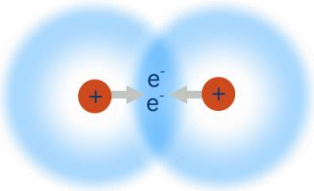
Na+Cl-

The atomic number of Na is 11 with electronic configuration 2, 8, 1 and the atomic number of Cl is 17 with electronic configuration 2,8,7. The sodium atom has tendency to lose an electron and Cl atom has the tendency to gain one electron to acquire the stable noble gas configuration. Sodium thereby becomes Na^+ and Chlorine Cl^-. These two ions are bonded together by electrostatic force of attraction resulting in the formation of NaCl.

2. **Covalent Bond**:-

The bond formed by mutual sharing of electrons between the combining atoms of the same or different elements is called as covalent bond. This is shown by a single line (-). The covalent bond formed by mutual sharing of **one pair** of electron is called a **single bond.** Similarly if **two electron** pairs are shared than **double bond** and if **three electron** pairs are shared than **triple bond** is formed

e.g. H_2, O_2, N_2



3. **Metallic Bond**:-

Metallic bond is a term used to describe the collective sharing of a sea of valence electrons between several positively charged metal ion.

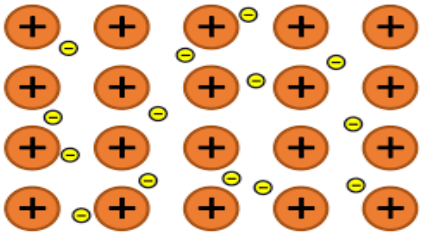
Electron Sea Model:-

The metallic bonding can be explained on the basis of Electron Sea or Gas model.

The following are the features of the model:-

1. A metal atom consists two parts **valence electron** and the remaining part known as **Kernel** which is positively charged.

2. The Kernel's occupy the fixed position while the space between the Kernels is occupied by valence electron.
3. The valence electrons are loosely held by the nucleus, these electrons are not fixed and are called as **mobile electron.**
4. The force of attraction between mobile electrons and **positive Kernels** is responsible for holding the metal atom together is called as **metallic bond.**



Physical properties of Ionic Compounds

1. These compounds exit in **Crystalline solid**.
2. They have **high** Melting and Boiling points.
3. They do not conduct electricity in **Solid State** however in fused or **Aqueous State** they conduct electricity.
4. They are generally soluble in Water or other Polar solvent.
5. Ionic bonds in these compounds are **non-directional** in nature.
6. These compounds undergo ionic reactions which are very **fast** in nature.

Physical properties of Covalent Compounds

1. These compounds are usually liquids or gases at room temperature.
2. These compounds have low Melting and Boiling parts.
3. They do not conduct electricity in fused or aqueous solutions.
4. They are soluble in organic solvent.
5. Covalent bonds are directional in nature.
6. There compounds undergo molecular reactions.

Difference between Ionic and Covalent compound

S.No	Ionic Compound	Covalent Compound
1	They contain ionic bond	They are found as a result of covalent bond
2.	They are mostly solid at room temperature	They are mostly lequids and gases at room temperature
3.	They have high melting and boiling point	They have low melting and boiling point
4.	They are polar in nature	They are mostly non polar in nature
5.	They are non- directional in nature eg NaCl etc	They are directional in nature eg H_2, O_2 etc

CHEMISTRY

NOTES

(1st Semester)

Unit II (Metals and Alloys)

Unit-II (Metals & Alloys)

Metals

The elements which are Hard, Dense, Malleable, Ductile, High lustre &High melting and Boiling points are called as metals e.g. Copper, Nickel, Gold etc.

Mechanical Properties of metals

1. **Strength & Stiffness**:-

   It is the property of a material which provide its ability to withstand various loads without deformation or breaking. Metals have good strength.

2. **Conductivity:-**

   It is the property of material which allows electric current to pass through it. Metals are good conductors of electricity.

3. **Malleability:-**

   It is the property of the material by which it can be beaten into sheets. Metals are malleable.

4. **Ductility:-**

   It is the property of a material by which it can be drawn into wires. Metals are ductile.

5. **Elasticity**:-

   It is the property of a material to regain its initial shape when the load producing deformation is removed. Metals are elastic in nature.

6. **Hardness:-**

   It enables a material to resist penetration or deformation.

7. **Toughness**:-

   It is the property which enables bending without fracture. Metals are usually tough.

8. **Brittleness**:-

   It is the tendency of a material to fracture while it is deformed. Metals are thus brittle.

9. **Impact-resistance** :-

   It is the property of a material which enables it to withstand heavy shocks such as in power hammering.

Uses of Metals

1. Metals like Iron, Aluminium etc. are the main materials used in constructions.
2. Metals are good conductors of electricity so they are used in making electronic equipment. **Silver is the best conductor of electricity.**
3. Metals are **good conductors** of heat so are used in **making utensils.**
4. Due to **elasticity** the metals are used in **making springs.**
5. Metals due to the property of **stiffness** are used in making **bridges, cycles, furniture** etc.
6. Metals due to the property of **brittleness** are used in making **army armours.**
7. Due to the property of **ductility** the metals are used in making **cables, Jewellery etc.**
8. Metals due to its property of **malleability** can be used in making **utensils, railway coaches, ornaments etc**.

Metallurgy

Metal occurs in two states

1. **Native or free State** :-

   The metals which occur in **free or pure** state are called native metals e.g. **gold, silver** etc.

2. **Combined State**:-

   The metals which occur in combination with others metal or non-metal are called combined state.

Definitions

1. **Minerals:-**

   The natural substances which contains metals and occur either in native state or in combined state are called minerals.

2. **Ore:-**

An ore is a mineral from which a metal can be **extracted economically and profitably**

" All ores are minerals but all minerals are not ores"

3. **Gangue or Matrix**:-

The earthy impurities like sand, rocks, limestone etc. associated with the ore are known as Gangue or Matrix e.g. SiO_2, P_2O_5 etc.

4. **Flux**:-

The substances which are added to the ore to remove gangue (impurities) during its reduction is called flux. It is of two types depending upon the nature of impurities

Acid Flux:- This flux combines with basis impurities e.g. SiO_2

Basic Flux:- This flux combines with acidic impurities e.g. $CaCO_3$

5. **Slag**:-

It is the waste material which is formed as a result of combination of **gangue** and **flux** is called **slag.**

Flux + Gangue $\longrightarrow$ Slag

Metallurgy of Iron

Iron is not found in free state rather it is found in **combined states** i.e in form of oxides, sulphide and carbonate .

The important ores of iron are:-

1. Haematite $\longrightarrow$ Fe_2O_3 (Oxide ore)
2. Magnetite $\longrightarrow$ Fe_3O_4 (Oxide ore)
3. Limonite $\longrightarrow$ $Fe_2O_3 3H_2O$ (Oxide ore)
4. Siderite $\longrightarrow$ $Fe\ CO_3$ (Carbonate ore)
5. Iron Pyrites $\longrightarrow$ FeS_2 (Sulphide ore)

Commercial Varieties of ion

1. Cast Iron:

It is the most **impure** form of iron. It is also called as **Pig iron.** It contains **2-5%** of Carbon

2. Wrought Iron :

It is the **purest** form of iron and contains **0.2 to 0.5%** of carbon.

3. Steel:

It contains **0.1 to 1.5%** of Carbon.

Extraction of Iron

Iron is usually extracted from oxide ore i.e. **Haematite (Fe_2O_3)** and involves following steps:-

1.Concentration of ore :

The ore is crushed with jaw crushes and is concentrated by **Gravity Separation** method to increase the percentage of **Fe** in the ore. In this concentration method the ore is passed through hydraulic pressure in the water. The lighter particles are washed away and the heavier ores settled down.

2. Calcination:

The concentrated ore is than heated in the absence of air. During calcination the following reactions takes place:-

i. Moisture is removed.

ii. $S + O_2 \longrightarrow SO_2$

$4As + 3O_2 \longrightarrow 2As_2O_3$

$4P + 5O_2 \longrightarrow 2P_2O_5$

iii. It converts ferrous oxide to ferric oxide

$4FeO + O_2 \longrightarrow 2Fe_2O_3$.

3. Smelling or reduction of ore:-

The calcinated ore is reduced with carbon in the **Blast Furnace**. The blast furnace is a **cylindrical** iron furnace lined with fire bricks. It has **cone and cup** arrangement at the top and at the bottom there is outlet for withdrawing molten Iron and Slag

The Calcinated ore is mixed with coke and lime in the ratio of **8:4:1**. The mixture is called **charge** which is then introduced from the top of furnace. Hot air is blown from the bottom. The coke present in the mixture serves as reducing agent and fuel.

The following reactions take place in furnace.

i. **Combustion Zone (1800k)**
The coke burns in this part of the furnace and CO_2 is produced.
$C + O_2 \longrightarrow CO_2$

ii. **Zone of fusion:-** The temperature of this zone is about **1600 K**. The CO_2 produced in combustion zone combine with the coke and CO is formed.
$CO_2 + C \longrightarrow 2CO$
The Fe produced in upper zone also melts here.

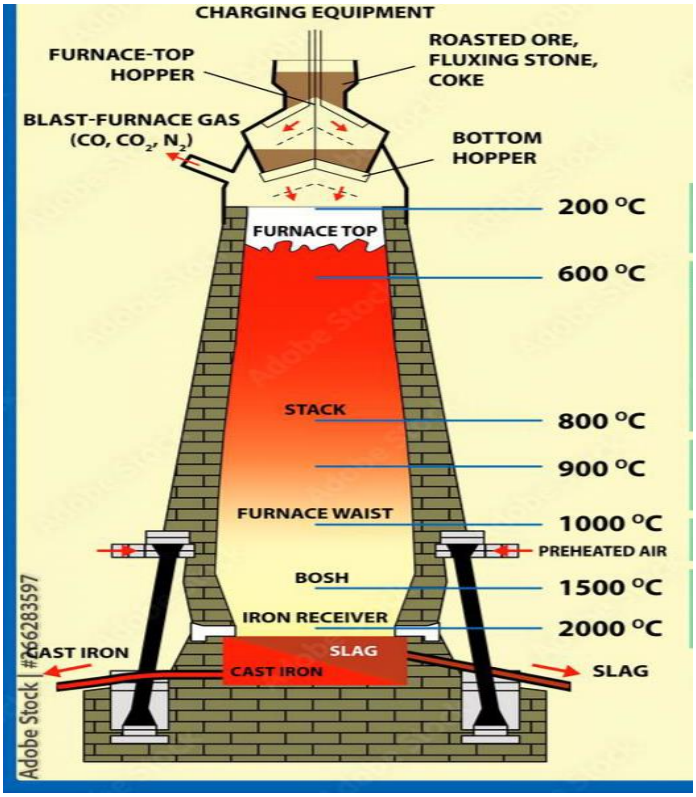
iii. **Slag formation Zone:-(1300K)** Lime stone present in the charge decomposes to from lime and CO_2.
$CaCO_3 \longrightarrow CaO(lime) + CO_2$
The lime produced acts as flux and it combines with silica.
$CaO + SiO_2 \longrightarrow CaSiO_3$
Lime Silica Calcium silicate (Slag)

iv. **Reduction Zone**:- **(800K)**

Iron present in the ore is reduced to Fe by CO

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

Iron produced in the reduction zone moves down slowly and melts in fusion zone. The iron collected at the bottom is known as **Pig iron** or **Cast iron**



Conversion of Cast iron into Wrought iron

The **Cast iron** can be converted into **Wrought iron** by heating it with haematite ore which oxidise carbon (impurity) into carbon monoxide.

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

$MnO + SiO_2$ (Silica/flux) $\longrightarrow MnSiO_3$**(Slag)**

Alloy

It is a **homogenous mixture** of two or more metals or metals and non-metals.

Purpose of alloying:-

1. **To improve the hardness of metal**:-

   Pure metals are generally soft. They can be harnded by mixing it with the other non-metal or metal e.g. hardness of pure **Iron** can be increased by missing it with **Carbon**.

2. **To lower the melting point of a metal:-**

   The melting point of an alloy is lower than its constituents. The solder an alloy of **Lead** and **Tin** has lower melting point than its constituent metals.

3. **To increase the tensile strength:-**

Alloying is used to increase the tensile strength of a metal. Addition of **1% Carbon** increases the tensile strength of **Iron** 10 times.

4. **To prevent metal from corrosion:-**

Alloy is made to prevent the metal from corrosion e.g. **Fe** can be protected from corrosion by alloying it with **Cr**.

Important Alloys

1. Duralium:-

Composition

Al = 95%
Cu= 4%
Mg=0.5%
Mn=0.5%

Properties

i. It is light, tough and highly Ductile.
ii. It is good conductor of Heat and Electricity.
iii. It approaches steel in strength however its density is one third of it.
iv. Its tensile strength can be raised by heat treatment.

Uses

(i) It is used for making aeroplanes and other machines where weight is a deciding factor
(ii) It is used in making sheets, tubes ,nuts and bolt etc.
(iii) It is used in making cables and surgical instruments.

2. Stainless Steel

It is alloy of Iron which resists corrosion by atmosphere and also by chemicals.

Composition

Fe = aprox. 85-80%
Cr = 10.5%
C = less than 1.2%
Other metal= In traces.

Properties

(i) It is resistant to corrosion and chemicals.
(ii) It has high tensile strength.

(iii) It is more ductile.

Uses:-

i. It is used in constructions of building, tools, ships etc.
ii. It is used in making automobile parts, utensils and electrical appliances.
iii. It is used as lining in petroleum industry.

Heat treatment of Steel

The process of heating and cooling of solid steel article under carefully controlled conditions to develop desired mechanically properties without altering its chemical composition.

The following are the heat treatment process:-

1.Quenching or Hardening:-

It is the process of heating of a metal to **brightness** and **cooled suddenly** in water or oil. The metal becomes hard and brittle.

2.Tempering:-

It is the process of **heating** of **quenched metals** to a temperature between **500-600 K** for some time and then followed by **slow cooling.** The product so formed will be slightly hard and tough but not brittle.

3.Annealing:-

It is the process of heating a metal to brightness and then allow it to cool slowly to room temperature resulting the metal soft.

4.Normalising:-

It is the process of heating a metal to a definite temperature and cooling gradually in air for refinement of grain structure and to increase toughness of metal.

CHEMISTRY

NOTES

(1st Semester)

Unit-III

Unit-III (Water, Solution, Acids and Bases)

Definitions

Solution

A solution is a homogenous mixture of two or more chemically non reacting substances. If the solution contains only two components it is called **binary** solution.

Solute + Solvent $\longrightarrow$ Solution

Solute

The component which is present in small amount in the solution is called **Solute**

Solvent

The component which is present in large amount in the solution and in which solute dissolves is called as **solvent**.

Expressing the Concentration of Solution

1. **Mass Percentage (w/w)**

It is defined as the mass of solute dissolve in 100 gm of solution.

$$\text{w/w \% of solute} = \frac{\text{Mass of Solute}}{\text{Total mass of Solution}} \times 100$$

2. **Weight by volume percentage (w/v)**

It is defined as the weight of the solute dissolved in 100 ml of solution.

$$\text{w/v \% of solute} = \frac{\text{Weight of Solute}}{\text{Total volume of solution}} \times 100$$

3. **Volume by volume percentage (v/v)**

It is defined as volume of solute dissolved in 100 ml of solution.

$$\text{v/v \% of solute} = \frac{\text{Volume of solute}}{\text{Total volume of solution}} \times 100$$

4. **Strength**-

The strength of a solution is defined as amount of solute in gms present per litre of solution.

$$\text{Strength} = \frac{\text{Weight of solute}}{\text{Volume of solution}} \times 1000$$

Units- It is measured in **gms/litre**

5. **Molarity (M)**

It is defined as the number of moles of solute dissolved per litre of solution.

$$\text{Molarity (M)} = \frac{\text{Weight of Solute}}{\text{Mol.Wt. of Solute}} \times \frac{1000}{\text{Volume of Solution}}$$

Unit: It is measured in **moles/litre (mol L-1)**

Effect of temperture:

With **increase** in temperature the molarity of a solution **decreases**.

Molarity Equation

If a solution having molarity M1 and Volume V1 is diluted to V2 so then the new molarity M2 is :-

$$\mathbf{M_1V_1 = M_2V_2}$$

This equation is called **molarity equation**.

6. **Normality (N)**

It is defined as the number of gram equivalent of the solute dissolved per litre of the solution.

$$\text{Normality (N)} = \frac{\text{Weight of Solute}}{\text{Equi.Wt. of Solute}} \times \frac{1000}{\text{Volume of Solution}}$$

Unit: It is measured in **gm equivalents /litre**

Effect of temperture:

With **increase** in temperature the normality of a solution **decreases**.

Normality Equation:-

If a solution having normality N1 and Volume V1 is diluted to V2 so then the new normality N2 is :-

$$N_1V_1 = N_2V_2$$

This equation is called **normality equation**.

7. Molality (m)

It is defined as the number of moles of the solute dissolved in 1000gm of the **solvent**.

$$\text{Molality(m)} = \frac{\text{Weight of Solute}}{\text{Mol. Wt. of Solute}} \times \frac{1000}{\text{Weight of the solvent}}$$

Unit: It is measured in **moles/Kg (mol Kg^{-1})**

Effect of temperture: It is independent of Temperature ie molality has no effect of increase or decrease in temperature

8. Parts per million (ppm)

One ppm is defined as one part by weight or volume of a solute dissolved in 1 million parts by weight or volume of a solution.

$$\text{Parts per million (ppm)} = \frac{\text{Weight or Vol.of Solute in (gm/ml)}}{\text{Weight or Vol. of Solution(gm/ml)}} \times 10^6$$

Numericals

Example 1

If 5 gm of sodium chloride is dissolved in 20 gm of solution. Calculate mass percentage of sodium chloride.

Wt. of NaCl= 5 gm.

Wt. of NaCl solution= 20 gm

Mass percentage of solute (m/m) = 5/20 x 100

= 25%

Example 2

If 5 gm of sodium chloride is dissolved in 20 ml of solution. Calculate weight/vol. percentage of NaCl.

Wt. of NaCl= 5 gm.

Wt. of NaCl solution= 20 ml

weight/vol.% of solute = 5/20 x 100

= 25%

Example 3

A solution is prepared by dissolving 4 gm of NaOH to give 500 ml of it. Calculate the molarity of solution. [Na=23, O=16, H=1]

Mass of NaOH= 4 gm.

Mol. Weight of NaOH= 23+16+1=40

Volution of solution= 500 ml.

$$\text{Molarity} = \frac{\text{Weight of solute}}{\text{Mol. Wt. of solute}} \times \frac{1000}{\text{Volume of Solution}}$$

$$= 4/40 \times 1000/500$$

$$= 0.2 \text{ M.}$$

Example 4

How much volume of 10 M HCl should be diluted with water to prepare 2 litres of 5 M HCl

The molarity equation is:-

$MV1 = M2V2$

$10 \times V1 = 5 \times 2000$

$V1 = \frac{5 \times 2000}{10} = 1000$ ml

Example 5

Calculate the normality of a solution containing 3.15 gm of hydrated oxalic acid in 500 ml of solution. [M Wt. of hydrated oxalic acid = 126]

Mol.Wt. of Oxalic Acid = 126

Basicity = 2

Eq. wt of Oxalic Acid = $\frac{\text{Mol.Wt.}}{}$

Basicity

= 126/2 = 63

$$\text{Normality} = \frac{\text{Mass of solute}}{\text{Eq. wt. of solute}} \times \frac{1000}{\text{Vol of solution}}$$

$$= \frac{3.15}{63} \times \frac{1000}{500}$$

= 0.1N

Example 6

2.82 gm of glucose (Mol. Wt.=180) are dissolved in 30 gm of water, calculate its molality

Mass of glucose = 2.82 gm.
Mol. Wt of glucose = 180
Wt. of Solvent = 30 gm.

$$\text{molality(m)} = \frac{\text{Wt of solute}}{\text{Mol. of solute}} \times \frac{1000}{\text{wt. of solvent}}$$

$$= \frac{2.82}{180} \times \frac{1000}{30} = 0.522 \text{ mol/kg}$$

Acids and Bases

Arrhenius Concept of Acids and Bases

1 **Acid:-**

An acid is a substance that gives H^+ ions when dissolved in water eg. HCl, H_2SO_4, HNO_3 etc.

2 **Base:-**

A base is a substance that gives OH^- ions when dissolved in water egNaOH.

3 **Acidity:-**

It is the number of hydroxyl (OH^-) ions furnished by one molecule of base in aqueous solution.

4 **Basicity:-**

It is the number of H^+ ions furnished by one molecule of acid when dissolved in water

5 **Strong Acids:-**

There are those acids when dissolved in water completely dissociates to give H^+ ions eg. HCl, H_2SO_4, HNO_3

6 **Weak Acids:-**

These are those acids when dissolved in water do not dissociate completely to give H^+ ions eg acetic acid (CH_3COOH).

7 **Strong Base:-**

There are those bases when dissolved in water completely dissociate to give OH^- ions eg NaOH.

8 **Weak Base:-**

There are those bases which do not dissociate completely into OH-ions when dissolved in water eg. $Ca(OH)_2$.

pH scale:- Representation of H_3O^+ ion concentration.

The nature of an aqueous solution whether it is acidic, basic or neutral depends upon the concentration of H^+ or OH^- ions in it.

Pure water has equal concentration of H^+ and OH^- and is treated as neutral

i.e. $[H^+] = [OH^-] = 1x\ 10^{-7}$

or otherwise $[H^+][OH^-] = 1x\ 10^{-14}$

If a solution having higher concentration of $[H^+]$ than$1X\ 10^{-7}$ then it is called acidic and the solutions having low concentration of $[H^+]$ than $1x\ 10^{-7}$ are called a basic.

There is another method of expiring $[H^+]$ conc. called as pH, i.e. power of Hydrogen.

Definition of pH

pH of a solution is defined as the negative logarithm of its hydronium ion (H_3O^+) concentration

$pH = -\log [H_3O^+]$

$pH = \log 1/[H_3O^+]$

Thus, pH of a solution may also be defined as logarithm of the reciprocal of hydronium ion conc.

For neutral solution

pH = - log[H_3O^+]

pH = - log [$1X10^{-7}$]

= -(-7) $\log_{10}$ [But $\log_{10}$ =1]

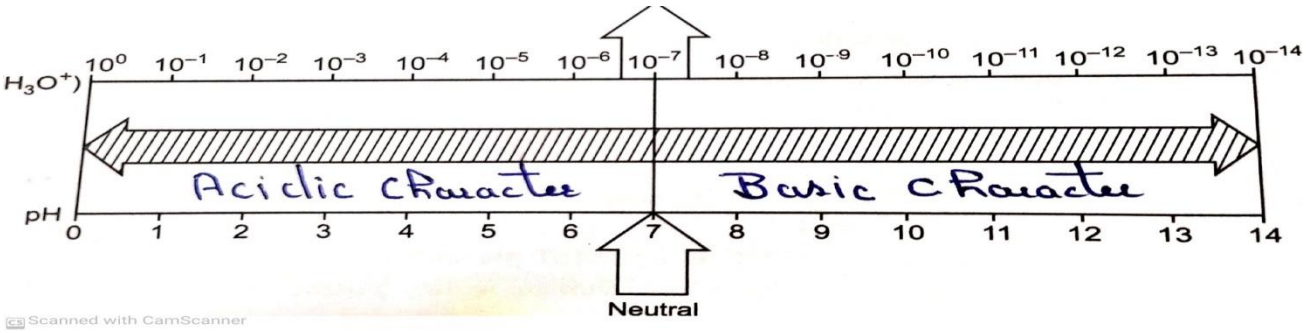
pH = 7

So For neutral solution pH=7

For acidic solution pH<7

For basic solution pH>7

pH scale



Significance of pH:-

1. It tells us about the nature of solution i.e. acidic, basic or neutral.
2. In acid base titrations the pH is used to detect the end point.
3. The control of pH of the medium is very important in the preservation of food.
4. pH plays important role in the preparation of drugs.
5. It plays important role in crystallisation of sugar.
6. It plays major role in the metabolism of food.
7. It is very helpful in electroplating.

Numerical on pH

Example 1

Calculate the pH value of .001M HCl solution

$HCl \rightarrow H_3O^+ + Cl^-$

$[H_3O^+] = [HCl] = 0.001\ M = 1X10^{-3}$

$pH = - \log[H_3O^+]$

$pH = - \log[10^{-3}]$

$pH = - (-3) \log_{10}$ (Because $\log_{10} = 1$)

$pH = 3$

Example 2

Calculate the pH value of .001M NaOH solution

$NaOH \rightarrow Na^+ + OH^-$

$[OH]^- = .001M = 10^3M$

We know that $[H^+][OH^-] = 10^{-14}$

$[H^+] \times 10^3 = 10^{-14}$

$[H^+] = 10^{-11}$

Now $pH = - \log[H_3O^+]$

$pH = - \log[10^{-11}]$

$pH = -(-11) \log_{10}$ (Because $\log_{10} = 1$)

$pH = 11$

Example 3

Calculate the pH of a solution having hydronium ion concentration $3.8x10^{-5}$ M. What is the nature of this solution. Given log 3.8=.5797

$[H_3O^+] = 3.8\ X10^{-5}$

$pH = - \log[H_3O^+]$

$pH = - \log[3.8x10^{-5}]$

$pH = - \log 3.8 - \log 10^{-5}$

$pH = - \log 3.8 - (-5 \log_{10})$ (log 3.8=.5797 and $\log_{10} = 1$)

$= -.5797+5$

$= 4.4203$

The solution is Acidic in nature

Water

Types of Water

Water may be classified into two types

1. **Soft Water**

   Water that forms good lather with soap solution easily is called as **Soft Water.**

2. **Hard Water**

   Water that does not form lather with soap solution is called as **Hard Water.**

Causes of Hardness of Water

The hardness of water is due to the presence of any of salt like bicarbonates, chlorides and sulphates of metals like Ca and Mg

The hardness can be two types

1 **Temporary Hardness**

This hardness of water is due to the presence of bicarbonates of Ca and Mg.

2 **Permanent Hardness of water**

The permanent hardness of water is due to the presence of Chlorides and Sulphates of Calcium and Magnesium.

Units / Degree of Hardness of water

The hardness is measured in terms of $CaCO_3$ because it is a insoluble salt that can be precipitated in water treatment moreover, its molecular mass is 100 which makes the calculation easily

Degree of Hardness

It is the number of parts of Calcium Carbonate equivalent hardness per a definite number of parts of water, depending upon the units in which degree of hardness is expressed.

1.Parts per million (ppm)

It is defined as the number of parts of calcium carbonate equivalent hardness present per million (10^6) parts of water.

1ppm = 1 part of $CaCO_3$ equivalent hardness in 10^6 parts of water.

Methods to Remove Temporary Hardness of water

The temporary hardness of water can be removed by any of the following methods:-

1. By Boiling

On boiling the bicarbonates of Calcium and Magnesium are converted into insoluble calcium carbonate and CO_2.

$$Ca(HCO_3) \xrightarrow{\text{Boiling}} CaCO_3 \downarrow + H_2O + CO_2\uparrow$$

$$Mg(HCO_3)_2 \xrightarrow{\text{Boiling}} Mg\,CO_3\downarrow + H_2O + CO_2\uparrow$$

2. Clark's process

In this method a controlled quantity of lime (Calcium hydroxide) is added in temperary hard water resulting in conversion of Calcium and Magnesium bicarbonate into insoluble $CaCO_3$, which is removed simply by filtration

(i) $Ca(HCO_3)_2 + Ca(OH)_2 \rightarrow 2CaCO_3$ (insoluble) $+ H_2O$

(ii) $Mg(HCO_3)_2 + 2Ca(OH)_2 \rightarrow 2CaCO_3$(insoluble) $+ Mg(OH)_2 + 2H_2O$

The insoluble $CaCO_3$ can be removed by filtration

Method to remove Permanent Hardness of water

This type of hardness can be removed by ion-exchange process.

Ion- Exchange Method:-

In this method ions present in hard water get exchanged by ion-exchange resins. These are of two types:-

a) Cation Exchange Resin:-

These are the organic polymers having acidic functional group like -COOH at one end which can exchange its H^+ ion with cations like Ca^{2+}& Mg^{2+} present in hard water.

b) Anion Exchange Resin :-

These are the organic polymers having basic functional group like -OH at one end which can exchange its $–OH^-$ ion with anions like Cl^- and SO_4^{2-} present in hard water.

Working

The hard water is passed through a bed of cation exchange resin in 1st tank. The following reactions takes place

$$2R\text{-}H + Ca^{2+} \rightarrow R_2Ca + 2H^+$$

$$2R\text{-}H + Mg^{2+} \rightarrow R_2Mg + 2H^+$$

The water coming out from 1st tank passes through 2nd tank which is packed with anion exchange resin. The following reactions takes place

$$R\text{-}OH + Cl^- \rightarrow RCl + OH^-$$

$$2R\text{-}OH + SO_4^{2-} \rightarrow R_2SO_4$$

The H+ ions coming from Cation exchange combines with OH^- ions coming from anion exchange to from water.

$$H^+ + OH^- \rightarrow H_2O$$

Regeneration of exhausted resin:-

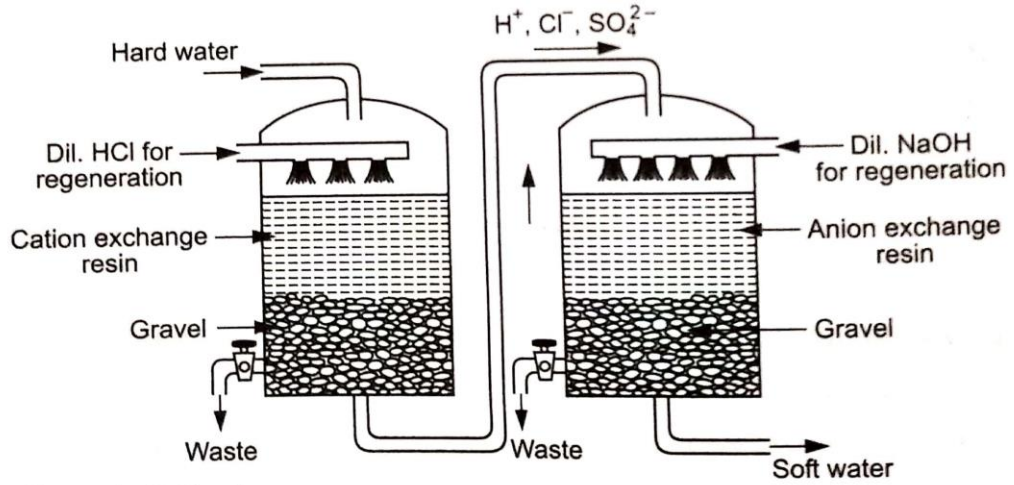
After continuous use the cation exchange resin and anion exchange resin are exhausted. They can be regenerated as under:-

The cation exchange resin can be regenerated by treating it with HCl or H_2SO_4

$$R_2\,Ca + 2H^+ \rightarrow 2RH + Ca^{2+}$$

The **anion exchange** resin can be regenerated by treating it with NaOH.

RCl + NaOH → R-OH + NaCl



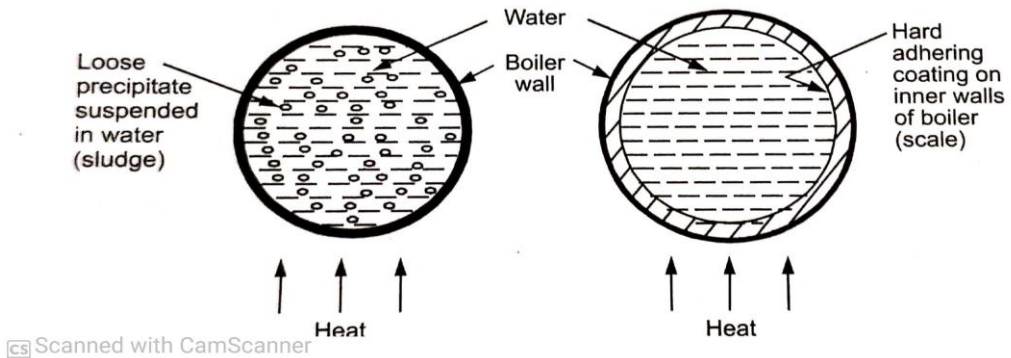
Disadvantages of Hard water in boilers

In boilers water is used for generating steam which can be used for different purposes. If hard water is used in boilers, the following problem may occur.

1 Scale and sludge formation.

On heating hard water forms ppt which are insoluble.

If the precipitation takes place in the form of loose layer, then it is called sludge and if it forms hard crust on the inner the walls of boiler then it is called **Scale.**



Disadvantages of Scale and Sludge

1. They are poor or bad conductor of heat, so lot of fuel is required to heat the water.
2. Due to sludge formation the opening of pipes is plugged causing choking.
3. The scale on heating may crack and due to which there will be sudden increase in pressure.

Prevention :-

1. Soft water must be used
2. By frequently ' Blow down operation ' ie partial removal of Conc. Water
3. By adding certain chemicals like sodium carbonate, sodium phosphate etc.

2.Priming and foaming

The formation of large number of bubbles on the surface of water in boiler is called foaming but if these bubble becomes extensive and explosive and enter in the engine then it is called priming.

Cause :-

1. Suspended particles in water helps the formation of bubbles
2. Soluble impurities increases the foaming capicity

Disadvantages:-

1. Due to priming and foaming it is difficult to maintain constant pressure.

2. Boiling point of water increase due to foaming causing loss of fuel.

3. It reduces the efficiency of engine.

Prevention :-

1. Foam forming substances should be removed from water.
2. No suspended matter in the feed water
3. Scale and sludge should be removed from time to time

3.Caustic Embrittlement:-

The boiler material becomes brittle due to the presence of caustic substances present in water. This is called caustic embrittlement.

Disadvantages

It make the boiler material brittle causing bursting of a boilers which leads to accidents.

Prevention :-

1. By the use of Sodium Phosphate instead of Sodium Carbonate for water softening
2. Alkalinity present in boiler feed water should be neutralised.

Drinking Water

Qualities of drinking water (Potable water)

1. It should be soft.

2. It should be colourless, odourless and free from disease producing microorganisms.

3. The pH of drinking water should be between 6.9 to 8.5.

4. It should not contain suspended particles.

Sterilisation or disinfection of water

1- Chlorination

This is the widely used method for sterilization of water throughout the world. It can be done in following ways:-

(i) By Adding Bleaching Powder ($CaOCl_2$)

Bleaching powder on reaction with water liberates chlorine gas which reacts with water to form hypochlorous acid. This acid decomposes to form HCl and nascent oxygen which kills germs and bacteria.

$$CaOCl_2 + H_2O \rightarrow Ca(OH)_2 + Cl_2$$

$$Cl_2 + H_2 \rightarrow HCl + HClO \text{ (hypochlorous acid)}$$

$$HClO \rightarrow HCl + [0] \text{ nacent oxygen}$$

ii) By Adding Chloramine:

In this **chlorine and ammonia** in the ratio of 2:1 are passed through water. This produces Chloramine which is a strong disinfectant

$$NH_3 + Cl_2 \rightarrow NH_2Cl \text{ (Chloramine)} + HCl$$

$$NH_2Cl + 2H_2O \rightarrow HOCl + NH_4OH$$

$$HOCl \rightarrow HCl + [0] \text{ (Nacent oxygen)}$$

(iii) By Using Chlorine Gas (Cl_2):

Chlorine can be used directly as gas or as Chlorine water for sterilization. It reacts with water to produce hypochlorous acid and nacent oxygen, both of which are powerful germicides.

$$Cl_2 + H_2O \rightarrow HCl + HOCl \text{ (Hypochlorous acid)}$$

$$HOCl \rightarrow HCl + [0] \text{ (Nacent oxygen)}$$

2. By Ultraviolet Rays

In this method, the water is exposed to the action of **ultraviolet rays.** There rays are powerful germicidal. This is an excellent method for the sterilization of water as

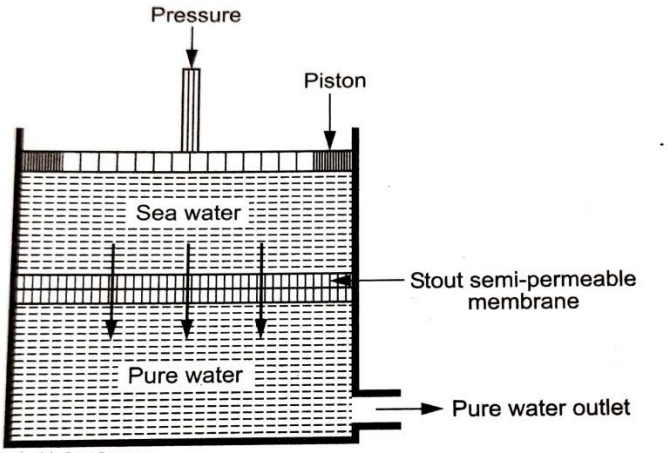
no chemical is added to water, so on odour or taste is developed and there are no bad effects of over treatment.

3. **Reverse Osmosis (RO) method**

Deionised water is water that is deionised with the help of Reverse Osmosis (RO)

Whenever a pressure in excess of osmotic pressure is applied on the concentrated side the solvent is forced to move from concentrated side to dilute across the semipermeable membrane, this is called reverse osmosis.

When pressure greater than osmatic pressure is applied on salt water side of a semi-permeable membrane, the pure water flows from the salt water side to pure water side. Thus pure water is obtained, which does not contain dissolved undesirable salt.



CHEMISTRY

NOTES

(1st/2nd Semester)

Unit 4 (Fuels and Lubricants)

UNIT-IV

Fuels and Lubricants

Fuels

Fuels are the **combustible** substances which on burning in air produce large amount of heat that can be used for industrial as well as domestic purposes e.g. wood, Charcoal etc.

Classification

Fuels can be classified on the basis of :-

1. Source
2. Physical State.

1. On the basis of Source

(i) **Natural or Primary**

These occurs in nature e.g. wood, coal, natural gas etc.

(ii) **Artificial or Secondary**

They are prepared artificially e.g. charcoal, diesel, petrol, water gas, oil gas, coal gas, biogas etc.

2. On the basis of Physical State

(i) **Solid**

They are solid, they can be natural artificial, wood, peat, coal are the examples of natural fuel whereas charcoal and coke are artificial fuels.

(ii) **Liquid**

They are liquid in nature e.g. Crude oil(Natural), petrol, diesel(Artificial) etc.

(iii) **Gaseous fuels**

These are gases in nature, they can be natural or artificial. Natural gas is an example of natural gaseous fuel whereas water gas, produce gas, coal gas or biogas are examples of artificial gaseous fuel.

Characteristics of Good fuel

1. They should have **High Calorific Value.**
2. They should have **moderate** ignition temperature.
3. They should have **low** moisture contents.
4. They should have **moderate** rate of combustion.
5. They should be cheap and easily available.
6. They should be easy to store.

Calorific Value of a fuel

Definition

It is defined as the amount of heat produced when a unit mass of fuel is completely burnt .

Types

1. **Higher or Gross Calorific Value**:-

It is the total amount of heat produced when a Unit mass or unit volume of fuel is burnt completely and the products of combustion are cooled to the room temperature.

2. **Lower or Net calorific value:-**

It is the net heat produced when a unit mass or volume of the fuel is burnt completely and products of combustion are allowed to escape.

Net calorific value = Gross Calorific volume - Latent heat of water vapours.

Units : It is expressed in Kcal/gm or Kcal/Lt. or B.T.U

Advantages of Gaseous fuel over Solid & liquid fuel

The Calorific value of gaseous fuel is high as compared to solid or liquid fuel.

1. They do not produce smoke and ash.
2. Their burning can be controlled easily.
3. Their ignition temperature is low.
4. They are more economical.

Advantage of Liquid fuels over Solid fuels

1. They have more calorific value than solid fuel.
2. They do not produce any ash or residue.
3. Their combustion is uniform and controlled.
4. They burns freely with high efficiency.
5. They are economical.

Petroleum

Petroleum or crude oil is a dark greenish brown, viscous oil found deep in Earth's crust which is formed as a result of earth quakes and other natural calamities like Volcano's etc.

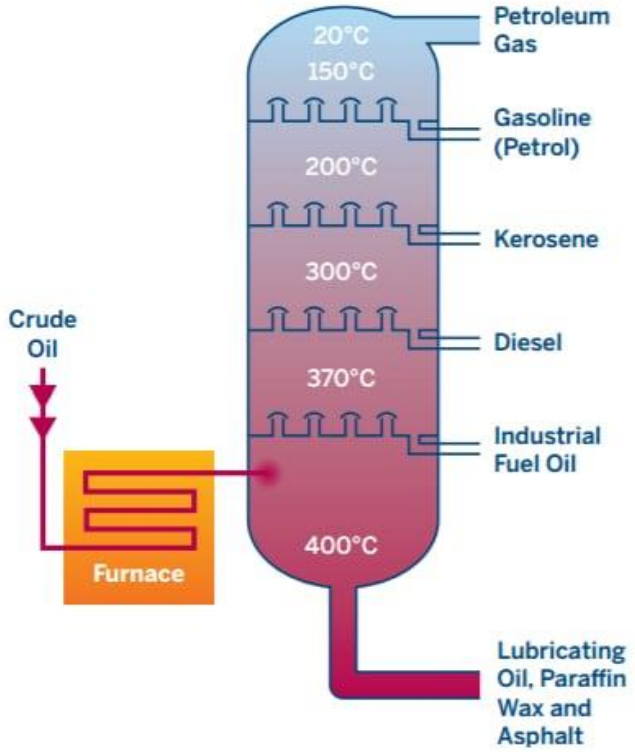
Composition of crude oil

It consists of mixture of aliphatic hydrocarbons particularly alkanes (C_1-C_{40}) with much lesser amounts of cycloparafins.

Refining of petroleum

The process of separating petroleum into different useful fractions having different boiling ranges with the simultaneous removal of undesirable impurities is called refining.

The crude oil is first neutralised by washing it with acidic or basic solution. It is than subjected to fractional distillation. For this the crude oil is heated to 400 degree Celsius in coiled pipes in a furnace. The vapours thus obtained are admitted to a fractionating tower containing number of horizontal stainless steel trays at a short distance. The vapours of oil rise up and condenses at different levels depending upon boiling ranges. High Boiling fractions condenses first while the lower boiling fractions turn by turn.



Gaseous fuels.

1. Compressed Natural Gas (CNG)

Composition

It is mainly methane with small amount of ethane and propane.

Properties

1. It is colourless, odourless and tasteless gas.
2. It is non-corrosive in nature.
3. It is non-toxic in nature.

Uses

1. It is used as a fuel for automobiles.

2. Piped Natural Gas (PNG)

It is piped natural gas. The **composition and properties are same as that of CNG.**

Uses

1. It provides uninterrupted supply.
2. It is used for cooking & heating appliances.

3.Liquefied Natural Gas (LNG)

It is liquefied natural gas that has been super cooled to **-162°C.** At this temperature natural gas condenses into liquid.

Use

1. In liquid form, natural gas takes up to **600 times less space** than its gaseous state due to which it is easier to transport.

4.Liquefied Petroleum Gas (LPG)

Composition

It consists of mainly **n-Butane (C_4H_{10})** with small amount of propane (C_3H_8) and propene (C_3H_6)

Properties

1. It is compressed under pressure as liquid and is stored in iron cylinders.

2. Its calorific value is about 27,800 Kcal/m^3.

3. For **strong smelling** a substance called **ethyl mercaptan (C_2H_5SH)** is added to LPG gas.

Use

It is used domestic and industrial fuel.

Scope of Hydrogen as future fuel

Hydrogen is a clean, versatile and abundant energy carrier that can help tackle energy challenges of industries and transport. It can replace fossil fuels across the world as it is more powerful and energy efficient and has almost zero emissions. Today, hydrogen fuel can be produced through several methods. The most common method is natural gas reforming (thermal process). In this method the steam reacts with hydrocarbon fuel to produce hydrogen. The other method of production of hydrogen is electrolysis, however this method is an expensive one. Much work is in process to initiate a shift from fossil fuel economy to hydrogen fuel economy. There is a possibility that hydrogen will be the fuel of the future and also accomplish the goal of being emission free.

Applications

1. **Transportation:**
   Fuel cells power can electric vehicals, heavy trucks, buses, and train
2. **Energy Storage :**
   Acts as a long duration, large scale storage medium for renewable energy.
3. **Power & Heating :**
   Can be blended into existing natural gas networks for residential heating or used directly in turbines to generate electricity
4. **Industry and Manufacturing :**
   Currently used in oil refining and in steel industry.

Lubricants

The substances which are used to decrease the force of function between the moving parts of a machine in contact are called as **lubricant.**

The process of decreasing the force of friction between the moving parts of machine in contact is called **lubrication.**

Functions of a Lubricant

1. It reduces **the force of friction** between the sliding part.

2. It acts as **coolant.**

3. It reduces the maintenance and running cost of the machine.

4. It reduces the noise level during running of a machine.

5. It increases the efficiency of machine.

6. It act as a **corrosion preventer.**

Classification of Lubricants

Lubricants can be classified into three types depending upon the **physical state.**

1. Liquid Lubricants
2. Sami solid Lubricants
3. Solid Lubricants.

1. Liquid Lubricants or Lubricating oils:-

The lubricants which are in liquid state are called as Liquid lubricants. They are of following types:-

(i) **Mineral oils**

There are obtained from **fractional distillation** of petroleum at 400 ^{0}C. They are cheap and available easily. They contain impurity like wax e.g. diesel etc.

(ii) Vegetable oils

They are obtained from vegetables sources

a) **Olive oil**- Obtained from olive tree and is used for lubricating bearings.
b) **Palm oil**- Obtained from Palm tree and is used for lubrication of watches.
c) **Castor oil**- Obtained from seeds of castor and is used for lubrication of vehicles.

(iii) Animal oils

They are obtained from animal source

a) Neat foot **oil**- Obtained from skin, bones and feet of cattle .Used for lubrication of sewing machines, watches, clocks etc.

b) Whale Oil- Obtained from fish whale.Used for Lubrication of light machinery.

c) Lord Oil- Obtained from pigs. Used for lubrication of machine.

d) Blended Oil- It is a mixture of animal or vegetable oil with mineral oil. This mixing is used to reduce pour point, improve viscosity and to increase oiliness.

e) Synthetic Oil- These are the chemical compounds and is used in jet engines, rocket motors etc.eg Silicones, Polyglycols, esters.

2. Semi Solid Lubricant

There lubricants include grease and emulsions.

(i) Greases-

They are the mixtures of metallic soap with lubricating oil. These are used where the machine is working at low speed and under high pressure. They are of following types:-

a) Calcium based Greases They are obtained by mixing Calcium soap with petroleum oil. They are used for lubrication of water pumps.

b) Soda based Greases Obtained from mixing sodium soap with petroleum oil and is used for ball bearings.

c) Lithium based greases Obtained from mixing Lithium soap with petroleum oil and are suitable to use at high temperature.

d) Axle greases - Obtained by mixing metal hydroxide and fatty acid. They are used in tractors rollers etc.

(ii) Emulsion-

They are obtained by mixing two immiscible liquids in high speed machines.

3. Solid Lubricants

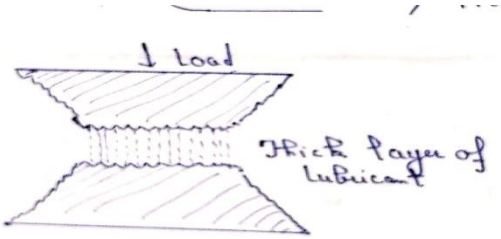
These lubricants are present in solid form. They are used in heavy machines working under high load and at low speed. They are used where oil and greases are undesirable. The two main solid lubricants are graphite and Molybdenum disulphide.

Mechanism of Lubrication

Lubrication makes the surface a smooth and reduces friction. Following are the mechanisms by which the process of lubrication can be explained.

1. **Hydrodynamic or fluid film or Thick film Lubrication**:-

This type of lubrication can be explained for those machines when the **speed is high and load is very low.** In this type of lubrication, the lubricant fill the irregularities of moving surface and form a thick layer in between them so that there is no direct contact between them. This reduced the wear and tear by reducing the frictional resistance.



This type of lubrication is provided in case of delicate instruments and light machines like watches, clocks, sewing machine and scientific instruments.

2. **Thin film or Boundary Lubrication**

This type of lubrication is done when a continuous film of lubricant cannot persists and direct metal to metal contact is possible. This happens when:-

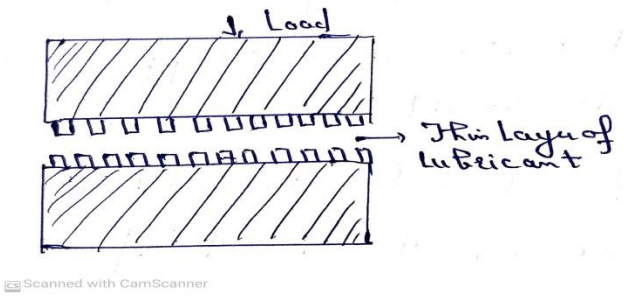
(i) A shaft starts moving from rest.

(ii) The speed is very low.

(iii) The load is very high.

(iv) Viscosity of lubricating oil is very low.

In the type of Lubrication, the lubricating oil is filled between the sliding surface is adsorbed on both metallic surface. The adsorbed layer avoids metal to metal contact. The load is carried out by the layers of adsorbed lubricant on both sides. The thickness of oil film is so small that the oiliness is restricted mainly to the boundaries of two surfaces.



Properties of Lubricants

1. Viscosity

It is defined as the property of a liquid by virtue of which it offers resistance to its own flow.

Machines moving at slow speed should use more viscous lubricant and machines with high speed should use less viscous lubricant. The viscosity of the liquid decreases with increase in temperature and vise a versa.

2. Viscosity Index

The rate of change of viscosity with temperature is known as viscosity index. Low viscosity index means viscosity of lubricant falls rapidly with temperature and high viscosity index means viscosity does not fall, rapidly with temperature. It is measured on the scale of 0 to 100.

It has no unit.

Significance- A good lubricant should have high viscosity index.

3. Flash and Fire points

Flash point

It is defined as the lowest temperature at which the lubricant ignites for a very short moment after vaporisation, but not continue to burn after ignition.

Significance- It tells us about the maximum temperature, a lubricant can form an ignitable mixture which will burn further on increasing temperature.

Fire point

It is that minimum temperature at which vapours of a lubricant continue to burn after being ignited even after the source of ignition is removed.

The fire point is always few degree higher than flash point.

Significance It gives an idea of risk fire hazards during storage and use of lubricant.

A good lubricant should have high flash and fire points at least above the temperature at which, it is to be used.

4. Pour point

When a lubricating oil is cooled slowly, the temperature at which oil ceases to flow or pour is called its pour point. The Lubricant used in a machine working at low temperature should possess low pour point, otherwise the lubricating oil will solidify and will cause jamming of machine.

5. Oiliness

The property of lubricant to form continuous film even at high temperature and pressure is called oiliness

OR

Oiliness can also be defined as the capacity of a lubricant to stick on the surface of a machine under high pressure and load.

Significance Oiliness of a lubricant reduces wear & tear and friction under different conditions. So, a lubricant should have proper oiliness required on the basis of its application.

6.Ignition temperature

Ignition temperature is the lowest temperature to which the fuel must be pre heated so that it starts burning smoothly.

A good fuel should have moderate ignition temperature.

Characterstics/ Qualities of a good lubricant

1. It should have **high viscosity index**
2. It should have **high boiling and low freezing point**
3. It should be **corrosion resistance**
4. It should be **thermally stable**
5. It should not have any **insoluble residue.**

CHEMISTRY

NOTES

(1/2 Semester)

Unit V

(Polymers and Electrochemistry)

UNIT-V

Polymers and Electrochemistry

Polymers and Plastic

Definition of Polymers

Polymer can be defined as a substance of high molecular mass formed by combination of large number of simple molecules. The simple molecule which combine to give polymer are called as monomers.

The process by which monomers are converted into polymers is called polymerisation e.g.

$$\underset{\text{ethene}}{\underset{\textbf{(Monomer)}}{n CH_2=CH_2}} \rightarrow \underset{\text{polyethene}}{\underset{\textbf{(Polymer)}}{(-CH_2-CH_2-)_n}}$$

Classification of Polymers

1. On the basis of type of Monomers

(i) **Homopolymers** These type of polymers are formed from one type of monomer **e.g. polythene.**

(ii) **Copolymers** A polymer formed from two or more different monomers **e.g. Nylon66.**

2. On the basis of origin

(i) Natural polymers There are obtained from nature **e.g. starch, cellulose etc.**

(ii) Synthetic polymers There are prepared in the laboratory **e.g. polythene.**

3. Classification based on molecular forces

(i) Elastomer: Polymers in which the intermolecular forces of attraction between polymer chains are the weakest are called elastomers e.g**Natural rubber.**

(ii) Fibres: Polymers in which the intermolecular force of attraction between the polymers chains are strongest are called fibres e.g. **Nylon 66.**

(iii) Thermoplastic: Polymers in which the intermolecular forces of attraction are in between those of elastomers and fibres are called thermoplastic e.g. **PVC etc.**

(iv) Thermosetting plastic:- These are normally semi-fluid substance with low molecular masses. When heated, they become soft and on further heating, they undergo chemical change and acquire three dimensional cross linked structure with strong covalent bond and set hard permanently eg **Bakelite**

4. Clasification on the basis of synthesis

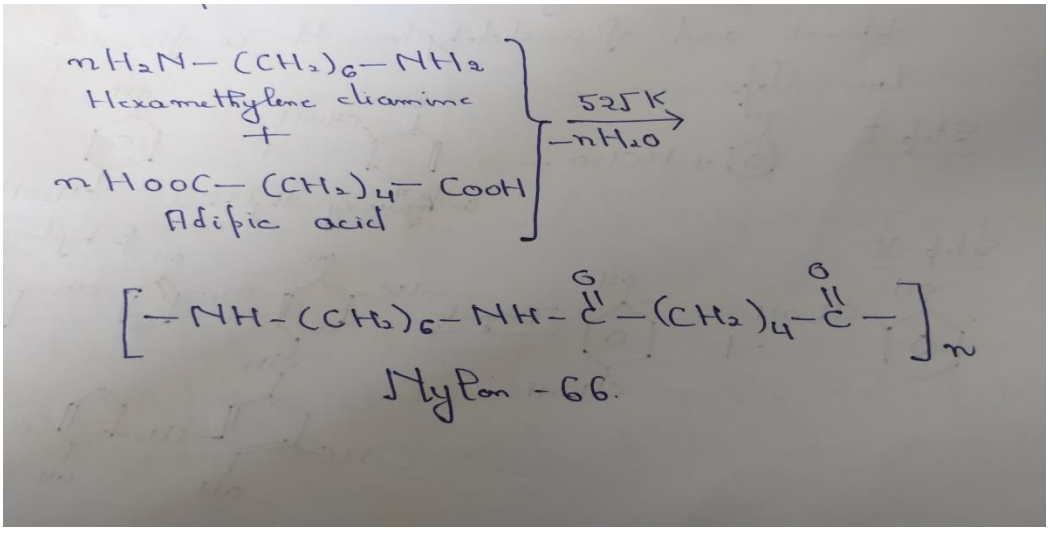
(1) **Addition polymer**

It is the process in which the molecules of the same or different monomers simply add on one another leading to the formation of a macromolecule without elimination of simple molecule e.g. ethene polymerises to give polythene.

$$\underset{\text{ethene}}{\underset{\textbf{(Monomer)}}{n\mathbf{CH_2{=}CH_2}}} \rightarrow \underset{\text{polyethene}}{\underset{\textbf{(Polymer)}}{\mathbf{(\text{-}CH_2\text{-}CH_2\text{-})_n}}}$$

(ii) Condensation polymer-

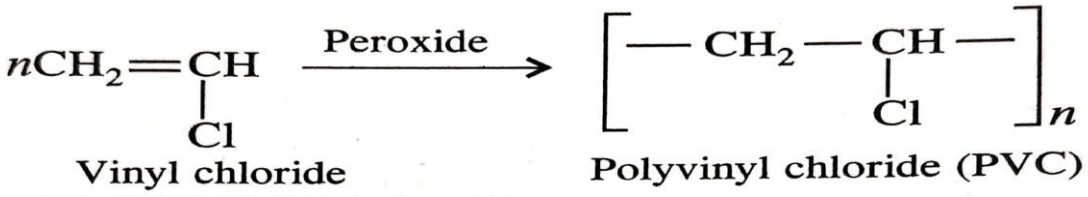
It is the process in which a large number of monomer molecules combine together with elimination of simple molecule like water, alcohol etc. to form a macromolecule e.g. Nylon 66 is obtained by the condensation polymerisation of **hexamethylene diamine** and **adipic acid.**



Some important Polymers

1. Polyvinyl chloride (PVC)

It is prepared by polymerisation of **vinyl chloride** in presence of peroxide.

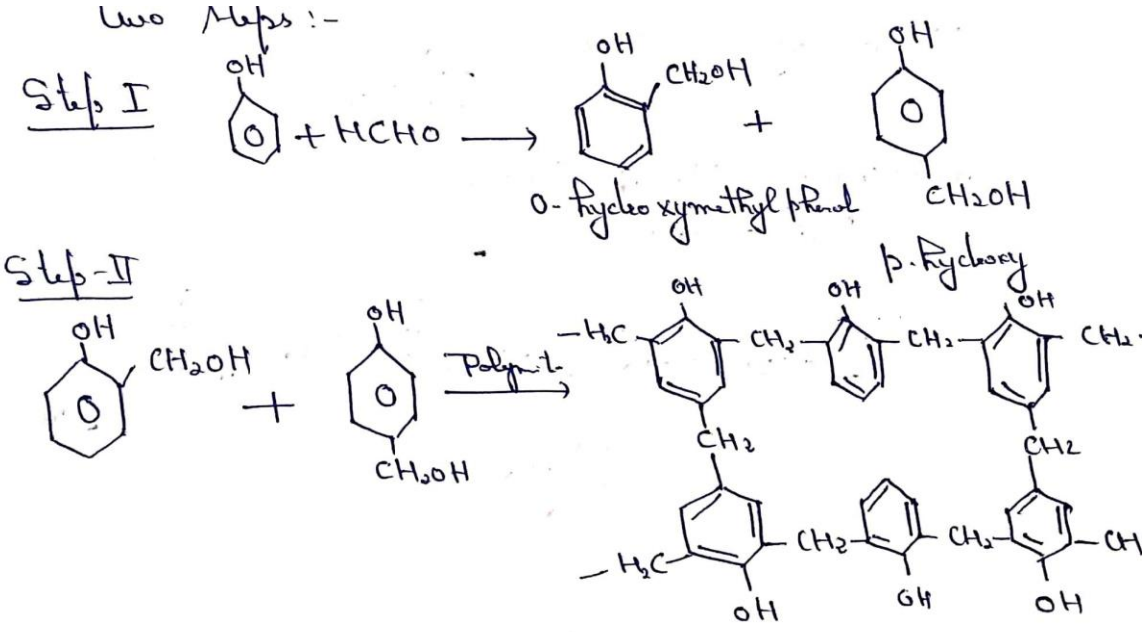


It is hard rubber like material. It is used for coating wires and other electrical goods.

2. Bakelite

It is an **example of condensation** polymers.

It is formed by the combination of phenol and formaldehyde. It is formed in two steps :-



Natural Rubber

It is a polymer of **isoprene (2 methyl-1,3butadione).**

It is obtained from the saps of trees like **Guayule**. A cut is made on the back of these trees and the sap called latex flows out. It in dilute with water and acetic acid is added to coagulate natural rubber. To increase the durability of rubber, the natural rubbers are heated by mixing it with S, this process is called vulcanisation of rubber.

$$\underset{\text{(Isoprene)}}{nCH_2=C(CH_3)-CH=CH_2} \rightarrow \underset{\text{(Polyisoprene)}}{(-CH_2-C(CH_3)=CH-CH_2-)n}$$

Neoprene Rubber (or GR-M)

It is prepared by polymerisation of chloroprene i.e. **chlorinated butadiene**.

$$\underset{\text{(Chloroprene)}}{nCH_2=C(Cl)-CH=CH_2} \rightarrow \underset{\text{(neoprene)}}{(-CH_2-C(Cl)=CH-CH_2-)n}$$

Property and Uses:-

It is soluble in polar solvent and is not attacked by alkalies. It is used in making laptop sleeves, orthopadic braces, electrical insulation and automobile fan belts.

Examples of Other synthetic rubbers

1) Nitrile rubber.
2) Butyl rubber.
3) Polyisoprene.
4) Silicon rubber.

Corrosion

Definition

Corrosion is defined as gradual destruction of metals by chemical reaction with their surroundings i.e. environment e.g. Rusting of iron

Types

1. **Dry Corrosion**
   Dry or Chemical Corrosion occurs mainly through the direct chemical action of environmental gases such as oxygen, halogens etc. directly in contact with the surface of a metal under consideration.
2. **Wet Corrosion**
   It takes place mostly under wet or moist conditions through the formation of short circulated galvanic cells. Wet corrosion is more common than dry corrosion.

Factors affecting the rate of corrosion

1. Nature of the metals

The metal undergo corrosion is dependent on the nature of the metals. Lesser is the percentage purity of a metal, faster is the rate of corrosion. Further larger the grain size of the metal or alloy, smaller will be its solubility and hence lesser will be its corrosion rate. The rate of corrosion also depends upon the position of the metal in the galvanic series. When the metal is higher up in the galvanic series, greater is the tendency to become anodic and hence greater is the rate of corrosion.

2. Nature of Corrosion Product

If the nature of corrosion products is insoluble, stable, non-volatile and non porous then it acts as protective films which prevents further corrosion. On the other hand if the nature of corrosion product is soluble, unstable and porous , then the corrosion process continue even after the formation of corrosion products.

3. pH of the medium

In general rate of corrosion is higher in acidic pH than in neutral and alkaline pH In case of iron, at very high pH protective coatings of iron oxide is formed which prevents corrosion.

4. Temperature

Rate of corrosion increases with increase in temperature. This is due to the increased conductance of the medium.

5. Humidity

The rate of corrosion will be more when the relative humidity of the environment is high.

6. Presences of impurities in atmosphere

Usually the corrosion of metals is more in industrial areas and sea due to the fact that corrosive gases like CO_2,H_2S and NaCl of the sea water leads to increased electrical conductivity of the liquid layer in contact with metal surface.

Prevention of Corrosion

The corrosion can be prevented by any of the following methods

1. Hot dipping
2. Metal Cladding
3. Cementation
4. Quanching
5. Cathodic protection methods.

1. Hot dipping method

In this method, the metal to be coated is dipped in the molten bath of coating molten metals for sufficient time and then removed out. This method is used for applying coating of low melting metals like zinc, tin, lead etc. over the metals with the higher melting point. The process of providing a zinc coating on iron or steel article to prevent rusting is called galvanizing and the one providing tin coating is called tinning.

2. Metal cladding

In the process a layer of coating metal is bonded firmly to the base metal on one or both sides permanently, when they are passed through heavy rollers under the action of heat and pressure. Nearly all corrosion resistant metals like Al, Zn, Cu etc. can be used ad cladding material.

3. Cementation

It in basically a diffusion process. In this method, the base metal is heated after packing it in powder of coating metal in a box. On heating , coating metal powder gets

diffused into the base metal, resulting into the formation of layers of alloys at the surface of base metal.

4. Quenching

Heat treatment of metals and alloys is done to them to enhance their machinability, reduce internal stress or improve their mechanical properties. Heating the metal to a temperature above critical ranges, holding for sufficient time at that temperature followed by cooling in a suitable medium such as water or oil, resulting metal becomes extremely hard and brittle. This process is called quenching or hardening.

5. Catholic protection

It is a method in which the base metal to be protected from corrosion is made to act as cathode by attaching more active anodic metals to it. The active anodic metal undergoes corrosion and base metal is protected from corrosion. The following methods are used to protect metal from corrosion.

a) Sacrificial anode cathodic protection

b) Impressed current cathodic protection

a) Sacrificial anode Cathodic Protection

In the method, metallic material to be protected is connected to a more active metal. Anodic metals like Zn or Mg can be employed to protect iron articles. When an anodic metal is in contact with iron specimen, a galvanic cell is set up, where anodic metal becomes anodic area and whole iron article becomes cathodic area. Anodic metal undergoes oxidation and hence provides electron to the specimen. The entire specimen becomes cathodic and thus protected from corrosion. In this process, anodic metal undergoes corrosion and sacrifies itself to protect metal. Sacrificial anodes have to be replaced in due course of time.

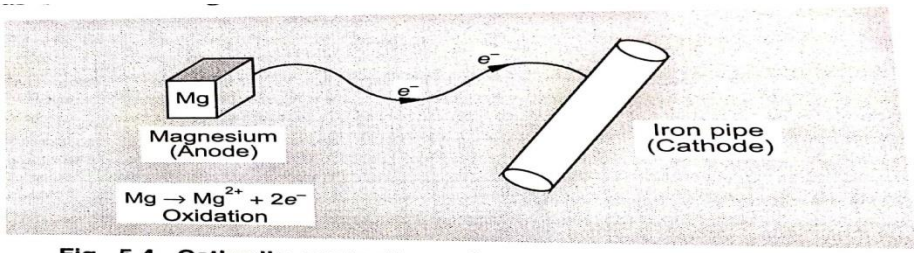
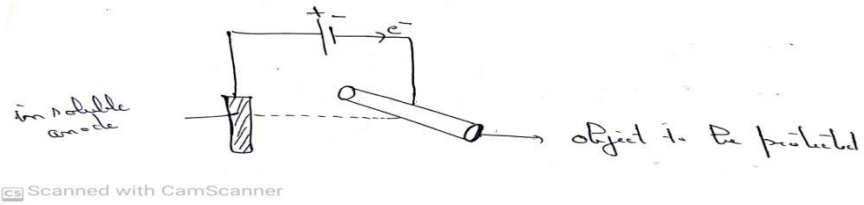


Fig. 5.4. Cathodic protection of underground iron pipes

b) Impressed current cathodic protection

In this method, the electrons are supplied from a source of direct current (DC) in opposite direction to nullify the correction current. Metal structure to be protected is connected to inert anode like Graphite to complete the circuit. Potential Grater than potential of anodic reaction is applied in reverse direction to prevent anodic reaction. Thus the whole metal becomes cathodic and hence protected from corrosion



Nanotechnology

Introduction

Nano means dwarf or something very small i.e. in range of 10^{-9} m. The material may exhibit unusual properties at nano level e.g. Gold can appear dark red or purple. Nanotechnology can increase the surface area of a material due to which materials can be stronger, more durable and conductive than their larger scale counterparts.

Definition

It is the branch of science and engineering related to designing, producing and using structures, devices and systems by manuplating atoms and molecules at nano scales.

Nanomaterials

There are the materials at the nano scale where properties such as conductivity, colour and mechanical hardness change due to their Nano scale dimensions.

Classification

The nanomaterial can be classified into four types:-

1. Carbon (inorganic) based material
2. Metal based material

3. Organic based material
4. Composities

1. Carbon Based material

These materials are compared mostly of carbon. There particles have many potential applications in improved films and coatings.

2. Metal based material

These include nanogold, nanosilver etc.

3. Organic based material

There are nanosized polymers built from branched units. This property can also be used for catalysis.

4. Composites

Composites combine nanoparticles with other nanoparticles or with larger, bulk type materials.

Application of nanotechnology in various Engineering Fields

1. Nanotechnology can help to improve the strength and durability of construction material including cement, steel, wood and glass.
2. Nano electronics refers to the application of nanotechnology on electronic components. It aims to improve the performance of electronic devices on displays and power consumption while shrinking them.
3. The energy application of nano technology relates to using the small size of nanoparticles to store more energy efficiently.
4. Nanotechnology is enabling the use of hydrogen energy at a much higher capacity.
5. It is giving rise to nanographene batteries that can store energy more efficiently and are light weight.
6. Nanoparticles are used in solar cells are increasing the amount of energy absorbed from sunlight.