Lecture note

On

ENGINEERING CHEMISTRY (Th-2.b)

1st and 2nd Semester (Diploma Course)

(As per the syllabus prepared by the SCTE&VT,
Bhubaneswar, Odisha)

IDEAL SCHOOL OF ENGINEERING
Retang, Bhubaneswar

ENGINEERING CHEMISTRY

CHAPTER-WISE DISTRIBUTION OF PERIODS & MARKS

Sl. No.	Name of Topics/Unit (as per Syllabus)	Sl.No. & Name of Chapter	No. of Periods Alloted	Expected Marks
A	Physical Chemistry	1. Atomic Structure	08	40
		2. Chemical Bonding	03	
		3. Acid and Base Theory	04	
		4. Solution	05	
		5. Electrochemistry	06	
		6. Corrosion	02	
B	Inorganic Chemistry	**7. Metallurgy**	05	20
		8. Alloys	02	
C	Organic Chemistry	**9. Organic Chemistry**	05	15
D	Industrial Chemistry	**10. Water Treatment**	04	25
		11. Lubricants	01	
		12. Fuel	04	
		13. Polymer	03	
		14.Chemicals in Agriculture	03	
Total			**55**	**100**

CHAPTER – 01

ATOMIC STRUCTURE

Learning Objectives:

- *Fundamental particles (electron, proton & neutron Definition,mass and charge).*
- *Rutherford's Atomic model (postulates and failure),*
- *Atomic mass and mass number,*
- *Definition, examples and properties of Isotopes, isobars and isotones.*
- *Bohr's Atomic model (Postulates only), Bohr-Bury scheme,*
- *Aufbau's principle, Hund's rule, Electronic configuration (up to atomic no 30)*

An atom has three sub- atomic / fundamental particles. They are -

i) Proton
ii) Neutron
iii) Electron

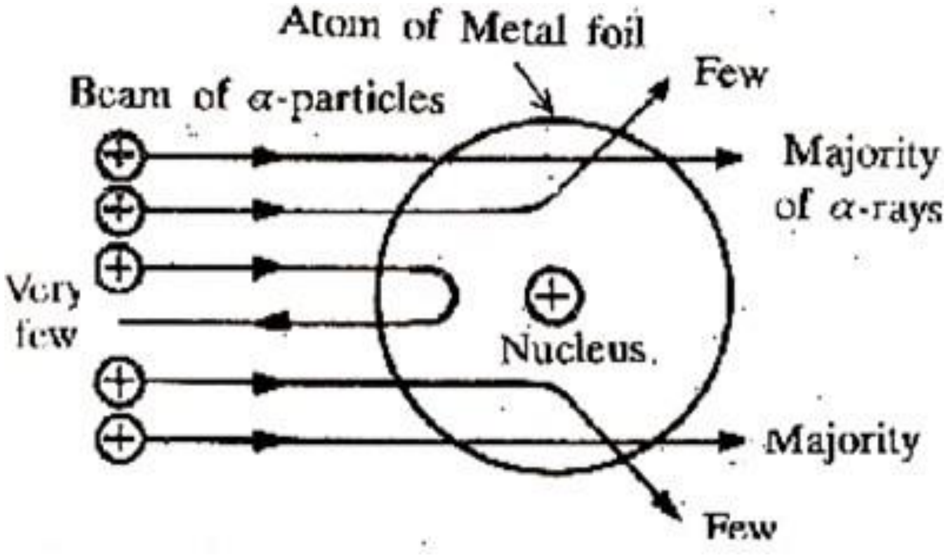
Name of Sub-atomic Particle	**Mass**	**Charge**
Proton	1.672×10^{-27} Kg	$+1.602 \times 10^{-19}$ coulombs
Neutron	1.675×10^{-27} Kg	0 coulombs
Electron	9.11×10^{-31} Kg	-1.602×10^{-19} coulombs

- In order to show the arrangement of sub-atomic particles in an atom, Rutherford performed **Gold foil Experiment**, on the basis of which he gave his Atomic Model.

Rutherford's Gold foil Experiment (Discovery of Nucleus)

- Rutherford bombarded a thin sheet of Gold foil (of thickness 0.00004cm) with α (alpha)- particles (α - particle = He^{++}).
- A circular screen coated with Zinc Sulphide (ZnS) was placed on the other side of the foil.

Figure-1



[POSITIVELY CHARGED NUCLEUS WITH EMPTY SPACE AROUND IT]

Observation

- It was observed that –

i) Most of the α - particles passed straight through the gold foil and caused illumination on the Zinc Sulphide (ZnS) screen.

ii) Very few particles were deflected at some angles after passing through the gold foil.

iii) A very few particles (one in 10,000) retraced their path.

Conclusion

- It was concluded that. -

i) Most of the space in an atom is empty.

ii) There is a heavy positive charge at the center of the atom i.e Nucleus which causes the repulsion.

- The conclusion of the Gold Foil experiment enabled Rutherford to give model of atom.

Rutherford's Atomic Model

1. An atom consists of two parts -
   i) Nucleus
   ii) Extra - Nuclear part.

2. Nucleus is an extremely small positively charged part which is situated at the centre of an atom.

3. The electrons which balance the positive charge are distributed in the extra nuclear part i.e space around the nucleus.

4. The extra - nuclear electrons are not stationary. These are revolving around the nucleus at high speeds in circular path called orbits.

- Rutherford's picture of an atom is comparable to solar system .The **Nucleus** representing the **sun** and the **revolving electrons** are called **planetary electrons**.

Drawbacks / Failure/ Limitation of Rutherford's atomic model

1) According to Rutherford's atomic model, the electrons are revolving around the nucleus. Clark Maxwell had shown that a charged particle which moves under the influence of an attractive force, continuously lose energy.

- Since electron is a charged particle, it must emit radiation and loss energy continuously while revolving round the nucleus. As electron loses energy, it starts coming nearer the nucleus i.e. its orbit becomes smaller and smaller and finally the electron would fall into the nucleus and the atom will be collapsed. Actually it is not happening. Thus, Rutherford's picture of an atom is faulty.

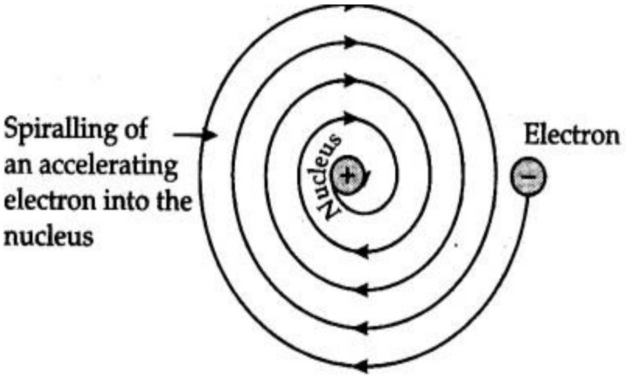


Fig. Spiralling of an accelerating electron

2) Rutherford’s atomic model could not explain the the Hydrogen Spectrum.

Atomic Number (Z)

- “The number of protons present in the nucleus of an atom, is known as its atomic number”.
- Atomic number is denoted by Z.

Atomic Mass (A)

- “The total number of protons and neutrons present in the nucleus of an atom is known as its atomic mass or mass number”.
- It is denoted by ‘A’.

Mathematically

Atomic Mass (A) = Number of proton (Z) + Number of Neutrons(n)

=> $A = Z + n$

=> $n = A - Z$

- Number of protons = Number of electron.

NOTE-1 (Assigning Atomic Number and Mass Number/Atomic Mass)

- If the symbol of an element is “X” then the atomic number (Z) and atomic mass (A) of the element is written as -

A← Atomic mass (superscript)

X

Atomic Number(subscript) → Z

Example

The symbol of sodium is ‘Na’.

Its atomic number is 11and atomic mass is 23.

The symbol, atomic number and atomic mass of sodium is written as –

$$_{11}^{23}\mathbf{Na}$$

Here-

Number of proton = 11

Number of electron = 11

Number of Neutron = 12

Isotope

- “ Isotopes are defined as the atoms of same element which have same atomic number but different mass number ”

Example- 1

- Let’s consider the isotopes of Hydrogen.

Isotopes of Hydrogen - $_1H^1$ (protium) , $_1H^2$ (Deuterium) , $_1H^3$ (Tritium)

Example- 2

- Let’s consider the isotopes of carbon.

$_6C^{12}$ $_6C^{13}$ $_6C^{14}$

- Isotopes are due to change in number of Neutrons.

Properties of Isotopes

i) Isotopes have same Physical and chemical properties.
ii) Isotopes have same number of protons.
iii) Isotopes have same position in the periodic table.
iv) Isotopes have different density & atomic volume.
v) Isotopes have different melting point and boiling point.

Isobars

- 'Isobars are the atoms of different elements having same mass number but different atomicnumbers.'

Example - 1

$_6C^{14}$ and $_7N^{14}$ are isobars

Example - 2

$_{18}Ar^{40}$ and $_{19}K^{40}$ are isobars

Properties of Isobars

i) Isobars have different physical and chemical properties.
ii) Isobars have different number of protons.
iii) Isobars have different position in the periodic table.
iv) Isobars have same density & atomic volume.
v) Isobars have same melting point and boiling point.

Isotones

- 'Atoms of the different element which possess same number of neutrons are called Isotones.'

Example - 1

$_6C^{13}$ and $_7N^{14}$ are called isotones.

Example - 2

$_{32}Ge^{76}$ and $_{33}As^{77}$ are called isotones.

Properties of Isotones

i) Isotones have different physical properties.

ii) Isotones have different chemical properties.

iii) Isotones have different density atomic volume.

iv) Isotones have different melting point and boiling point.

v) Isotones have different position in the periodic table.

BOHR'S ATOMIC MODEL

- In 1913 Niels Bohr, proposed an atomic model with the help of Plank's quantum theory.
- Bohr's atomic model explained the failure of Rutherford's atomic model.

- The main **postulates** of Bohr's theory are –
  1. An atom consists of a massive positively charged nucleus. The electrons are moving around the nucleus in certain fixed circular orbits without radiating energy. These non-radiating orbits are known as **stationary states**.

2. Each of the fixed circular orbits is associated with a definite amount of energy. Hence

stationary states are also called energy levels.

- The energy associated with different Energy levels increases with increase in distance from the nucleus.
- The letters K, L, M, N etc. or the

numbers 1, 2, 3, 4 etc. starting from nucleus

are used to designate the energy levels.

[Permitted orbits or energy levels]

So, the greater the shell, the greater energy. the greater the shell, the greater energy.

- The energy of the shells is given by -

$$\mathbf{E_n = -1312/n^2\ KJ\ mol^{-1}}$$

$$\textbf{or, } \mathbf{E_n = -313.6/n^2\ Kcal\ mol^{-1}}$$

where, n = No. of orbits
and, n = 1, 2 , 3 , 4 , …..

3. Only those orbits are permitted in which the angular momentum (mvr) of an electron is a whole number multiple of h/2π .

<u>Mathematically</u>

$$mvr = n \times h/2\pi$$

where, m → Mass of Electron
v → Velocity of Electron
r → Radius of Orbits
h → Planck’s Constant
and n → 1, 2 , 3 , 4 , ...

4. When an electron absorbs quantised energy , it jumps to higher energy level and vice versa.

BOHR-BURY SCHEME

- In 1921 Bohr and Bury gave the following rules for the distribution of electrons in different orbits.

1.The maximum number of electrons that can be present in an orbit is equal to $\mathbf{2n^2}$

where ‘n’ is the number of the orbits.

Value of ‘n’	**Name of shell**	**Maximum no. of electrons ($2n^2$)**
1	K	$2 \times (1)^2 = 2$
2	L	$2 \times (2)^2 = 8$
3	M	$2 \times (3)^2 = 18$

4	N	$2 \times (4)^2 = 32$

2. The outer most orbit of an element cannot contain more than 8 electrons and the orbit immediately before it i.e. penultimate orbit cannot contain more than 18 electrons.

3. It is not always necessary to complete an orbit before the next orbit starts filling. In fact, a new orbit starts filling when the previous orbit gets electrons.

NOTE -2 (Shell & Sub-Shell)

Value of ‘n’	1	2	3	4
Name of Shell	K	L	M	N
Value of ‘l’	0	1	2	3
Name of Sub-shell	s	p	d	f

NOTE – 3 (Sub-shell)

Value of “l “	***Name of Subshell***	***Maximum Electron***
0	s	2
1	p	6
2	d	10
3	f	14

NOTE-4 (Writing of Sub-Shell)

- The sub- shell electronic configuration is written as → nl^x
  Where, ‘ n’ is the digit. (1, 2, 3, …)

  ‘l’ is the letter (s, p, d, f)

  ‘x’ is number of electrons
- The value of ‘l’ depends on the value of ‘n’.

Example- 1

When n=1, then l=0

n=1

l=0 1s

Example-2

When n=2, then l=0,1

n= 2

l= 0 2s

n = 2

l = 1 2p

Example-3

When n = 3, then l = 0, 1, 2

n = 3
l = 0 3s
n = 3
l = 1 3p
n = 3
l = 2 3d

Note – 5 (Orbitals)

- The subshells are divided into **orbitals** except s- subshells which is not further sub -divided.
- An orbital contains maximum **two** electrons.

Note-6 (Number of Orbitals)

- The **orbitals** are assigned by **'m'** .

m = 2l + 1

and m = (-l,…….,0,…..,+l) values

Example-1

For l = 0 (**s- subshell**) , m = 2x 0 +1 = 1 i.e one value i.e '0'

- **s- subshell** is not further sub-divided.

Example-2

For l = 1 (**p- sub-shell**) , m = 2x 1+1 = 3 i.e three values i.e -1, 0 , +1

- **p- subshell** is sub-divided into three orbitals i.e p_x , p_y , p_z

Example-3

For l = 2 (**d- sub-shell**) , m = 2x 2+1 = 5 i.e Five values i.e -2, -1, 0 , +1,+2

- **d- subshell** is sub-divided into three orbitals i.e d_{xy} , d_{yz} , d_{zx} , $d_{x^2-y^2}$, d_{z^2}

Note-7

- Maximum Number of electrons in a Shell = **$2n^2$**
- Maximum Number of electrons in an Orbital = **2**
- Maximum Number of Orbitals in a Shell = **n^2**

Aufbau Principle

The term "**Aufbau**" is a German word which means'' **Build up**".

Statement

- **"The electrons are filled in various orbitals in order of their increasing energies."**
- An orbital with lowest energy will be filled first".
- The energy contained of two sub shells can be compared by (n+l) as explained below-

i) *The sub-shell with lower (n+l) value will posses lower energy and will be filled first.*

Example

Let us consider 4s and 3d subshell.

a) For 4s subshell : n+l = 4 + 0 = 4

b) For 3d subshell : n + l= 3 + 2 = 5

- Since (n+l) value for 4s subshell is less than 3d, the 4s subshell has lower energy and will be filled first.

So, 4s < 3d

ii) *The subshell with lower value of n possesses lower energy if (n+l) value for both the subshells are equal.*

Example

Let us consider 3p and 4s subshell

a) For 3p subshell : n + l = 3 + 1 = 4

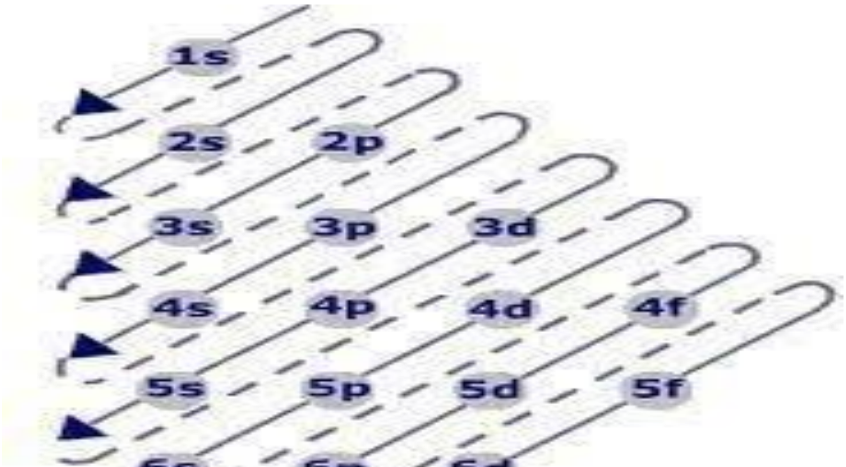
b)For 4s subshell : n + l = 4 + 0 = 4

- The value n=3 is less for 3p subshell as compared to the value n=4 for 4s subshell. Hence 3p subshell has lower energy than 4s subshell and will be filled first.

So, 3p < 4s

Calculation of Energy in various subshell

- The increasing order of various subshell is as follows -



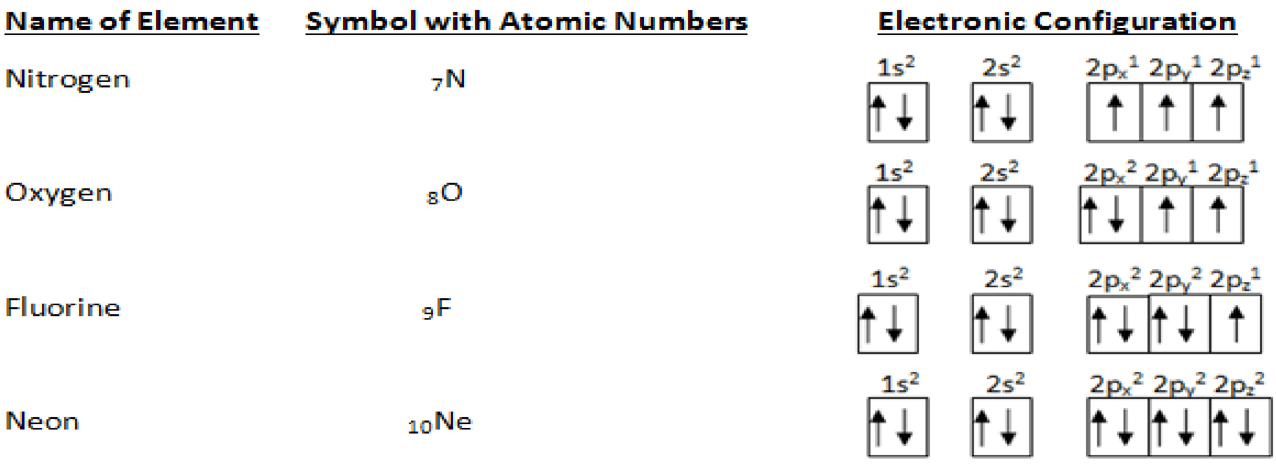
1s<2s<2p<3s<3p<4s<3d<4p<5s<4d<5p<6s<4f<5d<6p<7s<5f<6d<7p<8s

Hund's Rule

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

OR

- **"Orbitals of same sub shell first get single filled, then pairing occurs."**
- Applying Hund's rule, the electronic configuration of few elements are given below -



Name of Element	Symbol with Atomic Numbers	Electronic Configuration
Nitrogen	$_7N$	$1s^2$ ↑↓ $2s^2$ ↑↓ $2p_x^1$ ↑ $2p_y^1$ ↑ $2p_z^1$ ↑
Oxygen	$_8O$	$1s^2$ ↑↓ $2s^2$ ↑↓ $2p_x^2$ ↑↓ $2p_y^1$ ↑ $2p_z^1$ ↑
Fluorine	$_9F$	$1s^2$ ↑↓ $2s^2$ ↑↓ $2p_x^2$ ↑↓ $2p_y^2$ ↑↓ $2p_z^1$ ↑
Neon	$_{10}Ne$	$1s^2$ ↑↓ $2s^2$ ↑↓ $2p_x^2$ ↑↓ $2p_y^2$ ↑↓ $2p_z^2$ ↑↓

Electronic configuration of Elements from At.No 1 to 30

Name of Element	**Symbol with Atomic Number & Atomic Mass (Mass Number)**	**Electronic Configuration**
Hydrogen	$_1H^1$	$_1H = 1s^1$
Helium	$_2He^4$	$_2He = 1s^2$
Lithium	$_3Li^7$	$_3Li = 1s^2\ 2s^1$
Berylium	$_4Be^9$	$_4Be = 1s^2\ 2s^2$
Boron	$_5B^{11}$	$_5B = 1s^2\ 2s^2\ 2p^1$
Carbon	$_6C^{12}$	$_6C = 1s^2\ 2s^2\ 2p^2$
Nitrogen	$_7N^{14}$	$_7N = 1s^2\ 2s^2\ 2p^3$
Oxygen	$_8O^{16}$	$_8O = 1s^2\ 2s^2\ 2p^4$
Fluorine	$_9F^{19}$	$_9F = 1s^2\ 2s^2\ 2p^5$
Neon	$_{10}Ne^{20}$	$_{10}Ne = 1s^2\ 2s^2\ 2p^6$

Sodium	$_{11}Na^{23}$	$_{11}Na = 1s^2\ 2s^2\ 2p^6\ 3s^1$
Magnesium	$_{12}Mg^{24}$	$_{12}Mg = 1s^2\ 2s^2\ 2p^6\ 3s^2$
Aluminium	$_{13}Al^{27}$	$_{13}Al = 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$
Silicon	$_{14}Si^{28}$	$_{14}Si = 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^2$
Phosphorus	$_{15}P^{31}$	$_{15}P = 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^3$
Sulphur	$_{16}S^{32}$	$_{16}S = 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^4$
Chlorine	$_{17}Cl^{35.5}$	$_{17}Cl = 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$
Argon	$_{18}Ar^{36}$	$_{18}Ar = 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$
Potassium	$_{19}K^{39}$	$_{19}K = 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1$
Calcium	$_{20}Ca^{40}$	$_{20}Ca = 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2$
Scandium	$_{21}Sc^{45}$	$_{21}Sc = 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^1$
Titanium	$_{22}Ti^{48}$	$_{22}Ti = 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^2$
Vanadium	$_{23}V^{51}$	$_{23}V = 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2 3d^3$
* Chromium	$_{24}Cr^{52}$	$_{24}Cr = 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1\ 3d^5$
Manganese	$_{25}Mn^{55}$	$_{25}Mn = 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^5$
Iron	$_{26}Fe^{56}$	$_{26}Fe = 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^6$
Cobalt	$_{27}Co^{59}$	$_{27}Co = 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^7$
Nickel	$_{28}Ni^{59}$	$_{28}Ni = 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^8$
* Copper	$_{29}Cu^{63.5}$	$_{29}Cu = 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1\ 3d^{10}$
Zinc	$_{30}Zn^{65}$	$_{30}Zn = 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}$

Note

***** The element with fully filled electronic configuration in p, d, f, sub- shells i.e.p^6, d^{10} & f^{14} are stable.

* The element with exactly half filled electronic configuration p, d, f, sub-shells i.e. p^3 , d^5 , & f^7 are stable.

SHORT QUESTIONS WITH ANSWERS

1) Write the charge and mass of sub atomic particles. [W-10, 19]

- **Ans: -**An atom has three sub- atomic / fundamental particles. They are -
  i) Proton
  ii) Neutron
  iii) Electron

Name of Sub-atomic Particle	Mass	Charge
Proton	1. 672 x 10^{-27} Kg	+1.602 x 10^{-19} coulombs
Neutron	1. 675 x 10^{-27} Kg	0 coulombs
Electron	9. 11 x 10^{-31} Kg	-1.602 x 10^{-19} coulombs

2) What is isotope ? Give an example. [S- 19/ W-19]

Ans: - "Isotopes are defined as the atoms of same element which have same atomic number but different mass number"

Example

Let's consider the isotopes of carbon.

$_6C^{12}$ $_6C^{13}$ $_6C^{14}$

3. What is isotone? Give an example. [S-18,19]

Ans: - ''Atoms of the different element which possess same number of neutrons are called Isotones.''

Example

$_6C^{13}$ and $_7N^{14}$ are called isotones.

4. What is isobar? Give an example. [W-18]

- **Ans: -** ''Isobars are the atoms of different elements having same mass number but different atomic numbers.''

Ex ample

$_6C^{14}$ and $_7N^{14}$ are isobars.

5. Define atomic number.

Ans: - The number of protons present in the nucleus of an atom, is known as its atomic number.

- Atomic number is denoted by Z.

6. Define atomic mass.

Ans: - "The total number of protons and neutrons present in the nucleus of an atom is known as its atomic mass or mass number".

- It is denoted by 'A'.

7. What do you mean by alpha(α) particle?

Ans: - Alpha(α) particle means He^{++} ion.

8. State Aufbau Principle. [W-18, S-19]

ANS: - The term Aufbau is a German Word which means'' Build up".

The electrons are filled in various orbitals in order of their increasing energies.

9. What is Hund's Rule? [W-19]

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

10) Write the electronic configuration of Chromium and Copper. [W-09, 17, 18, 20]

Ans- $_{24}Cr = 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1\ 3d^5$

$^{29}Cu = 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1\ 3d^{10}$

11) Write the Maximum Number of electrons present in different Subshells.

Ans-

Name of Subshell	Maximum Number of Electrons
s	2
p	6
d	10
f	14

LONG QUESTIONS

1) Discuss Rutherford's atomic model. [W-17, S-19]

2) What are the drawbacks of Rutherford's atomic model? [S/W-18]

3) Explain Bohr's atomic model. [W-18]

4) Write down a short note on – [W-18, 19]

   I. Isotope
   II. Isobar
   III. Isotone

5) Describe Bohr-Bury scheme of atom. [W-09, S-19]

6) Explain briefly Aufbau principle. [W-17]

7) Explain Hund’s rule giving at least two examples. [S-18]

CHAPTER-2

CHEMICAL BONDING

Definition

- **“Chemical bond is defined as a force of attraction which holds together constituent atoms in a molecule .”**

Types of Chemical Bond

1) Ionic Bond (Electro-valent Bond)
2) Covalent Bond
3) Co-ordinate Bond (Dative Bond)

Ionic Bond

- **“The chemical bond which is formed by the transference of one or more electrons from one atom to the other , is called Ionic bond .”**

Example -1

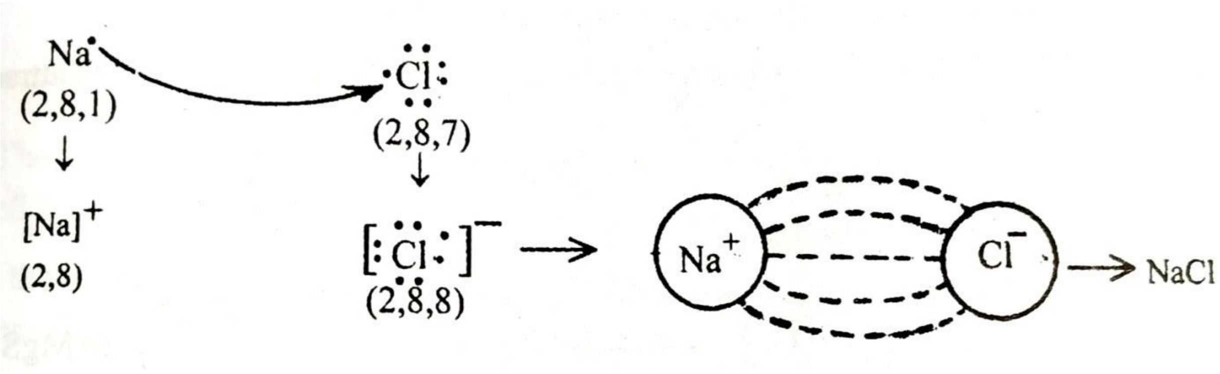
Let us consider the formation of NaCl molecule .

- In sodium Chloride (NaCl) , we have –

Sodium	**Chlorine**
Symbol = Na	Symbol = Cl
Atomic number =11	Atomic number = 17
No. of proton =11	No. of proton = 17
No. of electron =11	No. of Electron =17
Electronic Configuration = 2, 8 ,1	Electronic Configuration = 2,8, 7
$=1s^2\ 2s^2\ 2p^6\ 3s^1$	$=1s^2\ 2s^2\ 2p^6\ 3s^1 3p^5$

- There is one electron in the valence shell of sodium atom and seven electrons in the valence shell of chlorine atom .
- In order to maintain octet , Na-atom transfers its one valence electron to Cl- atom , Na - atom becomes Na^+ ion and Cl-atom becomes Cl^- ion.

- Theformation of Sodium Chloride is depicted as follows –



$$Na^+ + Cl^- \xrightarrow{\text{Electro -Static Force of attraction}} NaCl$$

- Finally the positively charged (Na^+) and negatively charged (Cl^-) ions get attracted by electro-static force of attraction and NaCl is formed .

Example-2

Let us consider the formation of $MgCl_2$ molecule.

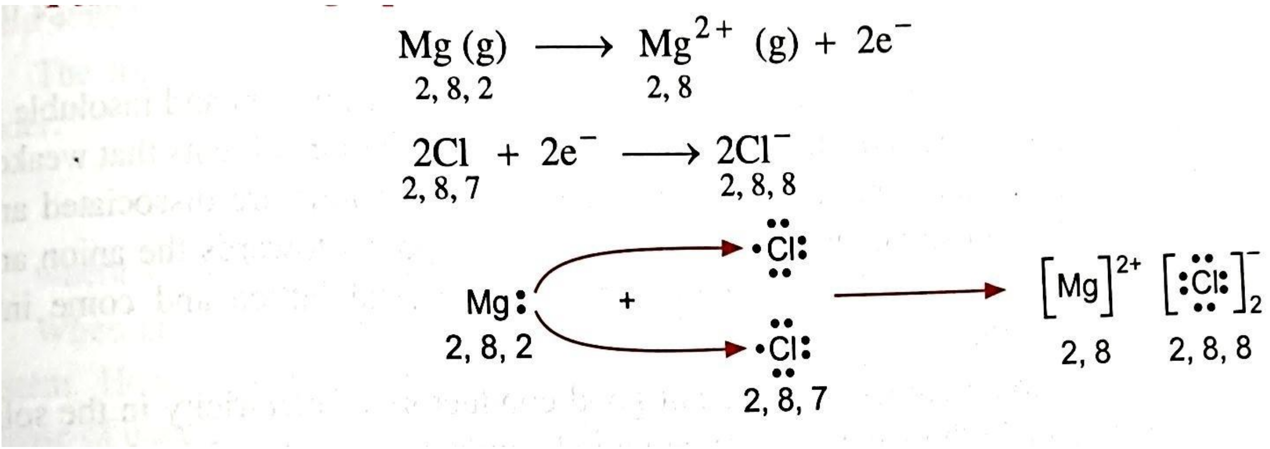
Magnesium	**Chlorine**
Symbol = Mg	Symbol = Cl
Atomic No = 12	Atomic No = 17
No. of proton = 12	No of protons = 17
No of electrons = 12	No of electron = 17
➢ Electronic Configuration = 2, 8 ,1 $=1s^2\ 2s^2\ 2p^6\ 3s^2$	Electronic Configuration = 2,8, 7 $=1s^2\ 2s^2\ 2p^6\ 3s^2 3p^5$

- There are two valence electrons in Mg- atom and seven valence electrons in Cl-atom.

  Mg-atom transfers its two valence electrons to two Cl-atoms.

- The Mg-atom becomes Mg^{2+} ion and two Cl-atoms becomes two Cl^- ions which are get attracted by electro-static force of attraction and $MgCl_2$ is formed.

- The formation of $MgCl_2$ is depicted below –



Covalent Bond

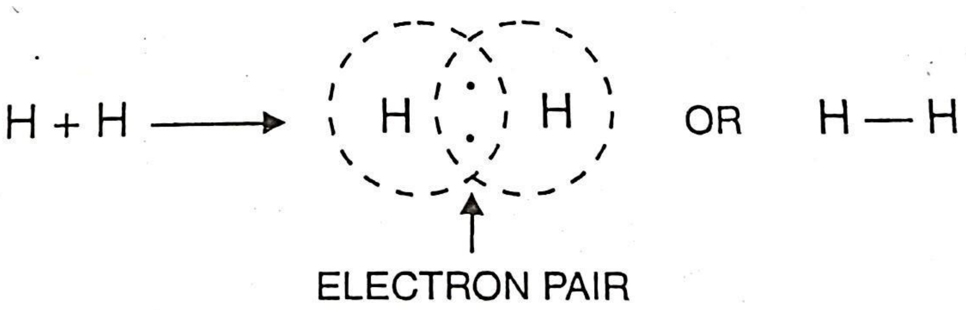
- "Covalent bond is defined as a force of attraction which arises by the mutual sharing of electrons between the participating atoms".
- The participating atoms have equal right on the shared of pair of electrons.
- The covalent bond is denoted by '-' sign.

Example-1

Let us consider the formation of hydrogen molecule (H_2).

$_1H = 1s^1$

- Two H-atoms share one electron each to form one convalent bond and get stable Helium atom configuration .



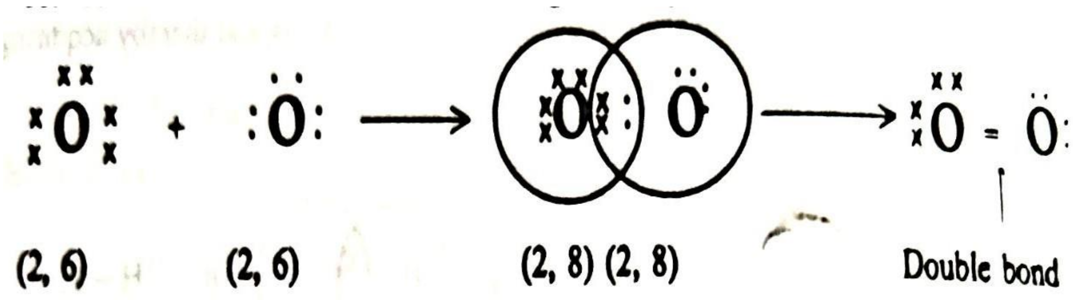
Example-2

Let us consider the formation of oxygen molecule (O_2) .

$_8O$ = 2 , 6

= $1s^2, 2s^2, 2p^4$

- Two O- atoms share two electron each to form two covalent bonds and get stable electronic configuration of Neon - atom .



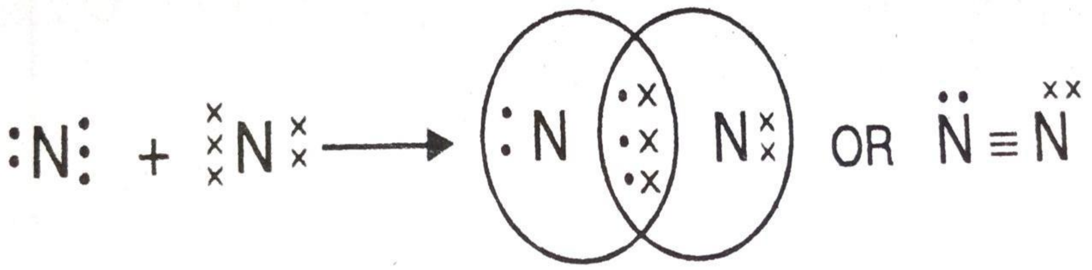
Example-3

Let us consider the formation of Nitrogen Molecule (N_2) .

$_7N$ = 2 , 5

= $1s^2, 2s^3, 2p^3$

- Two N- atoms share 3 electrons each to form three co-valent bonds and both bonded two N-atoms get the stable electronic configuration of Neon-atom .



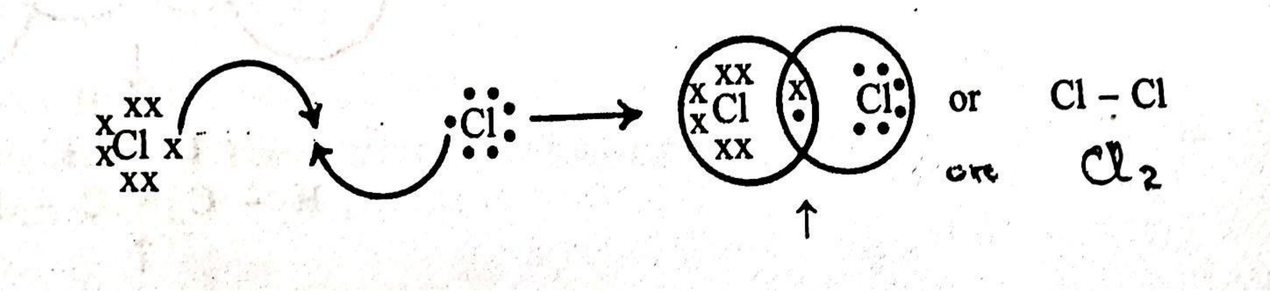
Example-4

Let us consider the formation of Chlorine molecule (Cl_2) .

$_{17}$Cl = 2 , 8 , 7

= $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$

- Two Cl- atoms share one electron each to form one co- valent bond and each Cl-atom get the stable electronic configuration of Argon – atom .



Example-5

Let us consider the formation of water molecule (H_2O) .

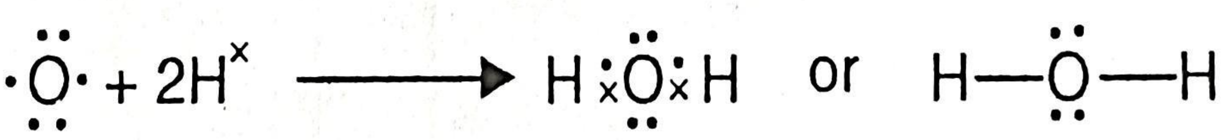
$_1$H = 1

= $1s^1$

^{8}O = 2 , 6

= $1s^2$, $2s^2$, $2p^4$

- O-atom shares two electrons with two H-atoms . i.e one electron with one H-atom .
- The O-atom gets stable electronic configuration of Ne –atom while each H-atom gets the stable configuration of He-atom .



Example -6

Let us consider the formation of Ammonia molecule (NH_3) .

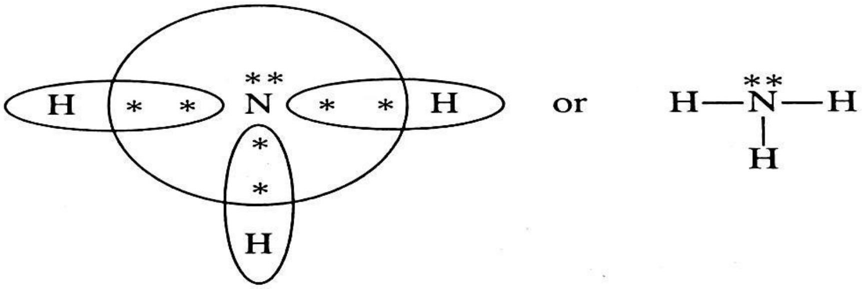
$_1H$ = 1

= $1s^1$

$_7N$ = 2 , 5

= $1s^2,2s^2, 2p^3$

- N-atoms shares 3 electrons with three H-atoms i.e . one electron with one H-atom .
- The N-atom gets stable electronic configuration of Ne-atom while each H-atom gets stable configuration of He-atom .



Example -7

Let us consider the formation of methane molecule (CH_4) .

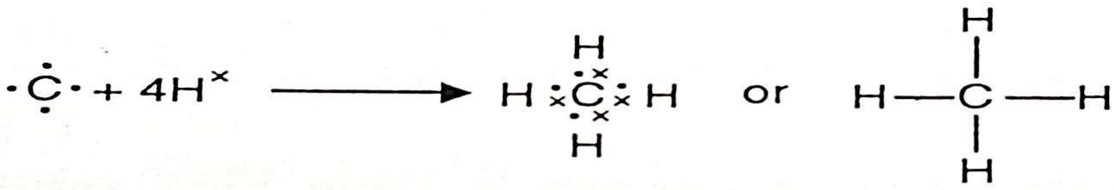
$_1H$ = 1

= $1s^1$

^6C = 2 , 4

= $1s^2$, $2s^2$, $2p^2$

- C-atoms shares 4 electrons with four H-atoms i.e one electron with one H-atom .
- The C-atoms gets stable electronic configuration of Ne-atom and each H-atom gets stable configuration of He-atom .



Co-ordinate Bond (Dative Bond)

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

(i) This type of bond is formed between two dissimilar atoms A and B .

(ii) Atom 'A' has one or more lone pair of electrons . Atom 'B' is short of a pair of electron then the nearest inert gas configuration .

(iii) Atom 'A' donates its lone pair of electrons to the atom 'B' . As a result both atoms get inert gas configuration . Atom 'A' is called "donor" while atom 'B' is called "Accepter" atom . The bond form is called co-ordinate or Dative bond .

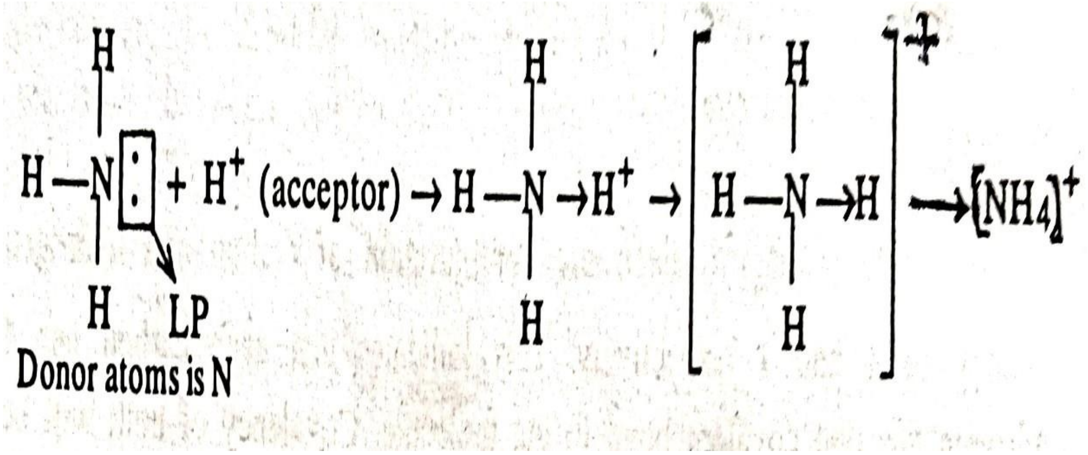
(iv) The dative bond is shown by (✂) sign. The head of the arrow is towards the Acceptor atom while the tail of the arrow is towards the Donor atom . i.e. A✂ B .

(v) The co-ordinate bond is directional bond .

Example – 1

Let us consider the formation of Ammonium ion (NH_4^+) .

- The NH_4^+ ion is formed by the combination of NH_3 and H^+ ion .
- The central atom of NH_3 is 'N' which has a lone pair of electrons .
- N-atom of NH_3 donates its lone pair of electron to H^+ ion to form a co-ordinate bond and NH_4^+ ion is formed .



Example-2

Let us consider the formation of SO_2 molecule .

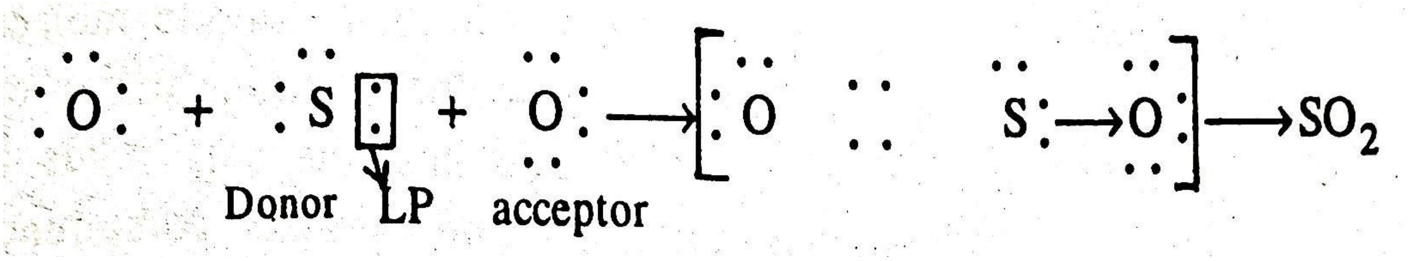
$_{16}S$ = 2, 8, 6

= $1s^2, 2s^22p^6, 3s^23p^4$

^8O = 2 , 6

= $1s^2,2s^2,2p^4$

- The central S-atom forms two covalent bonds with one O-atom and a co- ordinate bond with another O-atom .



Short Question with Answer

Q. 1) Difine chemical bond .

Ans. Chemical bond is defined as a force of attraction which holds together constituent atoms in a molecule .

Q . 2) Define ionic bond .

Ans . The chemical bond which is formed by the transference of one or more electrons form one atom to the other is called ionic bond .

Q . 3) Define covalent bond .

Ans . The chemical bond which is formed by the mutual sharing of electrons between the participating atom is known as covalent bond .

Q. 4) Define co-ordinate bond .

Ans. 'A co-ordinate bond is formed when an atom with complete octet (after mutual sharing) donates its pair of electron to the other atom (which is deficient in electrons).

Q. 5) Why do atoms combine ? [2019(S)(Old)]

Ans. Atoms combine to attain the stable configuration of their nearest inert gas .

LONG QUESTION

Q-1 What is chemical bond ? Define ionic bond. Discuss the formation of sodium chloride .

[2017(W)(N/2nd) , 2018(W)(O) , 2019(S)(N/2nd)]

Q-2 Define covalent bond. Discuss the formation of H_2O , NH_3 and CH_4 .

[2018(W)(O)]

Q-3 Define co-ordinate bond. Discuss the formation of NH_4^+ ion and SO_2 .

[2018(S)(O/2nd)]

CHAPTER-3

THEORY OF ACIDS ANDBASES

Learning Objectives:

- *Concept of Arrhenius ,Lowry-Bronsted and Lewis Theory for Acid and Base with examples(postulates and limitations)*
- *Neutralisation of Acid and Base .*
- *Definition of Salt, Types of salts (Normal, acidic , basic, double , complex ,and mixed salts. Definitions and 2 examples from each).*

1. Arrhenius Theory of Acid And Base

- The important postulates of Arrhenius theory of Acid and base are –

i) Acid

- "Acids are those substances which produces H^+ ion in its aqueous solution ."

Examples

HCl, H_2SO_4 , HNO_3 , CH_3COOH etc.

$HCl + aq \rightarrow H^+(aq) + Cl^-(aq)$

$H_2SO_4 + aq \rightarrow 2H^+(aq) + SO_4^{2-}(aq)$

ii) Base

- "Bases are those substances which produce OH^- ions in aqueous solution ."

Examples

$NaOH$, KOH , $Ca(OH)_2$ etc.

$NaOH + aq \rightarrow Na^+(aq) + OH^-(aq)$

$Ca(OH)_2 + aq \rightarrow Ca^{2+}(aq) + 2OH^-(aq)$

iii) Neutralisation

- Neutralization of an acid and base is based on the key reaction between H^+ ions from acid and OH^-ions from base to form water which is neutral .

$H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$

Limitations

i) According to Arrhenius theory of Acids and Bases , an acid produces H^+ ion is a proton which can not exist independently .

- H^+ ion reacts with H_2O to from H_3O^+ ion (Hydronium ion) .

ii) It fails to explain the acidic and basic properties of substances in solvents other than water .

iii) It fails to explain the acidic properties of substances like CO_2 , SO_2, P_2O_5 etc. which do not contain hydrogen .

- It does not explain the basic nature of substances like NH_3 , CaO etc. which do not contain 'OH' group .

iv) It fails to explain the neutralization reaction in absence of water .

2. Lowry-Bronsted Theory

- According to Lowry - Bronsted Theory of Acid and Base -

i) Acid

- "Acid is a substance (molecular ion) which has a tendency to donate a proton to any other substance ."

Examples

H_2O, HCl , H_2SO_4 , NH_4^+, H_3O^+ , HCO_3^- etc

HCl 👎 $H^+ + Cl^-$

NH_4^+ 👎 $H^+ + NH_3$

HCO_3^- 👎 $H^+ + CO_3^{2-}$

H_2O 👎 $H^+ + OH^-$

ii) Base

- Base is a substance (molecule or ion) which has a tendency to accept a proton from any other substance .

Examples

OH^-, H_2O, NH_3, CO_3^{2-}etc .

$OH^- + H^+$ 👎 H_2O

$H_2O + H^+$ 👎 H_3O^+

$CO_3^{2-} + H^+$ 👎 HCO_3^-

- Acid is proton donor while Base is proton acceptor .

- From this theory we have –
  A substance can only acts as an acid if another substance to accept its proton and vice versa .

Example

HCl acts as an acid in water but not in benzene . The reason is that water can take up its proton while benzene cannot .

Neutralisation

- Neutralisation is simply the transfer of proton between an Acid and Base which Produces another pair of acid and base .

$HCl + NH_3$ 🖓 $NH_4^+ + Cl^-$
Acid$_1$ Base$_2$ Acid$_2$ Base$_1$

Conjugale Acid and Base Pairs

- " The pair of acid and base which differ by a proton is said to from conjugate pair ."
- Let us consider the reaction between HCl (acid) and NH_3 (base) .

Example

HCl 🖓 $Cl^- + H^+$
Acid Base Proton

- HCl (acid) and Cl^- (base) are conjugate acid and base Pairs .

Limitation of Lowry -Bronsted Theory

1) It fails to explain the reaction between acidic oxides such as CO_2, SO_2 etc. and basic oxides such as CaO , MgO etc .
2) It fails to explain the acidic character of $AlCl_3$, $FeCl_3$, BF_3 etc .

3. Lewis Theory of Acid of Base

- Lewis Theory deals with the electronic concept of Acids & Bases .

Acid

- "Acid is defined as any substance that can accept a pair of electrons ."
- In short-
  Acid is an electron pair acceptor.
- Acids are electron deficient species .

- A Lewis acid may the of the following types -

i) All positive ions or cations .

Example

H^+ , Na^+, Ca^{2+} etc.

ii) Molecules having electron deficient atom .

Example

$AlCl_3$, $FeCl_3$, BF_3 etc .

iii) Molecules having atoms which can accommodate more electrons in the vacant d-orbitals .

Example

SiF_4 , $SiCl_4$ etc.

iv) Molecules having multiple bonds between atoms of different electro-negativities .

Example

CO_2 , SO_2 etc.

Base

- "Base is defined as any substance which can donate a pair of electrons."
- Base is electron pair donor .
- Base are electron rich species .
- A Lewis base may the of the following types -

i) All negative ion or anions .

Example

OH^-, Cl^- , CO_3^{2-} etc.

ii) Neutral molecule whose central atom possesses one or more lone pair of electrons

Example

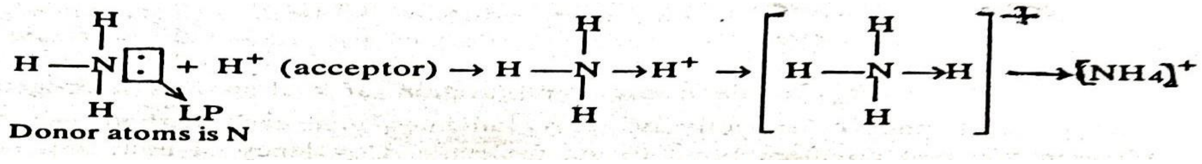
$\overset{..}{N}H_3$, $H_2\overset{..}{O}:$ etc.

Acid & Base reaction

- According to Lewis theory concept when an acid and a base react , a co-ordinate bond is formed .

Example

Let us consider reaction between Ammonia (NH_3) & a proton (H^+) .



Limitation

i) It fails to explain the strength of acids and bases as it does not consider ionisation .

ii) According to this theory , an acid reacts with a base with the formation of co-ordinate bond but no such bond is formed when HClreacts with NaOH .

iii) Acid- Base reactions are fast and instantaneous but the formation of co-ordinate bond is a slow process .

iv) Acid shows catalytic activity in many reaction because H^+ ions are produced by them but Lewis theory does not permit any such property .

Neutralisation of Acid and Base

- When an aqueous solution of an acid is added to an aqueous solution of base , a chemical reaction occurs resulting in the formation of salt and water .This Process is called acid- base **neutralisation .**

Acid + Base ⟶ Salt + Water

Example

Let us consider the neutralization of hydrochloric acid (HCl) with aqueous solution of sodium Hydroxide (NaOH)

HCl (aq) + NaOH (aq) 👎 NaCl(aq) + H_2O(l)

Salt

- "Salt is defined as crystalline compound which is formed by the neutralization of aqueous solution of acid with aqueous solution of base ."

Types of Salts

i) Normal salt
ii) Acidic salt
iii) Basic salt
iv) Double salt
v) Complex salt
vi) Mixed salt

i) Normal salt

- "These are the salts which are formed by the complete neutralization of aqueous solution of acid reaction with aqueous solution of base ."

Example

NaCl , K_2SO_4 , $CaCO_3$ etc .

ii) Acidic salt

- "Acidic salts are formed by the incomplete neutralization of polybasic acids ."

Example

$NaHCO_3$, $KHSO_4$, etc .

iii) Basic salt

- “Basic salts are formed by incomplete neutralization of polyacidic bases .”

Example

$Ca(OH)Cl$, $Zn(OH)Br$ etc.

iv) Double salt

- “These are the addition compounds formed by the combination of two normal salts”.

Example

$K_2SO_4 . Al_2(SO_4)_3 . 24H_2O$, $KCl . MgCl_2 . 6H_2O$

Complex salt

- “These are the compounds formed by combination of Normal salt or molecular compounds” .

Example

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

Mixed salt

- “These are the salt which produce more than one cation or anion when dissolved in water” .

Example

$Ca(OCl)Cl$, $NaKSO_4$ etc.

Short Questions with Answers

Q-.1) Write the name of two acids and bases according Arrhenius theory .

Ans - **Acid**

HCl , H_2SO_4, HNO_3 ,CH_3COOH etc .

Base

$NaOH$, KOH , $Ca(OH)_2$etc .

Q-2) What is amphoteric substance ? Give an example .
[2019(W/1st) (N) ,

Ans- The substance which is both acidic and basic is Known as amphoteric substance .

Example

Water (H_2O)

Q-3) HCl acts as acid in water but not in Benzene. Why ?

Ans - The reason is that water can take up protons from HCl but benzene cannot .

Q-4) What do you mean by conjugate acid and base pair ?
Give an example . [2019(S/1st) (O) ,

Ans - The pair of acid and base which differ by a proton is said to form a conjugate acid-base pair.

Example

The conjugate acid of base (NH_3) is NH_4^+ .

NH_3 and NH_4^+ are conjugate acid-base pair.

Q-5) What are basic salts ? Give two examples . [2018(W)(N/BP), 2020(W)(N/1st),

Ans - **Basic Salts**

The salts which are formed by the incomplete neutralization of Polyacidic bases , known as Basic Salts .

Examples

$Mg(OH)Cl$, $Zn(OH)Cl$, etc.

Long Questions

Q-1) Discuss Arrhenius theory of acids and bases. Write its limitations.
[2018(S)(O),2020(W)(N/1st),

Q-2) Discuss Lowry-Bronsted theory of Acids and Bases . Write its limitations .

Q-3) Discuss Lewis theory of Acids and Bases. Write its limitations.
[2017(W)(N/2nd),2018(W)(O), 2019 (S/2nd) (O)(N)

Q-4) Define neutralization reaction .

Q-5) What is Salt ? Discuss different types of salts with examples .
[2018(S)(N/1st) , 2019(S/2nd)(W)

CHAPTER - 4

SOLUTION

Learning Objective :

- *Definitions of atomic weight, molecular weight , equivalent weight.*
- *Determination of Equivalent weight of Acid , Base , and Salt.*
- *Modes of expression of the concentrations (Molarity, Normality and Molality) with Simple Problems .*
- *pH of solution (definition and simple numericals)*
- *Importance of pH in industry (sugar, textile paper industries only)*

Atomic Weight (Mass)

- "The atomic mass of an element is defined as the relative average mass of its atom as compared to the 1/12 of one atom of C^{12} taken as 12 ."

Mathematically

$$\text{Atomic mass of an element} = \frac{\text{Mass of one atom of the element}}{1/12 \times \text{Mass of an atom of } C^{12}}$$

- It is a number only .
- It has no unit .

Molecular Weight (Mass)

- "The molecular weight of a substance is defined as the average relative mass of one molecule of it as compared to the 1/12th of the mass an atom of C^{12} taken as 12 ."

Mathematically

$$\text{Molecular mass of a compound} = \frac{\text{Mass of one molecule of the compound}}{1/12 \times \text{Mass of an atom of } C^{12}}$$

- It has no unit .
- It is a number only .
- Molecular weight (mass) can be calculated by adding atomic masses of the elements present in a molecule.

Problem

Find the molecular mass of sulphuric acid.

Solution

Formula of Sulphuric acid = H_2SO_4

Molecular mass of H_2SO_4 = $1 \times 2 + 32 \times 1 + 16 \times 4$

$= 2 + 32 + 64 = 98$ a.m.u

Equivalent mass

- "The equivalent mass of a substance is the number of parts by mass of it that combines with or displaces 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 is a number only .
- It has no unit .

Example

Let us consider the reaction between magnesium and sulphuric acid .

$$\underset{24\ \text{parts}}{Mg} + \underset{\substack{2+32+64 \\ = 98\ \text{parts}}}{H_2SO_4} \longrightarrow MgSO_4 + \underset{2.016\ \text{parts}}{H_2}$$

i) 2. 016 part of hydrogen is displaced from 98 part of H_2SO_4.

1.008 parts of hydrogen is displaced from H_2SO_4 = 98/2.016 × 1.008 = 49

∴ Eq. mass of H_2SO_4 is 49.

ii) 2. 016 part of hydrogen is displaced by 24 part of 'Mg'

1.008 parts of hydrogen is displaced by 'Mg' = 24/2.016 × 1.008 = 12

∴ Eq. mass of 'Mg' is 12 .

NOTE

$$\text{Eq. mass of Element (E)} = \frac{\text{Atomic mass (A)}}{\text{Valency (n)}}$$

☯ $E = A / n$

Problem

Find the equivalent mass of trivalent element having atomic mass 27 .

Solution

Given that –

Atomic mass (A) = 27

Valency (n) = 3

∴ Eq. mass (E) = A/n =27/3 = 9

1) Equivalent Mass of Acid

Equivalent Mass of Acid = Molecular Mass of Acid / Basicity

- Basicity of Acid = No of H^+ ions in Acid .

Name of acid	**Basicity**
HCl	1
H_2SO_4	2
CH_3COOH	1

Problem

Find the equivalent mass of sulphuric acid.

Solution

Formula of Sulphuric acid = H_2SO_4

Molecular mass of H_2SO_4 = 1 × 2 + 32 × 1+ 16 × 4

= 2 + 32 + 64 = 98 a.m.u

Basicity of H_2SO_4 = 2

∴ Eq. mass of H_2SO_4 = Molecular mass of H_2SO_4 / Basicity

= 98/2 = 49

2) Equivalent mass of Base

- **Equivalent mass of Base = Molecular mass of Base / Acidity**
- Acidity of Base = No. of OH^- ions present in a Base .

Name of Base	**Acidity**
NaOH	1
$Ca(OH)_2$	2
$Al(OH)_3$	3

Problem

Calculate the equivalent mass of Calcium hydroxide .

Solution

Formula of Calcium hydroxide = $Ca(OH)_2$

Acidity of $Ca(OH)_2$ = 2

Molecular mass of $Ca(OH)_2$ = 40 × 1 + 2 [16 × 1 + 1×1]

= 40 + 2 × 17

= 74 a.m.u

Equivalent mass of $Ca(OH)_2$ = Molecular mass of $Ca(OH)_2$ / Acidity

= 74/2 = 37

3) Equivalent mass of Salt

$$\text{Equivalent mass of salt} = \frac{\text{Molecular mass of salt}}{\text{Total +ve valency or -ve valency}}$$

Problem

Find out the equivalent mass of Aluminium Sulphate .

Solution

Formula of Aluminium Sulphate = $Al_2(SO_4)_3$

Molecular mass of $Al_2(SO_4)_3$ $= 27 \times 2 + 3\,[32 \times 1 + 16 \times 4]$

$= 54 + 3\,(32+64)$

$= 54 + 3 \times 96$

$= 54 + 288$

$= 342$ a.m.u

Valency of Al = +3

$\therefore$. Eq mass of $Al_2(SO_4)_3$ = Molecular mass $AL_2(SO_4)_3$ / Total +ve valency

$$= \frac{342}{2 \times (+3)}$$

$= 342/6$

$= 57$

Modes of Expression of concentration

1. Normality (N)
2. Molarity (M)
3. Molality (m)

1) Normality(N)

- "Normality is define d as the number of gram equivalents of the solute present per litre of the solution" .
- It is denoted by 'N'.

Mathematically

$$\text{Normality (N)} = \frac{\text{Mass of Solute (W)}}{\text{Equivalent mass of solute (E)}} \Big/ \frac{\text{Volume of solution (V) in ml}}{1000}$$

☯ $$\text{Normality (N)} = \frac{\text{Mass of Solute (W)}}{\text{Equivalent mass of solute (E)}} \times \frac{1000}{\text{Volume of solution (V) in ml}}$$

☯ $$\text{Normality (N)} = \frac{W}{E} \times \frac{1000}{V \text{ in ml}}$$

Where w ✂ Mass of Solute

E ✂ Equivalent mass of solute

V ✂ Volume of solution in ml

2) Molarity (M)

- “Molarity is the number of moles of the solute present per litre of the solution.”

It is denoted by ‘M’.

Mathematically

$$\text{Molarity (M)} = \frac{W}{\text{Mol. Mass}} \times \frac{1000}{V \text{ in ml}}$$

Where , w ✂ Mass of solute

and, **V** ✂ Volume of solvent in ml .

3) Molality (m)

- “Molality is the number of moles of the solute present in 1000 gram of the solvent.”
- It denoted by ‘m’ .

Mathematically

$$\text{Molality (m)} = \frac{W_1}{\text{Mol. Mass}} \times \frac{1000}{W_2}$$

Where , W_1 ✂ Mass of solute .

and W_2 ✂ Mass of solvent

Problem-1

5.3 gram of sodium carbonate is dissolved in 200 ml of water . Find the molarity of the solution .

Solution

Formula of sodium carbonate = Na_2CO_3

Molecular Mass of Na_2CO_3 $= 23 \times 2 + 12 \times 1 + 16 \times 3$

$= 46 + 12 + 48$

$= 106$ a.m.u

Mass of solute (w) = 5.3 gm

Volume of solution (V) = 200ml

Calculation of Molarity

- We know that –

$$\text{Molarity (M)} = \frac{W}{\text{Mol. Mass}} \text{ x } \frac{1000}{V \text{ in ml}}$$

Where , w ✂ Mass of solute

and, **V** ✂ Volume of solvent in ml

Here , w = 5.3 gm

V = 200 ml

Molecular mass of Na_2CO_3 = 106

$\therefore$ Molarity = 5. 3/ 106 × 1000/200

= 0.25 M

Problem-2

5.3 gram of sodium carbonate is dissolved in 200 ml of water . Find the normality of the solution .

Solution

Formula of sodium carbonate = Na_2CO_3

Molecular Mass of Na_2CO_3 = 23 × 2 + 12 × 1 + 16 × 3

= 46 + 12 + 48

= 106 a.m.u

Eq. mass of Na_2CO_3 = Molecular Mass of Na_2CO_3 / Total +ve valency or -ve valency

= 106 ⁄ 2 = 53

Mass of solute (w) = 5.3 gm

Volume of solution (V) = 200ml

Calculation of Normality

- We know that –

Normality = W / E × 1000/ V in ml

Where w ✂ Mass of Solute

E ✂ Equivalent mass of solute

V ✂ Volume of solution in ml

Here w = 5.3 g

V = 200 ml

E = 53

$\therefore$ Normality = 5. 3 / 53 × 1000 /200

= 0. 5 N

Problem-3

Calculate the molality of the Potassium carbonate (K_2CO_3) Solution which is formed by dissolving 2.51 g of it in 1 litre solution (density of solution is 0.85 g/ml).

Solution

Formula of potassium carbonate = K_2CO_3

Molecular Mass of K_2CO_3 $= 39 \times 2 + 12 \times 1 + 16 \times 3$

$= 78 + 12 + 48$

$= 138$ a.m.u

- We know that –

$$\text{Density (d)} = \frac{\text{Mass}}{\text{Volume}}$$

☯ Mass of 1000 ml solution = Density (d) x Volume (V)

$= 0.85 \text{ g/ml} \times 1000 \text{ ml}$

$= 850 \text{ g}$

Given that -

Mass of solute (w_1) = 2. 51 g

Mass of Solvent (w_2) = 850 g - 2. 51 g

= 847.49 g

- We know that –

$$\text{Molality (m)} = \frac{W_1}{\text{Mol. Mass}} \times \frac{1000}{W_2}$$

$= 2.51/138 \times 1000/847.49$

$= 0.0214$ m

p^H

- ‘’ P^H of a solution is defined as the negative logarithm of hydrogen ion concentration in moles per litre .’’

Mathematically

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

- P^H ranges from 0 to 14 .
- For Acid , $P^H < 7$

  For Base , $P^H > 7$

  For water , $P^H = 7$

Note-1

$$P^H + P^{OH} = 14$$

Note-2 (Logarithm Formula)

1) $\log_{10}(M \times N) = \log_{10} M + \log_{10} N$

2) $\log_{10}(M/N) = \log_{10} M - \log_{10} N$

3) $\log_{10} M^n = n \log_{10} M$

4) $\log_e M$ or $\ln M = 2.303 \times \log_{10} M$

5) $\log_{10} 10$ or $\log 10 = 1$

Problem

Calculate the P^H of the acid solution whose H^+ ion concentration in 0 .5 N .

Solution

Given that-

$$[H^+] = 0.5N$$

$$P^H = -\log [H^+]$$

$$= -\log (0.5)$$

$$= -\log (5 \times 10^{-1})$$

$$= -[\log 5 + \log 10^{-1}]$$

$$P^H = -[\log 5 - \log 10]$$

$$= -[0.6990 - 1]$$

$$= -(-0.3010)$$

$$P^H = 0.3010$$

Applications of P^H in Industry

(i) In Sugar Industry

- The Sugar in prepared from sugar- cane Juice .
- The P^H of this Juice is carefully controlled to 7 i. e neutral before further processing .
- If sugar- cane Juice is acidic i.e $P^H < 7$, sucrose present in it , is hydrolysed to glucose and
- fructose . If sugar- cane Juice is alkaline i.e $P^H > 7$, undesirable substances are produced.
- P^H control is very necessary during crystallization of sugar .

(ii) In Textile Industry

- In textile Industry , the cloths are prepared from different types of fibres such as cotton , polyesters etc .
- P^H adjustment is essential during the fabrication of clothes .

(iii) In paper Industry

- The paper is prepared from pulp .The pulp is prepared from bamboos , woods etc .
- The P^H adjustment is essential during the preparation paper from pulp .
- The quality of the paper depends on the control of P^H . Acid free paper is a good is quality paper which is not easily affected by environmental factors .

Short questions with Answer

Q-1) Write the relationship between equivalent mass , atomic mass and valency .

Ans . Eq . mass (E) = Atomic mass (A)/ Valency (n)

Q-2) Atomic weight trivalent metal is 27 . What will be its equivalent weight ?

[2019(S/2nd)(O) ,

Ans-

We know that –

Eq . weight (E) = Atomic weight (A)/ Valency (n)

Here- $A = 27$ and $n = 3$

Eq . weight (E) = 27/ 3 = 9

Hence , equivalent weight of the metal is 9 .

Q-3) Define P^H / What is P^H ? Write the value of P^H for Acid , Base and Water ./ How does it decide the acidic and basic nature of solutions ?

[2018(S)(O) ,

Ans .

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

$$p^H = - \log [H^+]$$

- For Acid . $P^H < 7$
- For base . $P^H > 7$
- For water $P^H = 7$
- If the p^H value of a solution < 7 , it is acidic solution.

  If the p^H value of a solution > 7 , it is basic solution.

Q-4) Find the P^H of the solution having OH^- ion concentration 10^{-10} moles per litre.

[2019(S/1ST)(O) ,

Ans .

Given that-

$[OH^-] = 10^{-10}$ moles per litre

$P^{OH} = -\log[OH^-]$

$= -\log(10^{-10})$

$= -\log(5\times 10^{-1})$

$= -(-10)\log 10$

$= -10 \times 1 = 10$

- We know that –

$P^H + P^{OH} = 14$

☯ $P^H = 14 - P^{OH}$

☯ $P^H = 14 - 10$

☯ $P^H = 4$

Q-5) Derive a relationship between molarity and normality . Convert 10^{-2} M H_2SO_4 into normality.
[2017(W)(N) ,

Ans .

We know that –

$$\text{Molarity} \times \text{Mol. Mass} = \text{Normality} \times \text{Eq. Mass}$$

☯ $$\frac{\text{Molarity}}{\text{Normality}} = \frac{\text{Eq. Mass}}{\text{Mol. Mass}}$$

Molecular mass of H_2SO_4 = 1 x 2 + 32 x 1 + 16 x 4

= 2 + 32 + 64

= 98 u

Basicity of H_2SO_4 = 2

$$\text{Equivalent mass of } H_2SO_4 = \frac{\text{Molecular mass of } H_2SO_4}{\text{Basicity of } H_2SO_4}$$

= 98/2

= 49

Given that-

Molarity of H_2SO_4 = 10^{-2} **M**

Normality of H_2SO_4 = ?

☯ $$\text{Normality} = \frac{\text{Molarity} \times \text{Mol. Mass}}{\text{Eq. Mass}}$$

☯ $$\text{Normality} = \frac{10^{-2} \times 98}{49}$$

$= 2 \times 10^{-2}$ N = 0.02 N

Q-6) Define Molecular Weight (Mass) . Find the molecular mass of $KMnO_4$.
[2017(W)(N/2nd) ,

Ans-

Molecular Weight (Mass)

- "The molecular weight of a substance is defined as the average relative mass of one molecule of it as compared to the 1/12th of the mass an atom of C^{12} taken as 12 ."
- Molecular mass of $KMnO_4$ = 39 × 1 + 55 × 1+ 16 × 4
  = 39 + 55 + 64 = 158 a.m.u

Q-7) Define decinormal and molal solution .

[2018(W)(N/2nd) ,

Ans- **Decinormal solution**

" The solution in which 0.1 gram equivalent of a solute is dissolved in one litre solution is known as decinormal solution."

Molal solution

"When one mole of the solute is dissolved in 1000gm of the solvent , it is called one molal solution."

Q-9) Define Equivalent mass .

Ans- **Equivalent mass**

- "The equivalent mass of a substance is the number of parts by mass of it that combines with or displaces 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 is a number only .
- It has no unit .

Q-10) Calculate Equivalent mass (weight) of $Al_2(CO_3)_2$ .and acetic acid .

Ans-

i) $$\text{Equivalent mass (weight) of Salt} = \frac{\text{Mol. weight of Salt}}{\text{Total +ve or -ve valency}}$$

Mol. Weight (mass) of $Al_2(CO_3)_2$ = 27 x 2 + 3 [12 x 1 + 16 x 3]
= 54 + 3 (12 + 48)
= 54 + 3 x 60
= 54 + 180 = 234u

$$\text{Equivalent mass (weight) of } Al_2(CO_3)_2 = \frac{\text{Mol. weight of } Al_2(CO_3)_2}{\text{Total +ve or -ve valency}}$$

= 234 / 6 (Valency of Al = +3)
= 39

Hence , Eq. weight of $Al_2(CO_3)_2$ is 39 .

i) $$\text{Equivalent mass (weight) of Acid} = \frac{\text{Mol. weight of Acid}}{\text{Basicity}}$$

Mol. weight of Acetic acid (CH_3COOH) = 12 x 1 + 16 x 2 +1 x 4
= 12 + 32 + 4 = 60 a.m.u

Basicity of CH_3COOH = 2

$$\text{Equivalent mass (weight) of } CH_3COOH = \frac{\text{Mol. weight of } CH_3COOH}{\text{Basicity } CH_3COOH}$$

$$= 60/1 = 60$$

Hence , Eq. weight of CH_3COOH is 60 .

Long Questions

Q-1) Define Normality , molarity and molality .

Q-2) Define P^H of a solution. Write the industrial application of P^H ./ What is the importance of P^H in industries ?

[2009(W),2018(W)(N/BP) ,

Q-3) 40gms of Caustic soda is dissolved in water to prepare 5 litres of its solution having density 1.02gm/cc .Calculate the normality ,molarity , and molality of the solution.

[2019(S/2nd)(N) ,

Q-4) 3.15 g of HNO_3 is present in 500ml of its solution .Calculate the molality and P^H of solution.

[2018(S)(N/1st),

Q-5) Define P^H . Find P^H of a solution containing 8gm of NaOH in 2lit. of its solution.

[2017(W)(N/E),

CHAPTER - 5

ELECTRO CHEMISTRY

Electrolyte

- "The substance which allows electricity to pass through its aqueous solution or in the fused state is called electrolyte."

Example

1. Acids (HCl , H_2SO_4, HNO_3, CH_3COOH etc.)
2. Bases (NaOH , KOH , $Ca(OH)_2$, NH_4OH etc.)
3. Salts (NaCl , KCl , Na_2CO_3etc.)

Types of Electrolyte

1. Strong electrolyte .
2. Weak electrolyte .

1. Strong Electrolyte

- "Substances which get completely ionized in solution is known as **strong electrolyte**."

Examples

HCl , H_2SO_4 , NaOH , KOH , NaCl , $ZnSO_4$ etc .

2. Weak Electrolyte

- "Substances which get ionized only slightly in solution is known as **weak electrolyte.**"

Examples

CH_3COOH , H_2CO_3 , NH_4OH etc .

Electrolytic cell

- " It is a device in which electrical energy is converted to chemical energy."

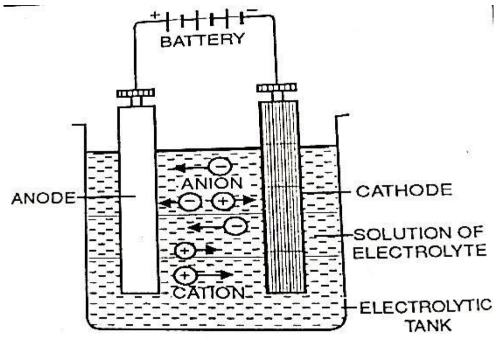
Electrolysis

- " The process of chemical decomposition of an electrolyte in solution or in the fused by the passage of electric current , is known as **electrolysis**."

Process of Electrolysis

- "The process of electrolysis is carried out in a vessel known as **electrolytic tank** which is made up of glass , cement etc ."
- Fused electrolyte or aqueous solution of electrolyte is taken in the electrolytic tank and two metallic plates are dipped in it which are called **electrodes** .
- The electrodes are connected with the two poles of battery .

FIGURE-1



[PROCESS OF ELECTROLYSIS]

- The electrode which is connected with positive poles of the battery is known as **anode** .
- The electrode which is connected with negative pales of the battery is known as **cathode.** (shown in figure -1).
- Current enters the electrolyte through the anode and leaves through the cathode .
- When an electrolyte is dissolved in water , it breaks up in cation (+ve ion) and anion (-ve ion) .
- When an electric current is passed through the solution, cation moves towards the cathode and gets discharged by accepting electrons while anion moves towards the anode and gets discharged by losing electrons .
- The movement of ions towards the oppositely charged electrodes is called as **electrolytic conduction** .

i) Electrolysis of molten (fused) Electrolyte

- Let us consider the electrolysis of fused sodium chloride

  $NaCl$ 👎 $Na^+ + Cl^-$
- When electric current is passed through fused Sodium chloride using platinum electrode the following changes takes place.

At Cathode

- Na^+ ion moves towards the cathode and gain electro (s) and changes into neutral atoms .
- Na - metal is obtained at cathode .

$$Na^+ + e^- \longrightarrow Na \text{ (metal)}$$

At Anode

- Cl^- ion moves towards the anode and lose electron (s) and changes into neutral atoms. .
- The Cl- atom is unstable and combines with another Cl - atom to from stable Chlorine molecule (Cl_2) .

$$Cl^- - e^- \longrightarrow Cl$$
$$Cl + Cl \longrightarrow Cl_2(g) \uparrow$$

ii) Electrolysis of aqueous solution of Electrolyte .

- Let us consider the electrolysis of aqueous solution of sodium chloride .

  $NaCl$ 👎 $Na^+ + Cl^-$

At Cathode

- Na^+ ion moves towards the cathode and gain electron(s) and changes into neutral atoms
- Na - metal reacts with water and hydrogen gas is produced along with sodium hydroxide

$$Na^+ + e^- \longrightarrow Na \text{ (metal)}$$
$$Na + H_2O \longrightarrow NaOH + H_2(g) \uparrow$$

At anode

- Cl^- ion moves towards the anode and lose electron(s) and changes into neutral atoms .
- The Cl-atom is unstable and combines with another Cl-atom to form stable Chlorine molecule (Cl_2).

$$Cl^- - e^- \longrightarrow Cl$$

$$Cl + Cl \longrightarrow Cl_2(g) \uparrow$$

Faraday's First Law of Electrolysis

- "The mass of substance liberated at the electrode as a result of electrolysis is directly proportional to the quantity of electricity passed through the electrolyte ."

Mathematically

- If 'W' is the mass of substance liberated at the electrode and 'Q' is the quantity of electricity (in coulombs) passed through the electrolyte, then –

$$W \ \alpha \ Q$$

$$\Rightarrow \quad W = Z\,Q \text{ .... (1)}$$

where , **'Z'** the proportionality constant

and **'Z'** is called **Electro- Chemical Equivalent** (E.C.E)

- We know that –

$$c = Q / t$$

$$\Rightarrow \quad Q = c \times t \text{ ....(2)}$$

where , c → Current in Ampere

and t → Time in Second .

- From Eq^n (1) and (2) , we get -

$$W = Z\ c\ t \text{ ....(3)}$$

- Electro-Chemical Equivalent is defined as the mass of substance liberated by the passage of one coulomb of electricity .
- Faraday's 1st law of electrolysis helps in determining the **Electro-Chemical Equivalent** .

Note

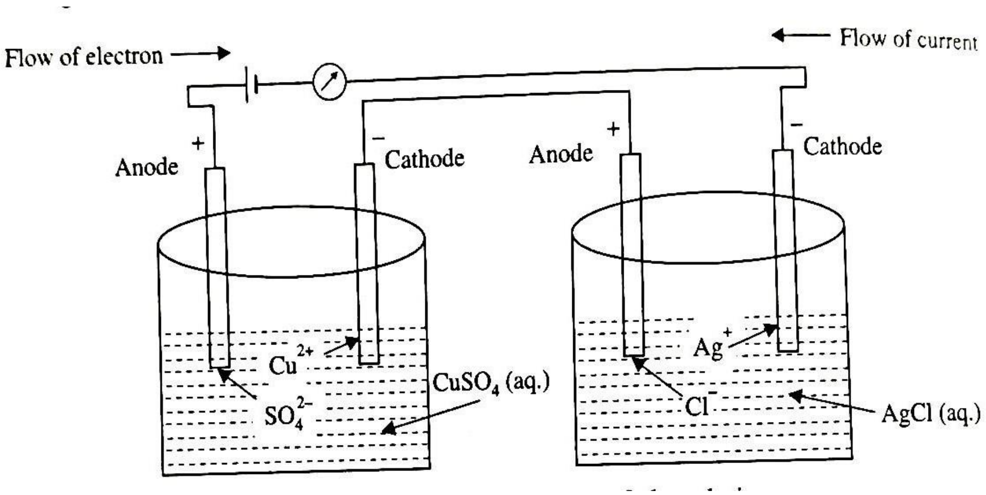
  - Faraday is the bigger unit of electricity. It is the amount charge on one mole of electrons.
  - 1 Faraday = $6.023 \times 10^{23} \times 1.602 \times 10^{-19}$ coul
  - **1 Faraday = 96500 coul**
  - On passing 1 Faraday or 96500 coul of electricity , 1 gram equivalent of the substance is deposited.

Faraday's Second Law of Electrolysis

- "It states that when same quantity of electricity is passed through different electrolyte solutions , then the weights of different substances produced at the electrodes are proportional to their equivalent weights ."

- Let's illustrate the law by considering two electrolytic cells containing $CuSO_4$ and AgCl solutions respectively and connected in series (shown in figure -2).

Figure-2



[FARADAY'S SECOND LAW OF ELECTROLYSIS]

- On passing current through the two electrolytic cells (voltameter) for same time , the t wo cells receive same amount of electricity .
- The weight of Copper and Silver liberated in the ratio of their equivalent weights .

$$\frac{\text{Weight of Copper } (W_{Cu})}{\text{Weight of Silver } (W_{Ag})} = \frac{\text{Eq . weight of Copper . } (\mathbf{E}_{Cu})}{\text{Eq . Weight of Silver } (\mathbf{E}_{Ag})}$$

- Faraday's second law of electrolysis helps in determining the **equivalent weight** .

Problem-1

Find the mass of Copper deposited from Copper Sulphate solution by a current of 0.25 ampere flowing for 1 hour. (At mass of Cu = 63)

Solution

Current (c) = 0.25 ampere
Time (t) = 1 hour = 3600 sec .
Electricity (Q) = c × t
= 0.25 × 3600
= 900 coul

Atomic mass of Cu = 63
Valency of Cu = +2
Eq. mass of Cu = 63/2 = 31.5

- We know that –

96500 coulomb of electricity produce 1 gm equivalent of the element .
96500 coulombs of electricity produce copper = 31.5 g
900 coulombs of electricity produce copper = 31 . 5/ 96500 × 900
= 0.2937 g

Industrial Applicaation of Electrolysis

Zinc Plating

- For Zinc plating , acid and alkaline solutions are used for deposition .

Electrolytic Bath

(a) The acid solution used in electrolytic bath consists of a solution of –

i) Zinc Sulphate (300g)
ii) Sodium Chloride (15g)
iii) Aluminium Sulphate (30g)
iv) Boric acid (20g)
v) Dextrin (15g) in 1000ml water .

(b) The alkaline solution used in electrolytic bath consists of a solution of -

i) Zinc oxide (40 g)
ii) Sodium cyanide (100 g)
iii) Sodium carbonate (10g) in 1000 ml water .

- The temperature of the solution is kept at 30 - 40 º C .
- Zinc plating is done on iron articles to protect them from rusting .

Short Question with Answers

Q-1) Define electrolyte . Give two examples of strong electrolyte.

[2010(W) , 2018(W)(N)

Ans - **Electrolyte**

"The substance which allows electricity to pass through its aqueous solution or in the fused state is called electrolyte ."

Strong Electrolyte

- "Substances which get completely ionized in solution is known as **strong electrolyte**."

Examples

HCl , H_2SO_4 , NaOH , KOH , NaCl , $ZnSO_4$ etc .

Q-2) **Define electrolyte and electrolysis** .

[2018(S)(N/1ST) ,

Ans - **Electrolyte**

"The substance which allows electricity to pass through its aqueous solution or in the fused state is called electrolyte ."

Electrolysis

"The process of chemical decomposition of an electrolyte in solution or in the fused state by passage of electric current is known as electrolysis ."

Q-3) **State Faraday's 1st law of electrolysis** .

Ans – The mass of substance liberated is directly proportional to the quantity of electricity passed through the electrolyte .

Q-4) **State Faraday's 2nd law of electrolysis** .

[2017(W)(N/E)

Ans – **Faraday's Second Law of Electrolysis**

"It states that when same quantity of electricity is passed through different electrolyte solutions , then the weights of different substances produced at the electrodes are proportional to their equivalent weights ."

Long Questions

Q-1) State and explain Faraday's 1st law of electrolysis. [2009(W),

Q-2) State and explain Faraday's 2nd law of electrolysis. [2018(W)(N/2nd), 2019(W) (N/1ST),

Q-3) Discuss about Zinc plating .

Q-4) State and explain Faraday's 1st law of electrolysis. If atomic weight of Cu is 63 then calculate the amount of copper deposited from CuSO4 solution by the passage of 0.5 ampere of current for 1.5 hours. [2018(W) (N/1ST),

CHAPTER - 6

CORROSION

- **" Corrosion is defined as a process involving the conversion of a metal into an undersirable compound (usually oxide) by a chemical or electro-chemical with reaction the environment. "**
- Corrosion is called **weeping of metal** .
- Corrosion reduces the mechanical strength of the metal.

Types of Corrosion

1- Atmospheric corrosion
2- Water- line corrosion

1. Atmospheric corrosion

- " The corrosion of metal which occur due to the exposure of the metal to the atmospheric condition is known as atmospheric corrosion ."
- Atmospheric corrosion is the deterioration and destruction of a metal due to electro-chemical and the other reactions on its surface with the constituents of the atmosphere surrounding the metal.
- Atmospheric corrosion oxygen and condensed water vapour cause corrosion of iron and steel surfaces , producing iron oxide which is commonly known as **rust.**

Examples

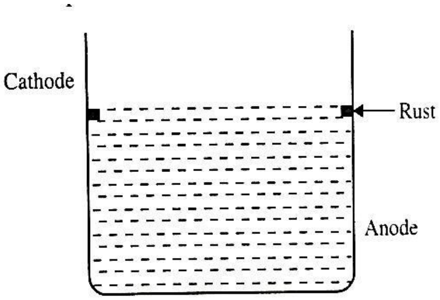
1) Rusting of iron .
2) Tarnishing of silver (Black coatings on Silver).
3) Development of green coatings on Copper.

2- Water-line Corrosion

- " Water line corrosion is caused due to difference in oxygen concentration ."

Figure - 1

- 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 **Figure – 1**.



[Waterline Corrosion]

- The area above the waterline is called the **cathode** as oxygen concentration is more and area just below the waterline is the **anode** as oxygen concentration is less.

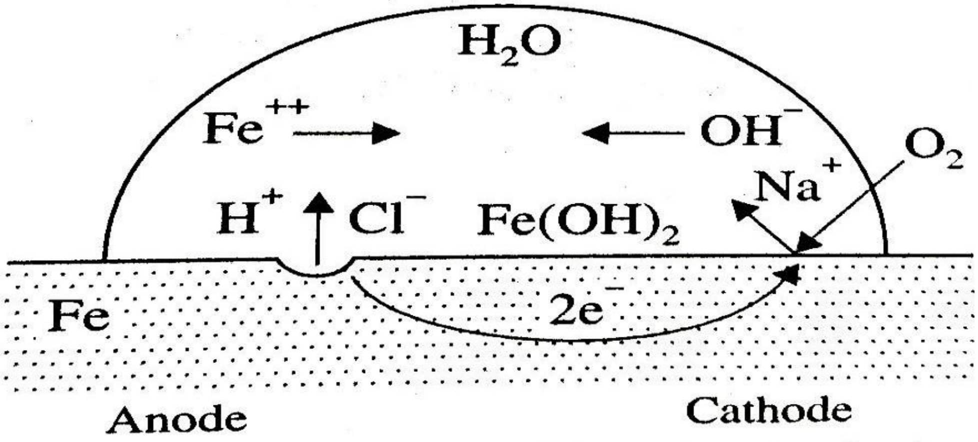
Examples

1) Water in water tank corrodes below the level of water .

2) Water-line corrosion in ship .

Mechanism of Rusting of Iron

- Formation of brown powdery material on the surface of Iron in presence of moist air is known as **rusting** .
- Rust mainly contains hydrated ferric oxide i .e $Fe_2O_3 . nH_2O$.
- The mechanism of rusting can be explained by the electrochemical theory.
- During the process of Rusting , Iron behaves like small electric cells in presence of water , oxygen etc . (**Shown in Figure – 1**)



[Mechanism of Rusting of Iron]

At Cathode

- Oxidation reaction occurs at Cathode .

$$2\,Fe \longrightarrow 2\,Fe^{2+} + 4\,e^-$$

At Anode

- Reduction reaction occurs at Anode .

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

- The Fe^{2+} ions and OH^- ions under the influence of dissolved oxygen and Fe^{2+} ions gets oxidized to Fe^{3+} ions . These Fe^{3+} ions combine with OH^- ions to from hydrated ferric oxides i.e **Rust** .

$$2\,Fe^{2+} + H_2O + O \longrightarrow 2\,Fe^{3+} + 2OH^-$$

$$2Fe^{3+} + 6OH^- \longrightarrow Fe_2O_3 \,.\, 3H_2O$$

(Rust)

Protection from corrosion

1) Alloying

- “ The process of mixing two or more metals or metals and non-metals such as carbon , phosphorus , silicon etc. to form a homogeneous solid is known as alloying. ”
- Metals can be protected from corrosion by alloying it .
- Alloying is done with the metals which are not active to the environment.
- Iron can be protected from corrosion by alloying iron with chromium and nickel .

(Iron 74% , Chromium 18% & Nickel 8%)

- It becomes corrosion resistant .
- It is used for making knives and domestic utensils .

2) Galvanisation

- It is the process of depositing a thin layer of zinc on Iron .
- The Iron coated with a thin layer of Zinc is called **Galvanisation .**
- Galvanisation can be done –

(i) By spraying molten Zinc on iron surface .

(ii) By dipping the Iron Sheet into molten Zinc .

Short Questions with Answers .

Q .1) Define corrosion ./What is Corrosion ? Write the Chemical formula of rust.

[2019(W) (N/1ST),

Ans . **Corrosion**

" Corrosion is defined as a process involving the conversion of a metal into an undersirable compound (usually oxide) on exposure to atmospheric condition i.e moisture and oxygen .

- The Chemical formula of rust is $Fe_2O_3 . nH_2O$

Q.2) Define Galvanisation . [2018(W) (N/1ST), 2019(W) (S/N), 2018 (S/1ST) (O),

Ans . It is the process of depositing a thin layer of Zinc on the surface of Iron .

Q.3) Define Alloying . [2017(W) (N/E), 2017(W) (N/2nd), 2020(W) (N/1ST)

- **Ans** - The process of mixing two or more metals or metals and non-metals such as carbon , phosphorus , silicon etc. to form a homogeneous solid is known as alloying.

Long Questions

Q-1) What is corrosion ? Write the mechanism of rusting of iron ./formation of rust.How it can be protected ?
[2017(W) (N/2nd), 2018(W) (N/2nd), [2017(W) (N/E),

Q-2 . **Write a notes on**
. [2018(W) (N/1ST), 2019(W) (S/N), 2018 (S/1ST) (O), [2017(W) (N/E), 2017(W) (N/2nd), 2020(W) (N/1ST)

i) Alloying

ii) Galvanisation

iii) Atmospheric corrosion .

iv) Water- line corrosion .

Q-3) What is corrosion ? Explain how Atmospheric corrosion/ Water- line corrosion occurs.
How it can be checked ? [2018(W) (O), 2019 (S/1ST) (O) ,2019(S/2nd) (N) ,

CHAPTER -7

METALLURGY

Learning Objectives :

- *Definition_ of Mineral , Ores , gangue with examples.*
- *Distinction between Ores and Minerals.*
- *General methods of extraction of metals*

i) Ore Dressing

ii) Concentration (Gravity Separation, magnetic separation , Froth floatation & Leaching)

iii) Oxidation (Calcination , Roasting)

iv) Reduction (Smelting ,Definition & flux ,slag)

v) Refining of the metal (Electro-refining, Distillation only)

Mineral

- The natural materials in which the metals or their compounds are found in the earth's crust are called minerals.
- All the minerals cannot be used for the extraction of metals because some minerals contain more percentage of metals while others contain only a small percentage of metals.

Example

1. Minerals of Copper – i) Copper glance (Cu_2S)
   ii) Cuprite (Cu_2O)
   and iii) Copper pyrite ($CuFeS_2$)
2. Minerals of Iron - i) Magnetite (Fe_3O_4)
   ii) Haematite (Fe_2O_3)
   iii) Limonite ($Fe_2O_3.3H_2O$)
   and iv) Iron pyrite (FeS_2)

Ore

- The minerals from which the metals can be extracted conveniently & profitably are called ore.
- An ore contains high percentage of metals and is free from objectionable of impurities.

Example

1. Ore of Copper - Copper pyrite ($CuFeS_2$)
2. Ore of Iron - Haematite (Fe_2O_3)
3. Ore of Aluminium - Bauxite ($Al_2O_3.\ 2H_2O$)

- *All the ores are minerals but all the minerals are not ores.*

Explanation

Let us consider Fe_2O_3 (Haematite) & FeS_2 (Iron pyrites) which are minerals of irons. But, Iron pyrites which contains lower percentage of iron with maximum objectionable impurities, where Haematite which contains higher percentage of Iron with minimum impurities. So, in this case Fe_2O_3 is the Ore of Iron rather than FeS_2.

Gangue (Martix)

- "Gangue is the commercially worthless/ unwanted material that surrounds or is closely mixed with, a wanted mineral in an ore."

Example

Sand, Rock and other impurities.

Difference between Ores and Minerals

Ores	Minerals
1) The minerals from which the metals can be extracted conveniently & profitably are called ore.	1) The natural materials in which the metals or their compounds are found in the earth's crust are called minerals.
2)) An ore contains high percentage of metals and is free from objectionable of impurities.	2) The minerals contain more percentage of impurities and a small percentage of metals.
3) All ores are minerals.	3) All minerals are not ores.
Example Fe_3O_4 (Magnetite), Fe_2O_3 (Haematite), $Fe_2O_3.3H_2O$ (Limonite) are the minerals of Iron.	**Example** Fe_2O_3 (Haematite) contains higher percentage of Iron with minimum impurities. So Fe_2O_3 is the Ore of Iron.

- The art of extracting metal from its ore is called **Metallurgy.**
- The gangue is eliminated before the actual process for the extraction of a metal is started . These processes are known as **Mineral benefication**.

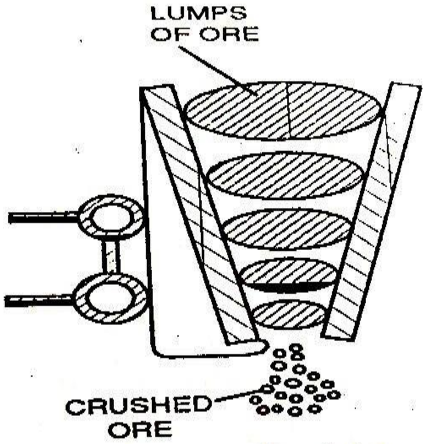
General Methods of Extraction Of Metals

- The General Method of Extraction Of Metals are –
  1. Crushing and Grinding of ore
  2. Concentration of Powdered ore
  3. Exraction of Metal from concentrated ore
  4. Refining of Crude Metal

1. CRUSHING AND GRINDING OF ORE

Figure-1

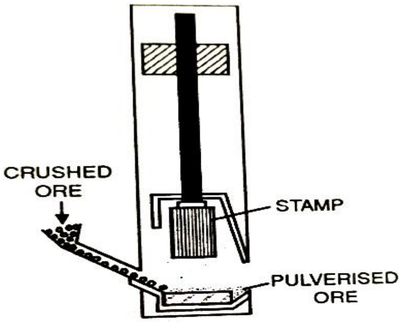
- Most of the ores are found in the form of huge lumps.
- The huge lumps are broken into smaller pieces with the help of **Jaw Crushers.**(Shown in Figure-1)



[Jaw Crushers.]

- The small pieces of ore are then changed into a fine powder with the help of a **Stamp Mill** . **(Shown in Figure -2).** The process is called **Pulverisation** of the ore.

Figure-2



[Stamp Mill]

2.CONCENTRATION OF POWDERED ORE (ORE DRESSING)

Ore dressing

- The process of removing gangue from metal ore is called **ore dressing.**

Concentration

- It is the process by which maximum quantity of gangue are removed from the ore.
- The following methods are used for concentration –

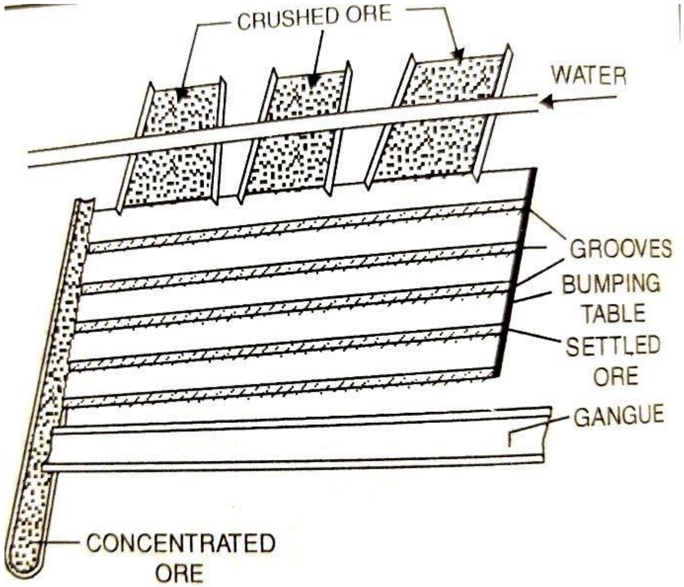
i) Gravity Separation

- In this process, the crushed ores are washed with a running stream of water as a result of which the lighter gangue particles are washed away and the heavier ore particles settle down rapidly.

Procedure

- The crushed ores are obtained from the preliminary treatmentis spread on long tables having transverse ridges, called **Wilfley tables. (Shown in Figure-3).**
- The table is given rocking motion and stream of water is flown over them.
- The gangue being lighter is carried away by water while ore is detained by the ridges.

Figure-3



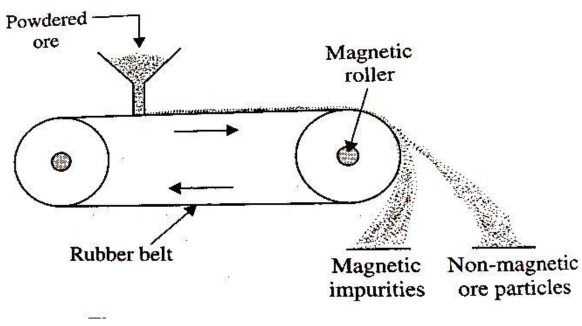
[Wilfley tables]

Example Let us consider the concentration of Galena (PbS) which occurs in lime stone. While stream of water is flown over crushed ore, the less dense Lime stone is carried away while galena is left behind.

ii) Magnetic Separation

- This method is meant for concentrating such ores which differ from their impurities in magnetic character. This process is used in case of ferromagnetic ores like iron, tinstone etc.
- In this process the powdered ore is dropped over a belt revolving round the two rollers where one of the rollers being a magnet. **(Shown in Figure-4).**

Figure-4



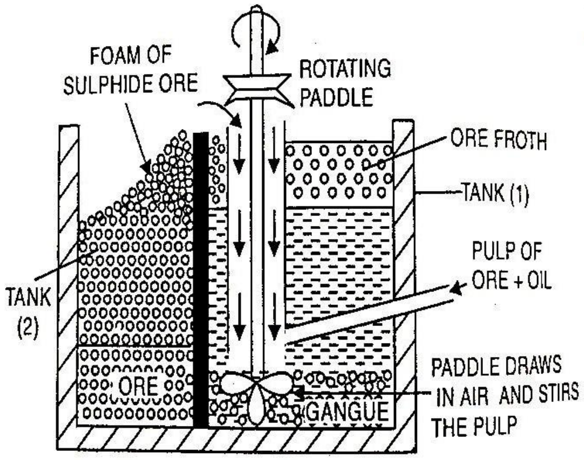
[Magnetic Separation]

- The magnetic part of the ore is attracted by the magnetic roller and forms a heap near it, whereas the non-magnetic part of the ore forms a separate heap a little away from the magnetic impurities.

iii) Froth floatation

- This method is employed for the concentration of sulphide ores only.
- This method is based on the preferential wetting properties of the ore by oil which is treated as frothing agent.
- In this method the crushed ore is added to a tank containing water. Then a cheap oil like eucalyptus oil is added into it. Now the suspension is violently agitated with the help of rotating paddle. **(Shown in Figure-5).**

Figure-5



[Froth floatation]

- The sulphide ore particles stick to the froth and rise to the surface with froth. Then the gangue particles are left behind in one tank where the froth containing sulphide particle is kept in another tank for some time. After sometime froth settle down and concentrated sulphide ore is obtained.

iv) Leaching

- It is a chemical method for the concentration of the ore.
- In this method the powdered ore is treated with a suitable reagent which dissolves the ore and not the impurities. Then the ore is recovered from the solution by suitable chemical process.

Example

- Bauxite is an ore of aluminium .
- It is concentrated by leaching process .
- Bauxite is leached with 45% solution of NaOH when Al_2O_3 goes into solution forming soluble sodium meta-aluminate.

$Al_2O_3 + 2\,NaOH \longrightarrow NaAlO_2 + H_2O$

- The solution is filtered to remove insoluble impurities.
- The filtrate is seeded with a little freshly precipitated aluminium hydroxide.

$NaAlO_2 + 2\,H_2O \longrightarrow Al(OH)_3$ 👓 $+ 2\,NaOH$

- The precipitated is separated by filtration , dried and ignited to get pure alumina.

$Al(OH)_3$ 👓 $\longrightarrow Al_2O_3 + H_2O$

Pure alumina.

3. EXTRACTION OF METAL FROM THE CONCENTRATED ORE

- The Extraction of metal from the concentrated ore involves the following steps -

(a) Conversion of the concentrated ore into its oxide.(**Oxidation**)

(b) Conversion of the metal oxide into metal.(**Reduction**)

(A) CONVERSION OF THE CONCENTRATED ORE INTO ITS OXIDE.

- In this process, the concentrated ore is formed into its oxide.
- It is usually done by two methods –

(i) Calcination

and (ii) Roasting

(i) Calcination

- It is a 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 point .
- This process is employed for carbonated ores .
- The carbonated ores decompose to form corresponding metal oxide and carbon dioxide.

Example

$CuCO_3$ ❒ $\longrightarrow CuO + CO_2$ ✂

$ZnCO_3$ ❒ $\longrightarrow ZnO + CO_2$ ✂

- This process is employed for hydrated ores which on heating produces metal oxide and water vapour (moisture).

Example

$Fe_2O_3 \cdot 2H_2O$ ❒ $\longrightarrow FeO + 2H_2O$ ✂

- This process helps to remove volatile impurities such as As and Sb in the form of vapours.

(ii) Roasting

- It is a process of heating the concentrated ore strongly in a controlled supply of oxygen .
- The Roasting process is carried out in a **reverberatory** furnace to get metal oxide.
- This process is generally used to convert sulphide ores into metal oxide along with sulphur dioxide is produced.

Example

$2\,PbS + 3O_2 \xrightarrow{\square} 2\,PbO + 2\,SO_2$ ✄

(Galena)

$2\,ZnS + 3O_2 \xrightarrow{\square} 2\,ZnO + 2\,SO_2$ ✄

(Zinc blend)

$2\,Cu_2S + 3O_2 \xrightarrow{\square} 2\,Cu_2O + 2\,SO_2$ ✄

(Copper glance)

- The changes takes place during Roasting are –

(i) This process removes moisture in the form of steam .

Example

$Fe_2O_3\,.\,2H_2O \xrightarrow{\square} FeO + 2H_2O$ ✄

(ii) It oxidises substances which can be easily oxidized .

Example

$4\,FeCO_3 + O_2 \xrightarrow{\square} 2\,Fe_2O_3 + 4\,CO_2$ ✄

(iii) It removes volatile impurities like Arsenic , Antimony , Sulphur, Phosphorus in the form of their gaseous oxide .

Example

$S + O_2 \xrightarrow{\square} SO_2$ ✄

$P_4 + 5O_2 \xrightarrow{\square} 2P_2O_5$ ✄

$4\,As + 3O_2 \xrightarrow{\square} 2As_2O_3$ ✄

- The Roasting process makes the ore porous.

(B) CONVERSION OF THE METAL OXIDE TO METAL (REDUCTION)

- The metal oxide formed in the process of calcination and roasting is reduced to the metal form by the method called **Reduction**.
- This reduction process is usually carried out by **smelting**.

Smelting

- The process of heating a roasted ore strongly above its melting point with a suitable quantity of coke or charcoal is known as **smelting.**
- In this method, coke or charcoal acts as a reducing agent which reduces the metal oxides into their respective metals .
- The mixture is heated to a high temperature above its melting point.
- For the reduction of oxides of less electropositive metals such as Zn , Fe ,Cu , Cr, etc., the reducing agents like C , CO , Co . Na , are used.

Examples

$$PbO + C \xrightarrow{\square} Pb + CO$$

$$CuO + CO \xrightarrow{\square} Cu + CO_2$$

- During the process of smelting , an additional chemical substance called ‘flux’ is added which combines with the solid impurities (gangue or matrix) to form fusible ‘slag’ .

Impurities + Flux ⟶ Slag

Flux

- The substance which combines with
- **impurities**(gangue) to form light and easily fusible materials is called **Flux**.
- The type of Flux to be used depends
- upon the nature of the impurities present in the ore .
- The flux is of two types –

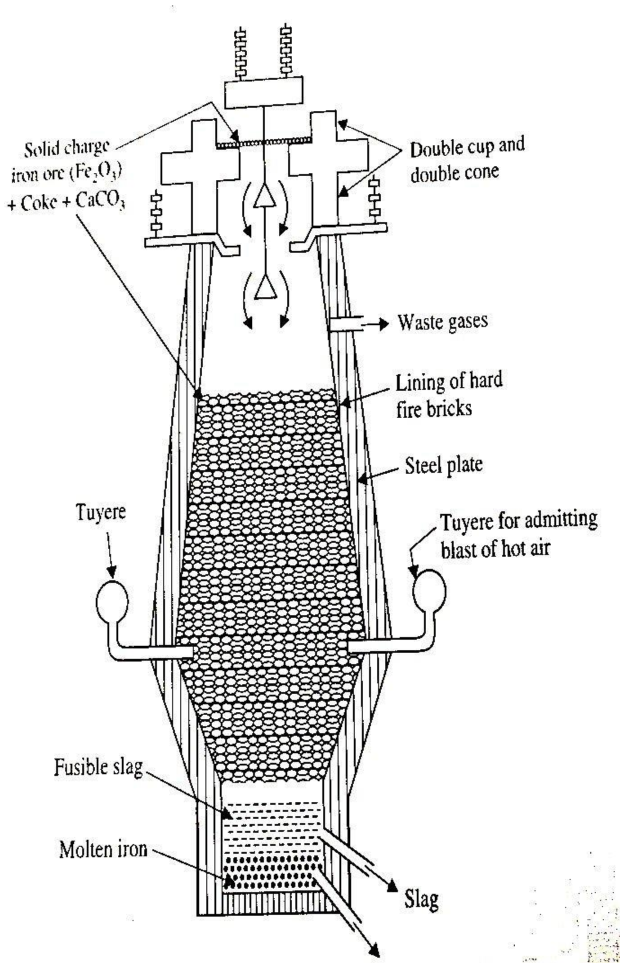
i) Acidic Flux

- It is used to remove basic impurities like lime, FeO etc., from the ore.
- The acidic Flux are the substance such as silica , borax etc.

Examples

$$\underset{\text{(Basic)}}{\underset{\text{Gangue}}{CaO}} + \underset{\text{(Acidic)}}{\underset{\text{Flux}}{SiO_2}} \longrightarrow \underset{\text{Slag}}{CaSiO_3}$$

Figure-6



[Blast Furnace]

ii) Basic Flux

- It is used to remove acidic impurities like Silica from the ore.
- The basic Flux are the substance such as CaO, $CaCO_3$, $MgCO_3$ etc. .

Examples

$$\underset{\substack{\text{Gangue}\\\text{(Acidic)}}}{SiO_2} \quad + \quad \underset{\substack{\text{Flux}\\\text{(Basic)}}}{CaO} \longrightarrow \underset{\text{Slag}}{CaSiO_3}$$

Slag

- The easily fusible material which is formed due to combination of gangue and flux, not soluble in the molten metal is called **slag.**

Gangue + flux = Slag

- The slag being lighter can be removed from the surface of the fused metal .
- The slag prevents the oxidation of the metals.
- **Smelting** is carried out in a blast furnace . **(Shown in Figure-6).**
- Blast furnace is a tall cylindrical furnace made of steel plates lined inside with fire bricks .
- Slag being lighter is floats over the molten metal which is removed before the collection of molten metal . After the removal of slag , the molten metal is tapped out at the bottom of the furnace.

3. Refining of metal

- The process of removal of impurities from a crude metal is called **Refining.**
- The methods of refining to be employed/followed depends upon the nature of the metal.

(i) Distillation Method

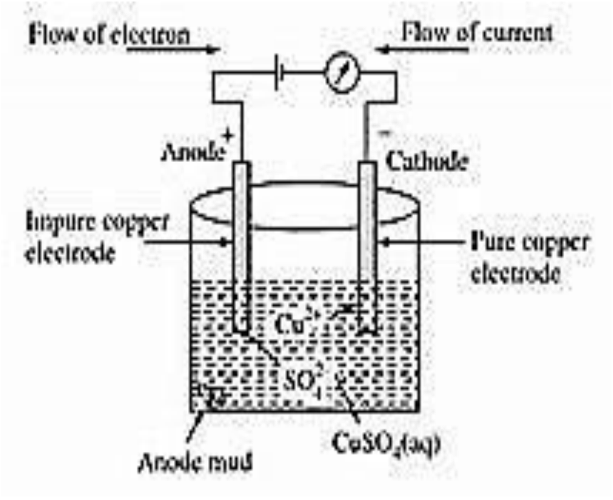
- This method of refining is employed for volatile metals like mercury, Zinc, lead , etc. containing non-volatile impurities.
- In this process, the pure metals volatilize while the impurities are left behind in the retort.

(ii) Electro- refining

- The process for refining metal in an electrolytic cell, in which the impure metal is used as the **anode** and the refined metal is deposited on the **cathode**.
- In this process a suitable electrolyte is chosen and put into an electrolyte cell.
- Now pure metal plate is dipped into the electrolyte and made the cathode.

- The impure metal is made the anode and a suitable e.m.f is applied.
- The pure metal from the electrolyte gets deposited on the cathode while an equivalent quantity of the metal from anode goes into the solution. (Shown in Figure-7).

Figure-7



[Electro- refining of Copper]

Short questions with answers

Q-1) Define Minerals and Ore./ What are Minerals and Ore ?
Give examples of each.

Ans: **Minerals**

- The natural materials in which the metals or their compounds are found in the earth's crust are called minerals.

Example

Minerals of Copper – i) Copper glance (Cu_2S)
ii) Cuprite (Cu_2O)
and iii) Copper pyrite ($CuFeS_2$)

Ore

- The minerals from which the metals can be extracted conveniently & profitably are called ore.

  Example

  1. $CuFeS_2$ (Copper pyrite) is the ore of Copper.
  2. Fe_2O_3 (Haematite) is the ore of Iron.

Q-2) Define Flux and Slag./ What are Flux and Slag ?
[2018(W/2nd)(N) , 2018(S)(O),

Ans: **Flux**

- The substance which combines with **impurities** (gangue) to form light and easily fusible materials is called **Flux**.

Slag

- The easily fusible material which is formed due to combination of gangue and flux, not soluble in the molten metal is called **slag.**

Q-3) Define Concentration ore and refining of Metal.
[2018(W/2nd)(N) ,

Ans: **Concentration ore**

- It is the process by which maximum quantity of gangue are removed from the ore.

Refining of Metal

- The process of removal of impurities from a crude metal is called **Refining.**

Q-4) Define Calcination and Roasting .
[2018(S/1st)(N) , 2019(S/2nd)(O),

Ans: **Calcination**

- It is a 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 point .
- It is the process by which maximum quantity of gangue are removed from the ore.

Roasting

- It is a process of heating the concentrated ore strongly in a controlled supply of oxygen .

- The Roasting process is carried out in a **reverberatory** furnace to get metal oxide.
- This process is generally used to convert sulphide ores into metal oxide along with sulphur dioxide is produced.

Q-5) What is the principle of Gravity Separation method of concentration of ore ?
[2019(S/1st)(O) , 2019(S/2nd)(O),

Ans: The principle of Gravity Separation involves the washing of the crushed ores with a running stream of water as a result of which the lighter gangue particles are washed away and the heavier ore particles settle down rapidly.

LONG QUESTIONS

Q-1) Define ore. Explain a suitable method to concentrate ore if the gangue and ore differ by their weights.

[2017(W/2nd)(N) ,

Q-2) Define Calcination. Discuss the functions of Calcination.
[2017(W/2nd)(N) ,

Q-3) Explain the process of leaching.
[2018(W/2nd)(N) ,

Q-4) Explain the magnetic separation method of ore.
[2018(S)(O) , 2019(S/2nd)(O) , 2020(S/1st)(N) ,

Q-5) Define Flux . What is acidic and basic flux ? Give two examples of each.
[2019(S/1st)(N) ,

Q-6) Write down a short note on :

(a) Calcination.

(b) Roasting.

(c) Magnetic separation process.

(d) Froth floatation method.

(e) Electro- refining.

CHAPTER- 8

ALLOYS

Learning Objectives :

- *Definition of alloy,*
- *Types of alloys (Ferro, Non-Ferro & Amalgam) with example*
- *Composition and uses of Brass , Bronze , Alnico ,Duralumin.*

- An alloy is a homogeneous mixture of two or more elements with metallic properties.
- "Alloys are solid solutions consisting of two or more metals, or metals and non-metals possessing metallic properties."

TYPES OF ALLOYS

1. Ferro alloys
2. Non-ferro alloys
3. Amalgam

1. Ferro alloys

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

Example

1. Stainless steel
2. Nickel steel
3. Chrome steel
4. Stellites

2. Non- Ferro alloys

- The alloys which do not contain iron as one of the major components are called **non- ferro alloys.**

Examples

1. Brass
2. Bronze
3. German silver

3. Amalgam

- The alloys which contain mercury as one of the components are called **Amalgam.**
- Amalgams are formed by treating metals such as Sodium, Copper, Tin etc. with mercury.
- Amalgams of different metals are used for different purposes.

Examples

1. Copper amalgams are used for filling dental cavities.
2. Tin amalgams are used for silvering cheap mirrors.

NOTE

Iron does not form amalgam with mercury. So, mercury can beTransported in iron vessels.

COMPOSITION AND USES OF BRASS, BRONZE, ALNICO AND DURALUMIN

1. Brass

- The composition of Brass is –

Cu = 60 – 80 %
Zn = 40 -- 20%

USES

i) It is used for making Utensils .

ii) It is used for making Condenser tube.

iii) It is used for making Catridges.

2. Bronze

- The composition of Bronze is –

Cu = 75 – 90 %
Zn = 25 --10%

USES

i) It is used for making Utensils .

ii) It is used for making Coin.

iii) It is used for making Statues.

3. Alnico

- The composition of Alnico is –

Steel = 50 %
Ni = 21%
Al = 20 %
Co = 9 %

USES

- It is used for making Permanent magnet.

4. Duralumin

- The composition of Duralumin is –

Al = 90 %
Cu = 4%
Mn = 0.5 %

Mg = 0.5 %

USES

i) It is used in aircraft construction.

ii) It is used for making Surgical instruments.

iii) It is used for making Light weight vehicular parts.

SHORT QUESTIONS WITH ANSWERS

Q- 1) Define Alloy.

Ans- Alloys are solid solutions consisting of two or more metals, or metals and non-metals possessing metallic properties.

Q- 2) What are Ferro-alloy? Give two examples.

[2018(S/1st)(N),

Ans- **Ferro alloys**

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

  Examples

  1. Stainless steel
  2. Nickel steel
  3. Chrome steel
  4. Stellites

Q- 3) What are Non ferro-alloy ?

Ans. **Non- Ferro alloys**

- The alloys which do not contain iron as one of the major components are called **non- ferro alloys.**

  Examples

  1. Brass
  2. Bronze
  3. German silver

Q- 4) What are Amalgams ?/ What do you mean Amalgams ?

[2018(S)(O),

Ans. <u>Amalgam</u>

- The alloys which contain mercury as one of the components are called **<u>Amalgam.</u>**

<u>Examples</u>

1. Copper amalgams are used for filling dental cavities.
2. Tin amalgams are used for silvering cheap mirrors

Q- 5) What are Amalgams and alloys ?

[2019(W/1st)(N),

Ans. <u>Amalgam</u>

- The alloys which contain mercury as one of the components are called **<u>Amalgam.</u>**

. **<u>Alloys</u>**

- **Alloys** are solid solutions consisting of two or more metals, or metals and non-metals possessing metallic properties.

<u>LONG QUESTIONS</u>

Q-1) Define Alloy./ What are Alloys ? Mention/Classify different types of alloys with examples. Explain the composition and uses of Alnico , Duralumin, Brass, Bronze .

[2017(W)(N), 2018(S)(O), 2019(S/1st)(O), 2019(S/2nd)(O)(N) ,

Q-2) Write the advantages of alloys over metals.

[2019(S/1st)(N),

Q-3) Write the preparation of Alloy.

[2018(W/2nd)(N) ,

CHAPTER-9

Organic Chemistry

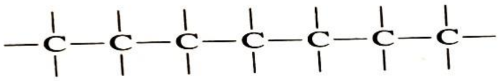
Learning Objectives

- *Hydrocarbons: Saturated and Unsaturated Hydrocarbons (Definition with example)*
- *Aliphatic and Aromatic Hydrocarbons (Huckel's rule only).*
- *Difference between Aliphatic and aromatic hydrocarbons.*
- *IUPAC System of nomenclature of Alkane, Alkane, Alkane, Alkyl halide and Alcohol(up to 6 carbons) with bond line notation .*
- *Uses of some common aromatic compounds (Benzene, Toluene ,BHC , Phenol , Naphthalene, Anthracene and Benzoic acid) in daily life.*

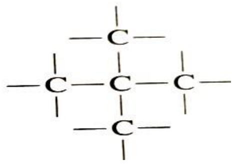
- "Organic Chemistry is defined as the chemistry of co-valently bonded carbon compounds other than carbides , carbonates and oxides of carbon ."
- $_6C = 2 , 4$
  $= 1s^2 , 2s^2, 2p^2$

There are **four** electrons in the valence shell of C-atom . So, C-atom is tetra-valent.

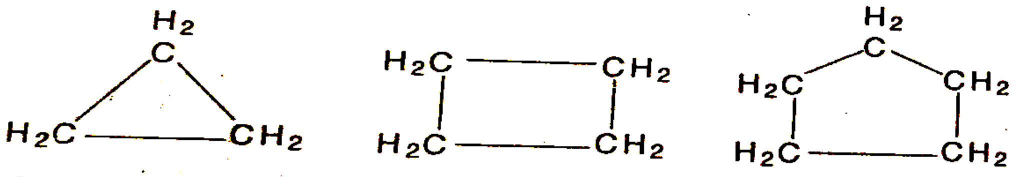
- C- atoms under goes self- linking process to form long Carbon- Chain which is called **catenation.**
- Due to catenation, carbon atoms are linked to form straight chain , branched chain or rings .



(Straight Chain)



(Branched Chain)



CYCLOPROPANE CYCLOBUTANE CYCLOPENTANE

(Ring or Cyclic Compounds)

Hydrocarbon

- The binary compounds of carbon & hydrogen is known as **hydrocarbon .**
- The Hydrocarbons are of two types –

1) Acyclic Hydrocarbons (Aliphatic Compounds)

2) Cyclic Hydrocarbons (Ring Compounds)

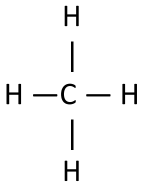
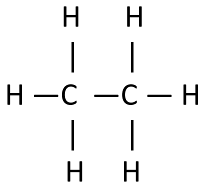
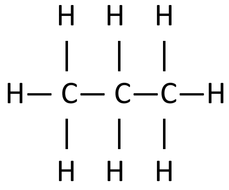
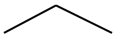
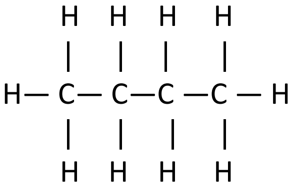
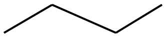
Aliphatic Hydrocarbon

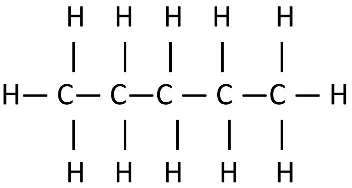
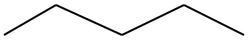
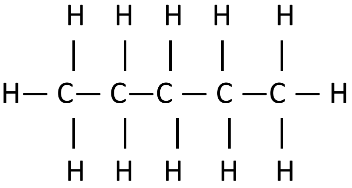
- The open chain hydrocarbon is known as Aliphatic Hydrocarbon.
- The Aliphatic Hydrocarbons are of two types –
  1) Saturated Hydrocarbon .
  2) Unsaturated Hydrocarbon .

1) Saturated Hydrocarbon (Alkane)

- **" The open chain hydrocarbon in which each C-atom in the carbon chain is attached by single co-valent bond only is known as Saturated Hydrocarbon."**
- The saturated hydrocarbon is known as **alkane** .
- The general formula of Alkane is C_nH_{2n+2}.
  where , n = 1 , 2 , 3 , ...

ALKANE

No. of C-atom (value of 'n')	Formula of Alkane (C_nH_{2n+2})	Name of Alkane	Structure of Alkane	Condensed Formula of Alkane & Bond line Notation
1	CH_4	Methane	 $\begin{array}{ccc} & H & \\ & \vert & \\ H- & C & -H \\ & \vert & \\ & H & \end{array}$	$CH_3 - H$
2	C_2H_6	Ethane	 $\begin{array}{ccccc} & H & & H & \\ & \vert & & \vert & \\ H- & C & - & C & -H \\ & \vert & & \vert & \\ & H & & H & \end{array}$	CH_3-CH_3
3	C_3H_8	Propane	 $\begin{array}{ccccccc} & H & & H & & H & \\ & \vert & & \vert & & \vert & \\ H- & C & - & C & - & C & -H \\ & \vert & & \vert & & \vert & \\ & H & & H & & H & \end{array}$	$CH_3-CH_2-CH_3$ 
4	C_4H_{10}	Butane	 $\begin{array}{ccccccccc} & H & & H & & H & & H & \\ & \vert & & \vert & & \vert & & \vert & \\ H- & C & - & C & - & C & - & C & -H \\ & \vert & & \vert & & \vert & & \vert & \\ & H & & H & & H & & H & \end{array}$	$CH_3-CH_2-CH_2-CH_3$ 

5	C_5H_{12}	Pentane	 $H-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-H$	$CH_3—CH_2—CH_2—CH_2—CH_3$ 
5	C_6H_{14}	Hexane	 $H-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-H$	$CH_3\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_3$ 

2) Unsaturated Hydrocarbon

- **" The open chain hydrocarbon which contains at least one carbon-carbon double or triple bond in the carbon chain is known as Unsaturated Hydrocarbon ."**
- The unsaturated hydrocarbon in of two types -

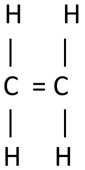
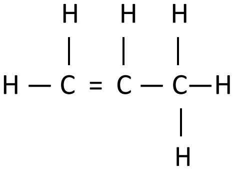
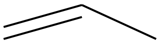
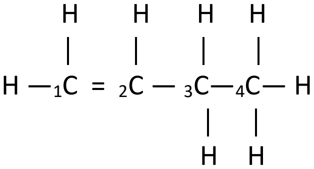
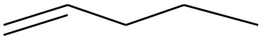
  i) Alkene

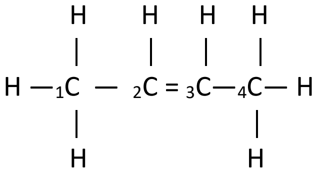
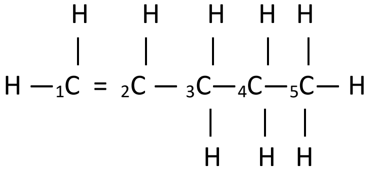
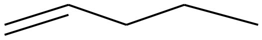
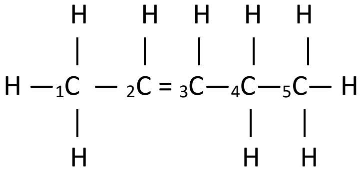
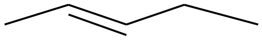
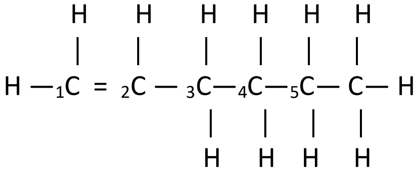
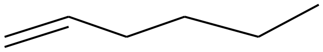
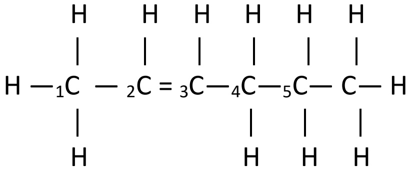
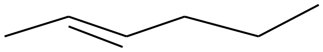
  ii) Alkyne

(i) ALKENE

- **The hydrocarbon in which there is at least one carbon- carbon bond (C=C) is known as Alkene .**
- The general formula of Alkene is $\mathbf{C_nH_{2n}}$.
  where, n = 2, 3, 4 , ………..

ALKENE

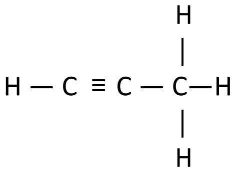
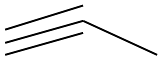
No. of C-atom (value of 'n')	Formula of Alkene (C_nH_{2n})	Name of Alkene	Structure of Alkene	Condensed Formula of Alkene & Bond line Notation
2	C_2H_4	Ethene (Ethylene)	 $\overset{H}{\underset{H}{C}}=\overset{H}{\underset{H}{C}}$	$CH_2= CH_2$
3	C_3H_6	Propene	 $H-\overset{H}{C}=\overset{H}{C}-\overset{H}{\underset{H}{C}}-H$	$CH_2= CH—CH_3$ 
4	C_4H_8	But-1-ene	 $H-{}_1\overset{H}{C}={}_2\overset{H}{C}-{}_3\overset{H}{\underset{H}{C}}-{}_4\overset{H}{\underset{H}{C}}-H$	${}^1CH_2= {}^2CH—{}^3CH_2—{}^4CH_3$ 

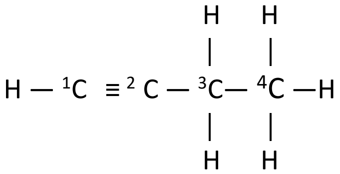
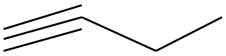
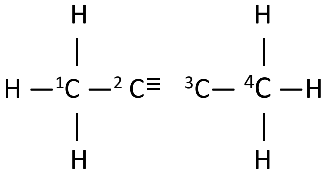
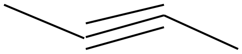
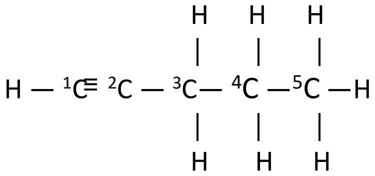
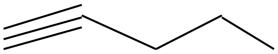
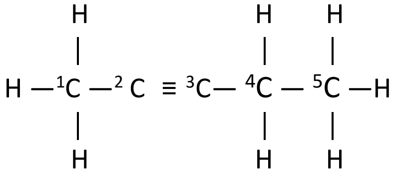
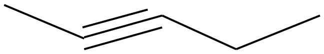
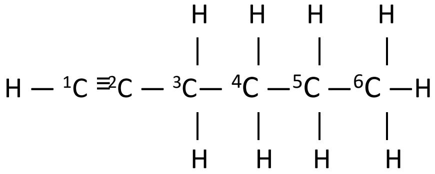
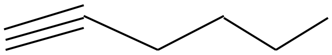
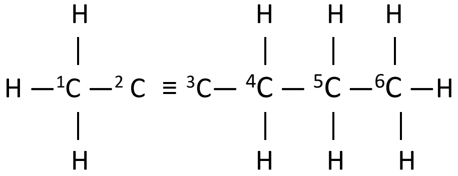
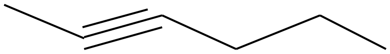
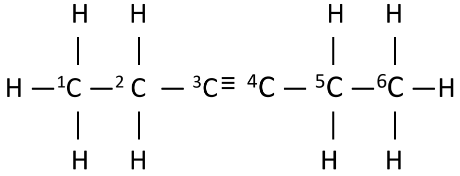
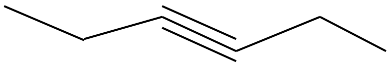
4	C_4H_8	But-2-ene	 $H-\underset{H}{\overset{H}{{}_1C}}-\overset{H}{{}_2C}={}\overset{H}{{}_3C}-\underset{H}{\overset{H}{{}_4C}}-H$	$^1CH_2-{}^2CH={}^3CH_2-{}^4CH_3$ 
5	C_5H_{10}	Pent-1-ene	 $H-\overset{H}{{}_1C}=\overset{H}{{}_2C}-\underset{H}{\overset{H}{{}_3C}}-\underset{H}{\overset{H}{{}_4C}}-\underset{H}{\overset{H}{{}_5C}}-H$	$^1CH_2={}^2CH-{}^3CH_2-{}^4CH_2-{}^5CH_3$ 
5	C_5H_{10}	Pent-2-ene	 $H-\underset{H}{\overset{H}{{}_1C}}-\overset{H}{{}_2C}={}\overset{H}{{}_3C}-\underset{H}{\overset{H}{{}_4C}}-\underset{H}{\overset{H}{{}_5C}}-H$	$^1CH_2-{}^2CH={}^3CH_2-{}^4CH_2-{}^5CH_3$ 
6	C_6H_{12}	Hex-1-ene	 $H-\overset{H}{{}_1C}=\overset{H}{{}_2C}-\underset{H}{\overset{H}{{}_3C}}-\underset{H}{\overset{H}{{}_4C}}-\underset{H}{\overset{H}{{}_5C}}-\underset{H}{\overset{H}{C}}-H$	$^1CH_2={}^2CH-{}^3CH_2-{}^4CH_2-{}^5CH_2-{}^6CH_3$ 
6	C_6H_{12}	Hex-2-ene	 $H-\underset{H}{\overset{H}{{}_1C}}-\overset{H}{{}_2C}={}\overset{H}{{}_3C}-\underset{H}{\overset{H}{{}_4C}}-\underset{H}{\overset{H}{{}_5C}}-\underset{H}{\overset{H}{C}}-H$	$^1CH_2-{}^2CH={}^3CH_2-{}^4CH_2-{}^5CH_2-{}^6CH_3$ 

(ii) ALKYNE

- **The open chain hydrocarbon in which there is at least one carbon-carbon triple bond ($C \equiv C$) is known as Alkyne .**
- The general formula of Alkyne is $\mathbf{C_nH_{2n-2}}$.
  where , n = 2 , 3 , 4 , - - - -

ALKYNE

No. of C-atom (value of 'n')	Formula of Alkyne (C_nH_{2n})	Name of Alkyne	Structure of Alkyne	Condensed Formula of Alkyne & Bond line Notation
2	C_2H_2	Ethyne (Acetylene)	$H-C\equiv C-H$	$CH_2=CH_2$
3	C_3H_4	Propyne	 $H-C\equiv C-\underset{H}{\overset{H}{C}}-H$	$CH\equiv C-CH_3$ 

4	C_4H_6	But-1-yne	 $H-{}^{1}C\equiv{}^{2}C-\underset{H}{\overset{H}{{}^{3}C}}-\underset{H}{\overset{H}{{}^{4}C}}-H$	${}^{1}CH\equiv{}^{2}C-{}^{3}CH_2-{}^{4}CH_3$ 
4	C_4H_6	But-2-yne	 $H-\underset{H}{\overset{H}{{}^{1}C}}-{}^{2}C\equiv{}^{3}C-\underset{H}{\overset{H}{{}^{4}C}}-H$	${}^{1}CH_3-{}^{2}C\equiv{}^{3}C-{}^{4}CH_3$ 
5	C_5H_8	Pent-1-yne	 $H-{}^{1}C\equiv{}^{2}C-\underset{H}{\overset{H}{{}^{3}C}}-\underset{H}{\overset{H}{{}^{4}C}}-\underset{H}{\overset{H}{{}^{5}C}}-H$	${}^{1}CH\equiv{}^{2}C-{}^{3}CH_2-{}^{4}CH_2-{}^{5}CH_3$ 
5	C_5H_8	Pent-2-yne	 $H-\underset{H}{\overset{H}{{}^{1}C}}-{}^{2}C\equiv{}^{3}C-\underset{H}{\overset{H}{{}^{4}C}}-\underset{H}{\overset{H}{{}^{5}C}}-H$	${}^{1}CH_3-{}^{2}C\equiv{}^{3}C-{}^{4}CH_2-{}^{5}CH_3$ 
6	C_6H_{10}	Hex-1-yne	 $H-{}^{1}C\equiv{}^{2}C-\underset{H}{\overset{H}{{}^{3}C}}-\underset{H}{\overset{H}{{}^{4}C}}-\underset{H}{\overset{H}{{}^{5}C}}-\underset{H}{\overset{H}{{}^{6}C}}-H$	${}^{1}CH\equiv{}^{2}C-{}^{3}CH_2-{}^{4}CH_2-{}^{5}CH_3-{}^{6}CH_3$ 
6	C_6H_{10}	Hex-2-yne	 $H-\underset{H}{\overset{H}{{}^{1}C}}-{}^{2}C\equiv{}^{3}C-\underset{H}{\overset{H}{{}^{4}C}}-\underset{H}{\overset{H}{{}^{5}C}}-\underset{H}{\overset{H}{{}^{6}C}}-H$	${}^{1}CH_3-{}^{2}C\equiv{}^{3}C-{}^{4}CH_2-{}^{5}CH_2-{}^{6}CH_3$ 
6	C_6H_{10}	Hex-3-yne	 $H-\underset{H}{\overset{H}{{}^{1}C}}-\underset{H}{\overset{H}{{}^{2}C}}-{}^{3}C\equiv{}^{4}C-\underset{H}{\overset{H}{{}^{5}C}}-\underset{H}{\overset{H}{{}^{6}C}}-H$	${}^{1}CH_3-{}^{2}CH_2-{}^{3}C\equiv{}^{4}C-{}^{5}CH_2-{}^{6}CH_3$ 

Alkyl Group (R–)

C_nH_{2n+2}– H ✂ C_nH_{2n+1}
(Alkane) (Alkyl Group)

- The alkyl Group is denoted by R – .
- 'R' is CH_3 - , CH_3-CH_2 – or C_2H_5 –
  (methyl) (Ethyl)

Alkyl halide(R –X)

- “**Alkyl halide is obtained by replacing H – atom (s) of alkane by halogen atom (s)** .”
- The general formula of alkyl halide is R – X

$$\underset{\text{Alkane}}{C_nH_{2n+1}-H} \xrightarrow[+\ X]{-H} \underset{\text{Alkyl halide}}{C_nH_{2n+1}X}$$

$$\underset{\text{Alkane}}{R-H} \xrightarrow[+X]{-H} \underset{\text{Alkyl halide}}{R-X}$$

where ,R = CH_3- , CH_3-CH_2- ,etc.

and, X = F , Cl , Br, I .

- The IUPAC (InternationalUnion of Pure and Applied Chemistry) name of Alkyl halide is “ Haloalkane” .

Example

1) CH_3-Cl

(Methyl chloride)← Common Name

Chloro methane← IUPAC Name

2) CH_3-CH_2-Br

(Ethyl bromide) ← Common Name

Bromo ethane ← IUPAC Name

Alcohol (R – OH)

- The alcohol is obtained by replacing H – atom of alkane by ‘OH’ group .
- The general formula of Alcohol is R – OH .

$$\underset{\text{Alkane}}{R-H} \xrightarrow[+OH]{-H} \underset{\text{Alcohol}}{R-OH}$$

- TheIUPAC nameof Alcohol is **Alkanol** .

Alkane + ol ⟶ Alkanol

Example

1) CH_3-OH

(Methyl alcohol) → Common Name

(Methanol) →IUPAC Name

2) CH_3- CH_2- OH

(Ethyl alcohol) →Common Name

(Ethanol) → IUPAC Name

AROMATIC COMPOUND

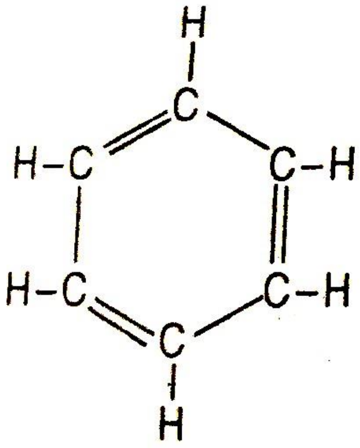
- **Aromatic compounds are the planar , ring compounds having (4n+2) ∏ electrons in alternate single and double bond system (conjugated system) , where n = 1,2,3, - - - and 'n' is the number of rings .**

- The possessionof(4n+2)∏electrons in aromatic ring as known as **Huckel's rule** .

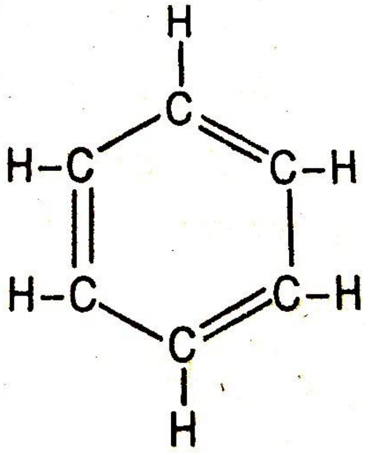
Example

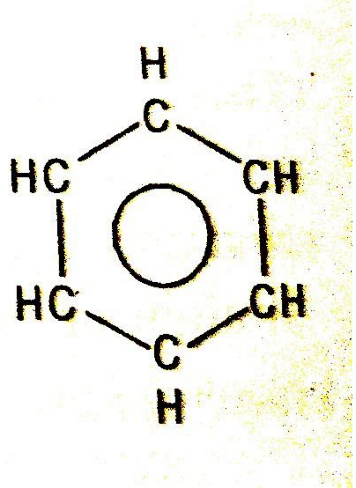
Let us consider the structure of Benzene (C_6H_6)

- The structure of Benzene may be written as -



OR





- For benzene , there are 6∏ electrons .

(4n+2) ∏= 6∏
⇨ 4n+2 = 6
⇨ 4n = 6-2
⇨ 4n = 4
⇨ n = 1

These are the hydrocarbons which obey Huckel's rule. They are known from their specific odour.

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
If $n = 2$, $(4 \times 2 + 2)\pi = 10\pi$ electrons
If $n = 3$, $(4 \times 3 + 2)\pi = 14\pi$ electrons

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

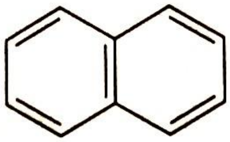
Example

(i)

Benzene (C_6H_6)

Since one bond is associated with two electrons and benzene contains three π bonds, it has $3 \times 2 = 6\pi$ electrons.

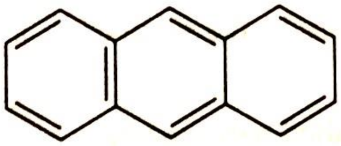
(ii)



Naphthalene ($C_{10}H_8$)

It contains $5 \times 2 = 10\pi$ electrons.

(iii)



Anthracene ($C_{14}H_{10}$)

It contains $7 \times 2 = 14\pi$ electrons.
Since benzene, naphthalene and anthracene contain 6π, 10π and 14π electrons, respectively, these are aromatic in nature according to Huckle's rule.
Other examples of aromatic compounds are pyrrole, furan, thiophene and pyridine, etc.

Examples of Aromatic compounds

Benzene (C_6H_6) , Toluene (C_6H_5– CH_3) , Phenol (C_6H_5– OH) , Benzoic Acid (C_6H_5 – COOH)

Napthalene ($C_{10}H_8$), Anthracene ($C_{14}H_{10}$) etc.

IUPAC*SYSTEM OF NOMENCLATURE*

- The system of giving names to Organic Compounds is called **Nomenclature.**
- The**IUPAC** System provides Rules **Nomenclature** of Organic Compounds .
- The full form of **IUPAC is International Union of Pure and Applied Chemistry**.
- According to the **IUPAC** System , the name of Organic Compounds consists of **three** Parts –
  - (a) Word root .
  - (b) Suffix
  - (c) Prefix

1. Word root

- The word root represents the number of carbon atoms presents in the selected Carbon chain i.elongest , continuous carbon chain.
- The number of C-atoms (n) and the corresponding ' **Word root'** are given in the In the following table.

No. of C-atoms (n)	Word root	No. of C-atoms (n)	Word root
1	Meth	6	Hex
2	Eth	7	Hept
3	Prop	8	Oct
4	But	9	Non
5	Pent	10	Dec

1. Suffix

- The **word root** is linked to the **Suffix** .
- The suffix is of two types –
  - (i) Primary Suffix
  - (ii) Secondary Suffix

(i) Primary Suffix

- The Primary Suffix indicates the types carbon-carbon linkages in carbon chain **.**

- The types carbon-carbon linkages in carbon chain **and** the corresponding **Primarysuffix** are given in the following table –

TYPES CARBON-CARBON LINKAGE	**PRIMARY SUFFIX**
C– C only	**ane**
C = C	**ene**
$C \equiv C$	**yne**

- If two or more double or triple bonds are present in the carbon chain then the numerical prefix ‘**di**’ for ‘**two’** , ‘**tri**’ for ‘**three’** , etc. are used before ‘ene’ or ‘ ‘yne’and are written as ‘**adiene**’ or ‘**atriene**’ .

(ii) Secondary Suffix

- The Secondary Suffix indicates the functional group present in the molecule.
- *“A functional group is defined as an atoms which gives the characteristic properties of an organic compound.* “
- The functional group **and** the corresponding**Secondary Suffix**are given in the following table –

Class of Organic Compound	**Functional Group**	**Name of Suffix**
Alcohol	– OH	– ol
Aldehydes	– C H O	– al
Carboxylic acid	– COOH	– oic acid

2.Prefix

- Prefixes are used to represent the name of alkyl groups or Lower Priority Functional groups (which are not regarded as principal fuctional groups) .
- It is used before the word root .

(a)

Alkyl group	**Prefix**
CH_3–	Methyl
$CH_3 – CH_2$–	Ethyl
$CH_3 – CH_2 – CH_2$–	Propyl

(b)

Functional Group	**Prefix**
– F	Fluoro
– Cl	Chloro
– Br	Bromo
– I	Iodo
– NO_2	Nitro

- The IUPAC name of Aliphatic Organic Compound is written as –
  Prefix (es) (alkyl group / lower priority functional groups) + Word root + Primary Suffix (ane / ene / yne) + Secondary Suffix (principal functional group)

- The **alkyl groups** are known as **Substituents**.
- If there is the repetitionof **Substituents or Primary Suffix (ene / yne) or functional groups then numerical prefix di , tri , tetra etc . are used with repetition of Position Numbers separated by commas i.e 1 , 2 , 3 , ...**

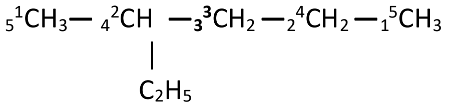
RULES FOR IUPAC NOMENCLATURE OF ALKANE, ALKANE ,ALKYNE, ALKYL HALIDE , ALCOHOL

RULE- 1(Longest Chain Rule)

- The longest , continuous carbon chain is to be selected which constitute the word root “Alk” .
- While selecting the longest , continuous carbon chain , the condensed alkyl groups like C_2H_5 – , C_3H_7 – etc . are to be expanded if needed .
- The selected carbon chain is numbered from both sides . The correct side of numbering is that , which provides minimum number to the substituents , double / triple bonded carbon atom , functional group .

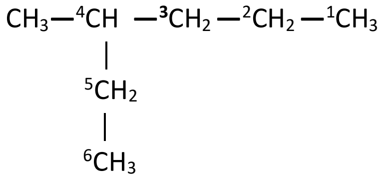
  Functional group >C=C / C — C>Alkyl substituents .
- The alkyl group which are not counted in the selected chain are treated as **substituents** along with halogen like groups i.e nitro group (– NO_2) and written as **prefix** .
- If , two or more same groups or substituents are present , then the numerical prefix , di - , tri-, tetra are used with repetition of the position numbers .

Example -1



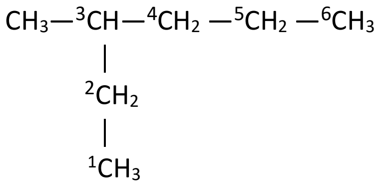
${}_5{}^1CH_3-{}_4{}^2\underset{\underset{C_2H_5}{|}}{CH}-{}_3{}^3CH_2-{}_2{}^4CH_2-{}_1{}^5CH_3$

Ethyl pentane(WRONG)



$CH_3-{}^4\underset{\underset{\underset{\underset{{}^6CH_3}{|}}{{}^5CH_2}}{|}}{CH}-{}^3CH_2-{}^2CH_2-{}^1CH_3$

4 - Methyl hexane (WRONG)



$CH_3-{}^3\underset{\underset{\underset{\underset{{}^1CH_3}{|}}{{}^2CH_2}}{|}}{CH}-{}^4CH_2-{}^5CH_2-{}^6CH_3$

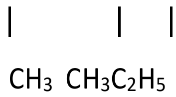
3- Methyl hexane (CORRECT)

2. RULE- 2 (Lowest Sum Rule)

- If there are two or more Substituents , then Lowest Sum Rule is applied i.e the main chain is numbered in such a way that the sum of the position numbers of the Substituents must be **Lowest**.
- If there are two or more same substituents present in the main chain then the Numerical prefix di , tri , tetra , etc. are to be written before the name of substituent with the repetition of position numbers.
- If there are two or more different substituents present in the main chain then the Numerical prefix di , tri , tetra , etc. are to be written before the name of substituent with the repetition of position numbers and the **substituents are written in alphabetical order.**
- **The First Letter of Numerical Prefix is not considered during alphabetical arrangement of substituents**
- The ‘ **comma** ‘ (,) is used between two numbers and ‘hyphen’ (-) is used between Numbers and name of substituents.
- .**No ‘ comma ‘ (,) or ‘hyphen’ (-) is used before Word root**.

Example -2

${}_6{}^1CH_3-{}_5{}^2CH-{}_4{}^3CH_2-{}_3{}^4CH-{}_2{}^5CH_2-{}_1{}^6CH_3$



$$\underset{CH_3}{|}\qquad\underset{CH_3}{|}\;\underset{C_2H_5}{|}$$

Sum of position Numbers (L✂ R): 2 + 3 + 4 = 9(Lowest)

Sum of position Numbers (R✂L) : 3 + 4 + 5 = 12

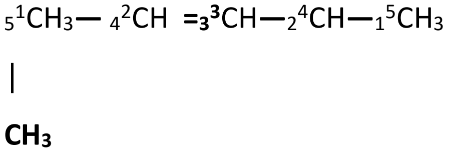
2, 3 – Dimethyl - 4 - ethyl hexane (WRONG)

4 - Ethyl -2, 3 – dimethyl hexane (CORRECT)

3. **<u>RULE- 3</u>(Naming of Unsaturated Hydrocarbon)**

- **I**f an aliphatic organic compound contains **C = C or C =C then the carbon Chain is numbered in such a manner that the C = C or C =C gets minimum** number **In the** carbon chain , irrespective of the position of the **substituents .**

<u>Example -3</u>

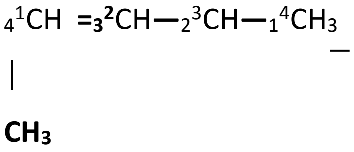


$$\underset{\displaystyle CH_3}{\underset{|}{{}_5{}^1CH_3}}—{}_4{}^2CH={}_3{}^3CH—{}_2{}^4CH—{}_1{}^5CH_3$$

2- Methyl pent -3 -ene (WRONG)

4 -Methyl pent -2-ene (CORRECT)

<u>Example - 4</u>



$$\underset{\displaystyle CH_3}{\underset{|}{{}_4{}^1CH}}={}_3{}^2CH—{}_2{}^3CH—{}_1{}^4CH_3$$

2- Methyl but - 3 - yne (WRONG)

3 - Methyl but - 2-yne (CORRECT)

- When both double bond and triple bond are present in a compound then the multiple bond which comes first in the main chain gets minimum number and it is named as **Alkenyne**.The terminal 'e' of 'ene' is dropped as it is follow by 'y' of 'yne' .

Example -5

${}_{5}{}^{1}CH={}_{4}{}^{2}C —{}_{3}{}^{3}CH={}_{2}{}^{4}CH—{}_{1}{}^{5}CH_3$

Pent -3 - en – 1- yne

- When both double bond and triple bond are present in a compound at equivalent position from both the end of the main chain , in such a case C=C gets minimum number in the main chain and it is named as **Alkenyne**. The terminal 'e' of 'ene' is dropped as it is followed by 'y' of 'yne'

  Example -6

${}_{4}{}^{1}CH={}_{3}{}^{2}C—{}_{2}{}^{3}C={}_{1}{}^{4}CH$

But -1 - en - 3 - yne

- When a main chain contains two double bonds (C=C) or two triple bonds (C=C) are present in a compound then the suffix called '**diene**' or '**triyne**' is attached to
  Word rootby adding the terminal **'a'** with it.

  Example -7

${}_{4}{}^{1}CH_2={}_{3}{}^{2}CH —{}_{2}{}^{3}CH={}_{1}{}^{4}CH_2$

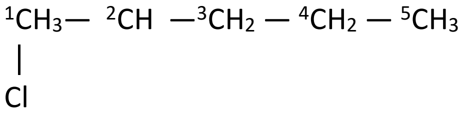
Buta -1 , 3 –diene

4 .RULE- 4 (Naming of Alkyl halide)

- The IUPAC name of Alkyl halide is **Haloalkane .**
- The halogen is treated as Substituent and written as Prefix with position number before the word root .
- If two or more different halogens are present in the main chain then they are written in alphabetical order with position number before the word root .
- If two or more same halogens are present in the main chain then the numerical prefix di , tri , etc are with repetition of position numbers and are written before the word root .

- **If halogen(s) are present along with carbon-carbon double bond or triple bond in the main chain then the C= C or C = C gets priority over halogens and named accordingl**y .

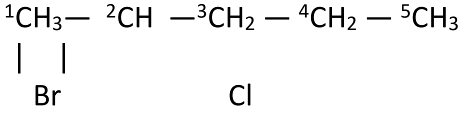
Example -8



$$\underset{Cl}{\underset{|}{^{1}CH_3}}-{}^{2}CH-{}^{3}CH_2-{}^{4}CH_2-{}^{5}CH_3$$

2- Chloropentane

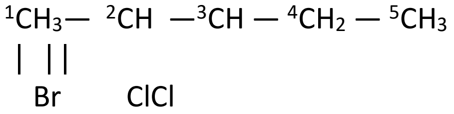
Example -9



$$\underset{Br}{\underset{|}{^{1}CH_3}}-\underset{|}{^{2}CH}-\underset{Cl}{^{3}CH_2}-{}^{4}CH_2-{}^{5}CH_3$$

2 –Bromo - 4- chloro pentane

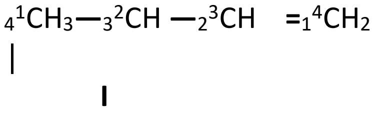
Example -10



$$\underset{Br}{\underset{|}{^{1}CH_3}}-\underset{Cl\,Cl}{\underset{|\,|}{^{2}CH}}-{}^{3}CH-{}^{4}CH_2-{}^{5}CH_3$$

2 -Bromo -3, 4- dichloro pentane

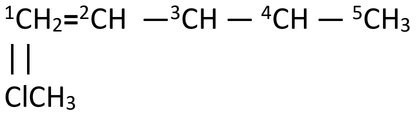
Example -11



$$\underset{|}{{}_{4}{}^{1}CH_3}-\underset{I}{{}_{3}{}^{2}CH}-{}_{2}{}^{3}CH={}_{1}{}^{4}CH_2$$

2- Iodobut -1 - ene

Example -12



$$\underset{Cl}{\underset{|}{^{1}CH_2}}=\underset{CH_3}{\underset{|}{^{2}CH}}-{}^{3}CH-{}^{4}CH-{}^{5}CH_3$$

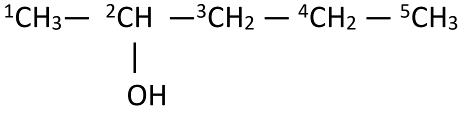
3- Chloro - 4-methyl pent-1-ene

5 .RULE- 5(Naming of Alcohol)

- The **IUPAC** name of Alcohol is **Alkanol.**

- Alcohol **is** written as Secondary Suffix .
- The Suffix for Alcohol is 'ol' which is attached to the Primary Suffix (ane / ene / yne) by dropping terminal 'e' .
- The functional group of Alcohol is **"– OH " .**
- Alcohol gets Priority over halogen , alkyl substituent and multiple bonds.

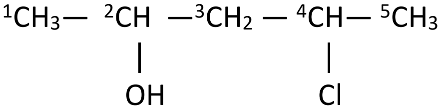
Example -13



$${}^{1}CH_3-{}^{2}\underset{\underset{OH}{|}}{C}H-{}^{3}CH_2-{}^{4}CH_2-{}^{5}CH_3$$

Pentan - 2- ol

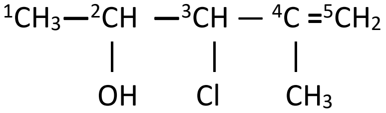
Example -14



$${}^{1}CH_3-{}^{2}\underset{\underset{OH}{|}}{C}H-{}^{3}CH_2-{}^{4}\underset{\underset{Cl}{|}}{C}H-{}^{5}CH_3$$

4- Chloropentan- 2- ol

Example -15



$${}^{1}CH_3-{}^{2}\underset{\underset{OH}{|}}{C}H-{}^{3}\underset{\underset{Cl}{|}}{C}H-{}^{4}\underset{\underset{CH_3}{|}}{C}={}^{5}CH_2$$

3- Chloro - 4-methyl pent - 4 - en- 1-ol

BOND LINE NOTATION

- IUPAC names are represented by Bond Line Notations.
- In bond line notations –

(i) Bonds are represented bylines .

- A single line represents a single bond .
- Two parallel lines represent double bond .
- Three parallel lines represent triple bond.

(ii) Carbon atoms are denoted by the line ends or line intersection's .

(iii) Hydrogen atoms are assumed to be present in the required number in order to satisfy the tetra covalency of carbon .

DIFFERENCE BETWEEN ALIPHATICCOMPOUNDS AND AROMATIC COMPOUNDS

ALIPHATIC COMPOUNDS	AROMATIC COMPOUNDS
1.**Aliphatic** compounds are open chain compounds .	1. **Aromatic** compounds are ring compounds with alternate single and double bonds i.e conjugated system.
2. These compounds does not follow Huckel' s rule .	2. These compounds follow Huckel' s rule .
3 . **Aliphatic** compounds have no pleasantodour.	3. **Aromatic**compounds have pleasantodour.
4 . **Aliphatic** compounds burns with non-sooty flame.	4 . **Aromatic** compounds burns with sooty flame.
5. The Carbon to hydrogen ratio is more in **aliphatic** compounds .	5. The Carbon to hydrogen ratio is less in **Aromatic** compounds .
Example Ethane , Propane , Butane , ... etc.	**Example** Benzene ,Napthalene , Toluene , ... etc.

USES OF SOME COMMON AROMATIC COMPOUNDS IN DAILY LIFE

1- Benzene

- It is used for dry cleaning of woolen cloth .
- It is used as a motor fuel alog with petrol
- It is used for preparation of phenol which is required for making Bakelite .

2- Toluene

- It is used for blending petrol .
- It is used as a solvent for synthetic resins and adhesives .

3-Benzene Hexa Chloride (BCH)

- It is used as insecticide .

4- Phenol

- It is used for Preparation of Bakelite
- It is used for preparation of Aspirin .
- It is used for preparation of various dyes .

5-Napthalene

- It is used as moth- balls to protect clothes from moth .
- It is used for the preparation of dyes , medicinal Products .

6-Anthracene

- Anthracene has fluorescent property so , it is used in criminal detection work .
- It is used for the preparation of Alizarin which is a dye .

7- Benzoic Acid

- It is used as germicide in medicines for urinary infection .
- It is used for preparation of sodium benzoate for preserving pickles , fruit juice .

SHORT QUESTIONS WITH ANSWERS

Q-1) What is Catenation ?

Ans- Carbon atoms under goes self- linking process to form long Carbon- Chain which is called **catenation .**

- Due to catenation, carbon atoms are linked to form straight chain , branched chain or rings

Q-2) Write the general formula of Alkane , Alkene , Alkyne .

[2009(W), 2019(S/1st)(O),

Ans-

- The general formula of Alkane is $\mathbf{C_nH_{2n+2}}$.
  where , n=1 , 2 , 3 , ...
- The general formula of Alkene is $\mathbf{C_nH_{2n+2}}$.
  where , n=2 , 3 , ...
- The general formula of Alkyne is $\mathbf{C_nH_{2n+2}}$.
  where , n=2 , 3 , ...

Q-3) What is alkyl halide ? Write its general formula .

[2009(W),

Ans-Alkyl halide is obtained by replacing H – atom (s) of alkane by halogen atom (s) .

- The general formula of alkyl halide is R – X.
  where , R = CH_3 – , CH_3 – CH_2 – , etc.
  and, X = F , Cl , Br, I .
- The IUPAC name of Alkyl halide is " Haloalkane" .

Q-4) What is Alcohol ? Write its general formula .

Ans- The alcohol is obtained by replacing H – atom of alkane by 'OH' group .

- The general formula of Alcohol is R – OH .
- The IUPAC name of Alcohol is **Alkanol** **.Q-**

5) What is Huckel's rule ?

Ans- The possession of (4n+2)∏ electrons in aromatic ring as known as

Huckel'srule , where n = 1,2,3, - - - and 'n' is the number of rings .

Q-6) What are Aromatic Compounds ? Give examples.

[2018(S/1st)(N),

Ans-Aromatic compounds are the planar , ring compounds having (4n+2) ∏ electrons in alternate single and double bond system (conjugated system) , where n = 1,2,3, - - - and ‘n’ is the number of rings .

Examples

Benzene (C_6H_6) , Toluene (C_6H_5– CH_3) , Phenol (C_6H_5– OH) ,

Benzoic Acid (C_6H_5 – COOH) , Naphthalene ($C_{10}H_8$), Anthracene ($C_{14}H_{10}$) etc.

LONG QUESTIONS

Q - 1) Distinguish between Aliphatic and Aromatic hydrocarbon.

[2017(W), 2018(S/1st)(O), 2019(S/2nd)(O),

Q -2) Write the general formula of Alkane , Alkene , Alkyne with examples.

Q-3) Write the Uses of the following compounds –

B.H.C , Benzoic acid , Phenol, Toluene and Naphthalene.

[2019(S/2nd)(N),

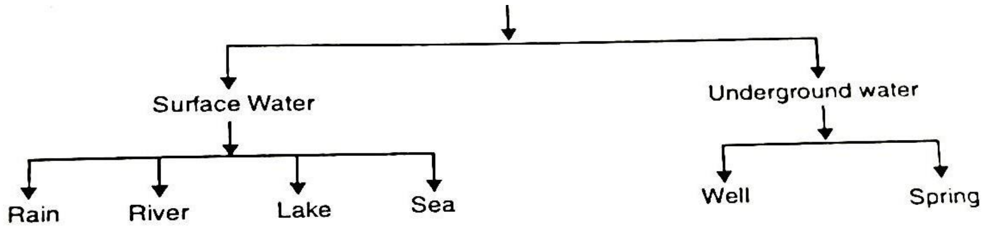
CHAPTER- 10

WATER TREATMENT

***Learning Objectives* :**

- *Sources of water, Soft water , Hard water*
- *Hardness, types of hardness ,(temporary or carbonate and permanent or non-carbonate)*
- *Removal of hardness by lime soda method (hot lime & cold lime – Principle , process& advantages)*
- *Advantages of hot lime over cold lime process.*
- *Organic ion exchange method (principle ,process & regeneration of exhausted resins)*

- Water is most abundantinEarth containing 75% of its surface.
- It is essential for the survival of all living beings on earth. It is not only essential for the survival of life, but it is also used for the operation in a large number of industries, agriculture & domestic purposes.



Sources of water

SOURCES OF WATER

- Water is available from different sources. It is classified into two types -

1.Surface water

2.Underground water.

A. Surface water

- Water found on the surface of earth in the form of oceans ,rivers , lakes , ponds and streams is called**Surface water.**

- It is of following types –

1. Rainwater

- Rainwater is the purest form of natural water.
- When the rain droplets fall,they dissolve gases like carbon dioxide (CO_2) ,oxidesof sulphur(SO_2,SO_3) and oxidesof nitrogen (NO_2) which make the rain slightly acidic.

$$CO_2+H_2O \longrightarrow H_2CO_3$$
$$SO_3+H_2O \longrightarrow H_2SO_4$$

2. River water

- Rivers are the most important naturally flowing water sources.
- Water in a river comes from rain , melting of snow on mountains or other sources .
- Itusually contains freshwater,flowing towards a sea, lake or another river.
- Rivers are alsonourished by surface runoff,through springs or from melting of glaciers.
- It contains high percentage of dissolved minerals like $NaCl$,KCl,$NaNO_3$,$CaCO_3$,$NaHCO_3$ etc.
- River water is the main source of water for industrial and domestic purpose.

3. Lake water

- Lake is a relatively large body of slowly moving or standing water that occupies an inland basin of appreciable size.
- The water in the Lake comes from rain water and melting of snow on mountains .
- Lake water contains lesser amounts of dissolvedmineralsas it is confined in a particular place.
- It contains considerable amount of suspended and organic matters.

4. Sea water

- Sea water is the water from seaor ocean.
- It is the most impure from of all naturally occurring water.

- It contains about 3.5% of dissolved minerals out of which about 2.5% is only NaCl.
- Sea water also contains a number of dissolved gases like nitrogen,oxygen,carbon dioxide and

noble gases .

- It contains biomaterials like carbohydrates,proteins, amino acids etc.
- It contains chlorides , bromides ,iodides , and bicarbonates of calcium and magnesium including

Sodium chloride.

B.Underground Water

- Underground water is the water which is present below the surface of Earth.
- A part of the rain water on the surface percolates into the earth . During its downward journey, it dissolves some minerals. This process continues till water reaches hard rock and deposited as Underground water.

or

- It is naturally replenished by rain and snow melt that seeps down into the cracks and crevices beneath the land's surface.
- Underground water is of two types –

1. Spring Water

- A spring is a natural outflow of water from an underground supply to the ground surface.
- It is a clearer from of natural water.
- It contains high percentage of minerals like magnesium,calcium,sodium and potassium & thus its hardness is very high.
- The spring water contains Sulphur in colloidal form . Due to germicidal action of sulphur , further contamination of water is prevented. So, this water is used as medicine against skin diseases.

2. Well water

- A well is a hole drilled , dug or driven into the earth to obtain groundwater.
- It is a clearer formof natural water.

- It contains many dissolved minerals and some organic matter.
- The well water is used for drinking purposes.

TYPES OF WATER

- Water is of three types-

1. Heavy water
2. Hard water
3. Soft water

1. Heavy water

- *Water which contains deuterium (an isotope of hydrogen) in place of hydrogen is called heavy water.*
- Heavy water is D_2O .
- It is used as a moderator in the nuclear reactor.

2. Hard water

- *The water which does not form lather with soap solution is called the **hard water** .*
- It forms curdy white precipitate with soap solution.
- It contains contains bicarbonates, chlorides and sulphates of calcium & magnesium.

Example

Sea water, Riverwater, Pondwater , etc.

3. Soft water

- *The water which forms lather with soap solution is called the **soft water** .*
- It does not contain bicarbonates, chlorides and sulphates of calcium &magnesium.

Example

Rain water, Distilled water, demineralisedwater etc.

HARDNESS OF WATER

- *It is the characteristic of water which prevents the lathering of soap due to the bicarbonate , sulphate and chlorides of calcium and magnesium in it .*

- Soap reacts with hard water as –

$2C_{17}H_{35}COONa + MgSO_4 \longrightarrow (C_{17}H_{35}COO)_2Mg + Na_2SO_4$

(Sodium stearate) (Impurity in Magnesium
Soap hard water) Stearate)

TYPES OF HARDNESS

- There are two types of hardness of water.

a) TemporaryHardness or Carbonate hardness

b) PermanentHardness or Non-carbonate hardness

1.Temporary Hardness of Water

- The temporary hardness of water is due to the presence bicarbonates of calcium & magnesium.
- It is named as temporary hardness because the soluble bicarbonates of calcium & magnesium

decomposes into insoluble carbonates simply on heating and the water becomes soft.

- It is also called **Carbonate hardness.**

2.Permanent Hardness of Water

- The permanent hardness of water is due to the presence chlorides & sulphates of calcium & magnesium.
- It is named as permanent hardness of water because the chlorides and sulphate present cannot be removed by simply on heating the water .
- The permanent hard water is also called as non-carbonate hardness of water.

UNITS OF HARDNESS

i) ppm – parts per million

ii) mg/L – milligrams per litre

SOFTENING OF WATER (REMOVAL OF HARDNESS)

- Water softening is the process of removing the dissolved calcium and magnesium salts that causes

Hardness in water.

REMOVAL OF HARDNESS OF WATER (SOFTENING OF WATER)

- It is the process of removal of dissolved salts i,e. bicarbonates, chlorides and sulphates of calcium & magnesium.
- The different methods used for softening of water depending upon the nature of dissolved salts are described as follows –

1) Removal of Hardness by Lime Soda Method

- Lime soda process is one of the water softener systems. In this system calcium hydroxide and soda ash are used as reagents.

- By this process soluble magnesium and calcium salts are removed as calcium carbonate and magnesium hydroxide precipitated. After removal of this precipitate, soft water is obtained.

- Both temporary water hardness and permanent water hardness are removed by this lime softening water softener systems.

- Before water treatment ,the amount of temporary and permanent water hardness is calculated , and then the amount of lime and soda ash is estimatedand added with careful control.

- In case of temporary hardness of water, the following reactions are take places -

$$Ca(HCO_3)_2 + Ca(OH)_2 \longrightarrow 2CaCO_3 + 2H_2O$$

$$Mg(HCO_3)_2 + Ca(OH)_2 \longrightarrow 2CaCO_3 + MgCO_3 + 2H_2O$$

$$MgCO_3 + Ca(OH)_2 \longrightarrow Mg(OH)_2 + CaCO_3$$

- In case of permanent hardness of water, the following reactions are take places -

$$CaSO_4 + Na_2CO_3 \longrightarrow CaCO_3 + Na_2SO_4$$

$$MgSO_4 + Na_2CO_3 \longrightarrow MgCO_3 + Na_2SO_4$$

$$MgCO_3 + Ca(OH)_2 \longrightarrow Mg(OH)_2 + CaCO_3$$

- There are two types of lime-soda process.
  i) Cold lime soda process
  and ii) hot lime soda process.

i) Cold lime soda process

Principle

- In the cold lime soda process, the hard water is treated with calculated quantity of lime and soda at room temperature.
- The soluble salt of calcium and magnesium present in hard water are converted into precipitate of calcium carbonate ($CaCO_3$) and magnesium hydroxide [$Mg(OH)_2$] which are removed by filtration and soft water is obtained .

$$CaCl_2 + Na_2CO_3 \longrightarrow CaCO_3 \downarrow + 2\,NaCl$$

(From hard water) Soda Precipitate

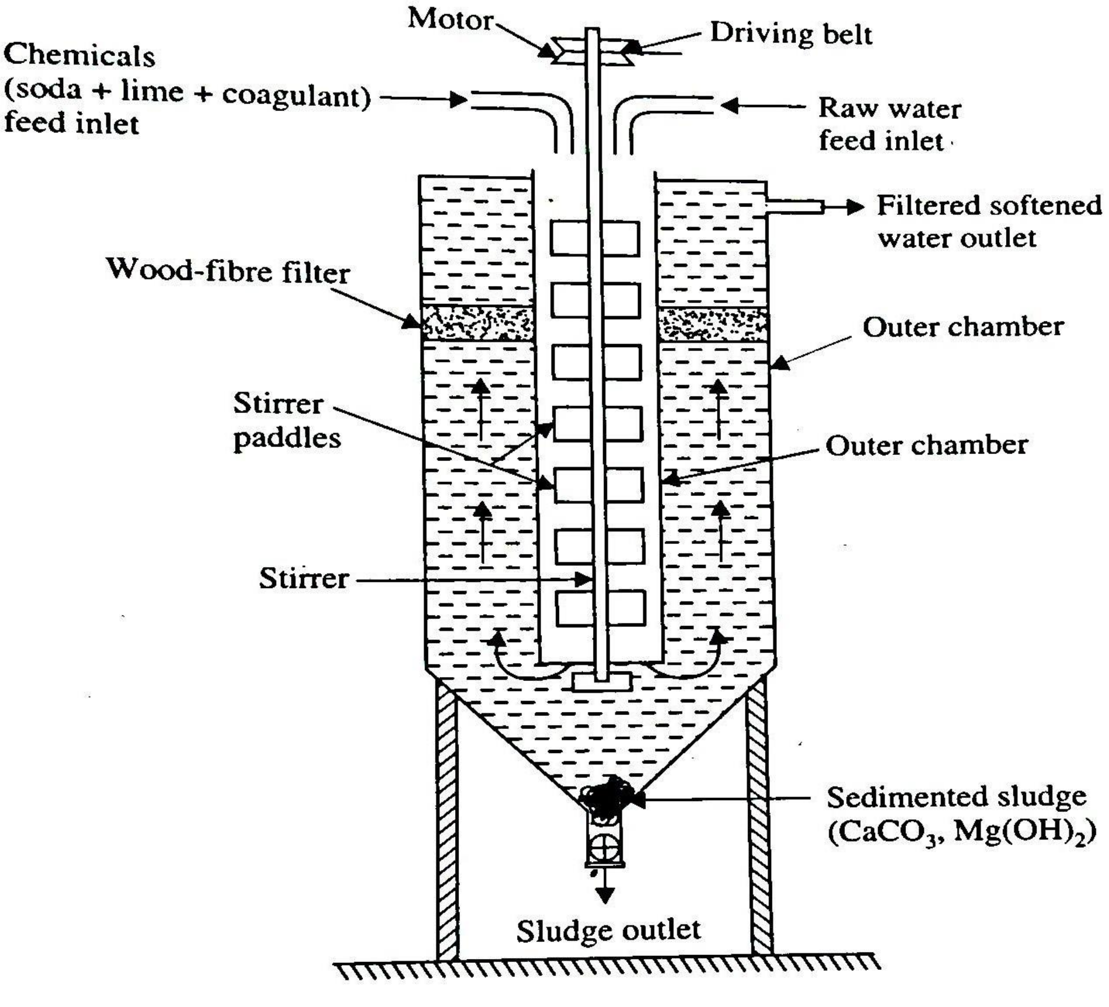
$$MgCO_3 + Ca(OH)_2 \longrightarrow Mg(OH)_2 + CaCl_2 \downarrow$$

(From hard water) Lime Precipitate

Process

- The apparatus consists of a conical shaped steel tank.(Shown in Figure -1)
- The raw water , lime , soda and coagulant like alum are added from the top inner vertical circular chamber which is fitted with rotating shaft carrying many paddles .

FIGURE-1



[Cold lime soda Process]

- The dissolved salts of calcium and magnesium combine with lime soda and coagulants and form an insoluble precipitate as sludge .

- Softened water rises upwards and heavy sludge settles down . The softened water passes through wood fibre filter and the filtered soft water is collected through the outlet.
- The sludge setting down at the bottom is removed.
- The processes is conducted at room temperature (at 25^0C).
- It takes about 24 hours to complete.
- The hardness left in the water is about 60 ppm. (parts per million).
- The cold lime soda process is used for municipal water and cooling water softener systems. The reason is that in case of municipal purpose, it is not necessary to remove all water hardness forming ions .

Disadvantages

1 .The cold lime soda process is not suitable for all purposes. It is limited for those purposes where partially softened water needed because this process fails to precipitate completely all the hardness forming salts.

2 . It is a slow process .

3 . It requires coagulants for setting particles of ppt. formed during reaction of water softening.

4 . Softening capacity is less in this process.

5 . Soft water obtained by this process consists of dissolved gases.

Advantages of cold lime soda process

1. It can be carried out by four ways. So as per necessary, its required type can be used.
2. Soft water obtained by this process has residual hardness about 50-60 ppm.

ii) Hot lime soda process

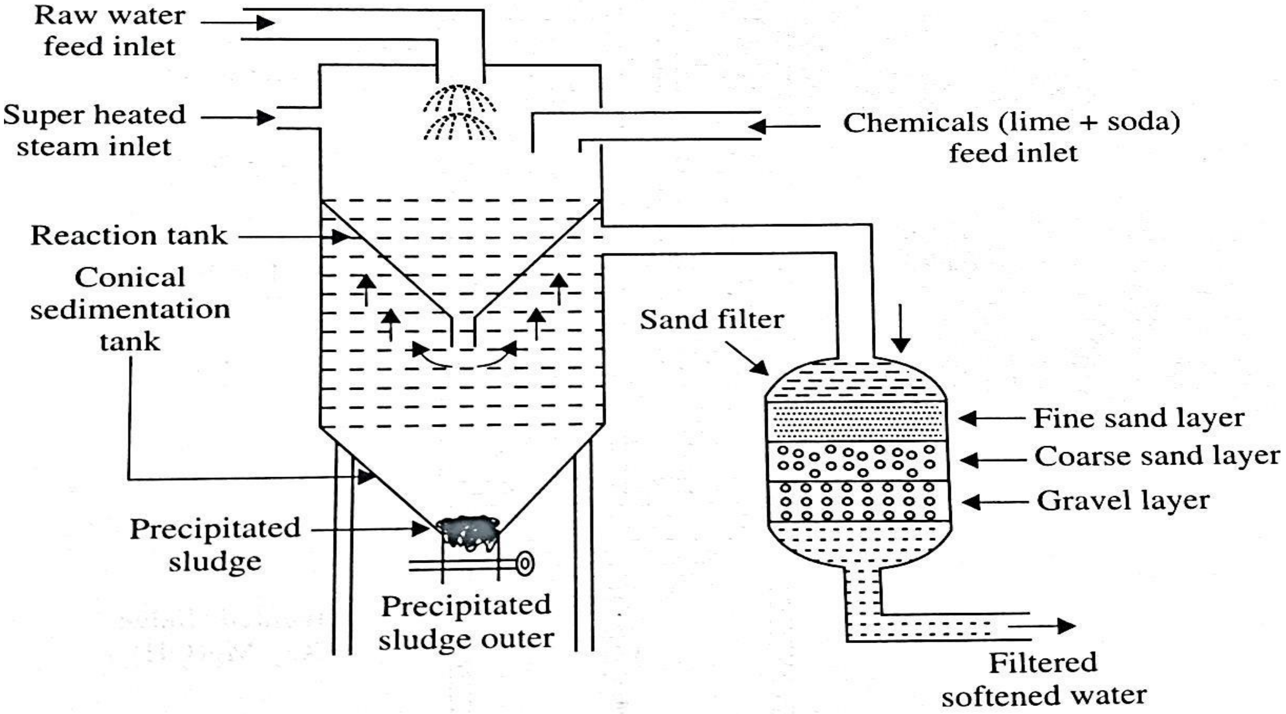
Principle

- In the hot lime soda process the reactions take place at higher temperature near about boiling point of water.
- In this process, hard water is treated with lime & soda at 80^0 - 150^0C.
- The process is faster & reaction gets completed within 15 minutes.

Process

- The apparatus consists of three parts -
  (i) 'Reaction tank ' in which complete mixing of ingradientstakes place .
  (ii)' Conical sedimentation vessel ' where the sludge settle down.
  (iii) 'Sand filter ' where the sludge is completely removed .(Shown in Figure -2)

FIGURE-2



[Hot lime soda process]

- The chemical mixing process is same as the cold lime soda process, i.e. the raw water , lime , soda are added but steam is applied in mixture tank. As a result, precipitation becomes almost complete very quickly. This process is more effective than cold lime soda process.
- In this process it is possible to remove magnesium water hardness completely and calcium hardness may be remains very low.
- The hot lime soda process water softener systems are exclusively used for boiler purpose.
- The dissolved corrosive gases also removed by hot lime soda process.

Advantages of Hot lime soda process

i)The viscosity of soft water is lower,hence filtered easily.

ii)The reaction takes place faster.

iii) The sludge settles rapidly.

iv) No coagulant is needed as the sludge settles down easily.

v)Dissolved gases are removed.

vi) Pathogenic bacterias are destroyed .

vii) The residual hardness left in this process is much lower (15-30 ppm) as compared to that in the cold lime soda (L-S) process(50-60 ppm) .

vii) It is much econmical.

Disavantages of Hot lime soda process

i) Huge amount of sludge is formed which is difficult for disposal.

ii) It removes hardness only upto 15ppm , which is not suitable for high pressure boilers.

iii) Careful calculation of additives are needed.

iv) For efficient and economical softening , careful operation and skilled supervision is required.

Advantages of Hot lime soda process over Cold lime soda process

i)The reaction takes place faster.

ii)The sludge settles rapidly.

iii) No coagulant is needed as the sludge settles down easily.

iv)Dissolved gases are removed.

v) The residual hardness low as compared to the cold lime soda process .

vi) The precipitation reaction becomes almost complete.

Difference between cold lime soda & hot lime soda process

Cold lime soda process	Hot lime soda process
1. This process is coducted at roomTempreture(25^{o}C)	1.The process is conducted at high tempreture80^{o} -150^{o}C .
2. Coagulant like alum is neededin it.	2.No co agulant is needed in it.
3.It takes 24 hours to complete.	3.It takes 15 minutets to complete.
4.Hardness left in the water is about 50-60ppm.	4.Hardness left in this process is 15-30 ppm .
5. Filtration is comparatively slower.	5. Under hot condition ,the viscosity of soft water is lower,hence filtered easily.
6. Pathogenic bacterias are not destroyed .	6. Pathogenic bacterias, if any , are destroyed .
7. The residual hardness left in this process is much higher i.e 50-60 ppm .	7. The residual hardness left in this process is much lower i.e 15-30 ppm.
8. It is costlier.	8. It is much econmical.

Ion-Exchange Process

- This is the most modern method of softening water.

- In this method , the ions responsible for hardness are exchanged with other ions which donot make water hard.
- Temporary as well as permanent hardness of water can be removed with the help of two types of ion exchangers -

1. Organic ion exchangers called ion exchange resins.

2. Inorganic ion exchangers such as permutits, calgon etc.

Organic ion exchange method

- This method involves Organic Ion- exchangers i.e Ion- exchange resins which are organic polymers having –

(i) high molecular weight .
(ii) open and permeable molecular structure.
(iii) acidic (-COOH , - SO_3H) or basic groups (-OH , -NH_2) attached with them.

- In this method, the hardness is removed in two steps –

1.Cation exchange resins

- Resins containing acidic groups like -COOH or - SO_3H group are called Cation exchange resins .
- The active part in a Cation exchange resins is a cation .

Example

Resin-H^+

2.Anion exchange resins

- Resins containing basic groups like -OH , -NH_2group are called Anion exchange resins .
- The active part in a Anion exchange resins is anAnion .

Example

Resin-OH^-

Process

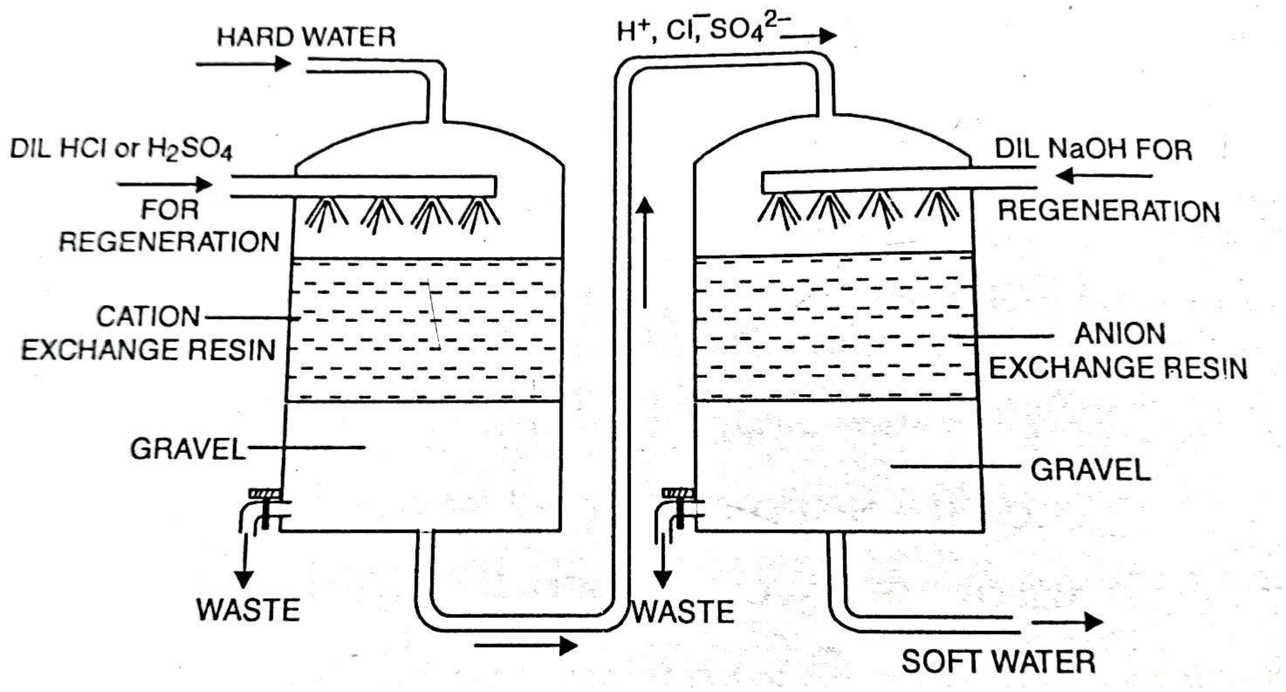
(i) Removal of Cations from hard water

- The ion exchange unit as shown in Figure-3 consists of two tanks , containing cation exchange resin and anion exchange resin.
- First , the hard water is passed through a column of cation exchange resin.
- All the cations present in the hard water are exchanged with the Resin-H^+ .

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

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

FIGURE-3



[Organic ion exchange]

(ii) Removal of Anions from cation free water

- The cation free water is now allowed to passthrough the column of anion exchange resin.
- All the anions present in the water get exchanged with the $OH^-$of the Resin.

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

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

- H^+ and OH^- ions released from the cation and anion exchange columns respectively get combined to produce water molecules.

$H^+ + OH^- \quad H_2O \quad \longrightarrow$

- **The water coming out from the exchanger is free from cations as well as anion which is known as deionized or demineralized water.**

Regeneration of resins

- When all H^+ and OH^- ions of the resins are exchanged by the cations and anionspresent in hard water , then the resins are said to be exhausted and regeneration can be done .

- The cation exchange resin is regenerated by the treatment with dil. HCl or dil. H_2SO_4

. Ca(resin)$_2$ + 2HCl2H$^+$ resin$\rightarrow$+ $CaCl_2$

(Exhausted(Regenerated

resin) resin)

- The anion exchange resin is regenerated by the treatment with dil. NaOH.

Cl-resin + NaOHOH$^-$ resin + NaCl$\rightarrow$

(Exhausted(Regenerated

resin) resin)

- The regenerated resins may be used again .

SHORT QUESTIONS WITH ANSWERS

Q-1)Which one is the purest form of water available on the surface and write down the name of the gases it contains.

[**2010 (W/1st) ,**

Ans-Rain water is the purest form of natural wateravailable on the surface.

- When the rain droplets fall, they dissolve gases like carbon dioxide (CO_2) , oxides of sulphur(SO_2,SO_3) and oxides of nitrogen (NO_2) .

Q-2)What is hardness ? Which chemical substances are responsible for the permanenthardness of water ?
[2017 (W/2nd) , 2018 (S/1st) (N) ,
Ans-<u>HARDNESS OF WATER</u>

- It is the characteristic of water which prevents the lathering of soap .

- The chemical substances are responsible for the permanent hardness of waterare bicarbonate , sulphate and chlorides of calcium and magnesium in it .

Q-3)Define hard water and hardness of water .
[2018 (W/2nd) ,
Ans-<u>HARD WATER</u>
- It is the type of water whichdoes not form lather with soap solution.

<u>HARDNESS OF WATER</u>
- It is the characteristic of water which prevents the lathering of soap .

Q-4) Define soft waterand hard water with example .
Ans.<u>**Soft water**</u>
- It is the type of water which forms lather with soap solution.

<u>**Examples**</u>

Rain water, Distilled water, demineralised water etc.

<u>**Hard water**</u>
- It is the type of water whichdoes not form lather with soap solution.

<u>**Example**</u>

Sea water, River water, Pond water etc.

Q-5) What do you mean by temporary hard water and permanent hard water?
Ans.<u>**Temporary hard water**</u>
- It is the type of water which contains bicarbonates of calcium & magnesium.

<u>**Permanent hard water**</u>
- It is the water which contains chlorides & sulphates of Calcium & Magnesium.

Q-6) How Na_2CO_3 removes permanent hardness from water ?
[2019 (S/2nd)(N),

Ans-

Na_2CO_3 removes permanent hardness from waterby reactingwith the chlorides and sulphates of calcium and magnesium (causing permanent hardness)present in hard water are converted into precipitate of calcium carbonate ($CaCO_3$) and magnesium carbonate ($MgCO_3$) which are removed by filtration and soft water is obtained .

$CaCl_2 + Na_2CO_3\ CaCO_3 + \longrightarrow 2\ NaCl \quad \downarrow$

(From hard water)   Soda   Precipitate

$MgSO_4 + Na_2CO_3 \quad MgCO_3 + \longrightarrow Na_2SO_4 \quad \downarrow$

(From hard water)	Soda	Precipitate

LONG TYPE QUESTIONS.

Q-1) Define soft water and hard water with example . Discuss the causes of hardness of water . Explain how temporary hardness water can be removed / eliminated.
[**2017 (W)(N) ,**

Q-2) Explain Cold lime soda process of removal of hardness from water with neat and labelled diagram.
[**2017 (W)(N) ,2020 (W)(N/1st) ,**

Q-3) Write down the advantages of hot lime soda process over cold lime soda process.
[**2018 (W/2nd)(N) ,**

Q-4)Write down the difference between cold lime soda & hot lime soda method.
[**2018 (W/2nd)(N) ,2019 (W)(N/1st) ,**

Q-5)Explain the regeneration process of exhausted ion-exchange resins.

[**2018 (S/1st)(N) ,**

CHAPTER-11

LUBRICANT

Learning Objectives :

- *Definition of lubricant*
- *Types (Solid ,liquid ,and semisolid with examples only) and*
- *specific uses of lubricants (Graphite ,Oils , Grease)*
- *Purpose of lubrication*

- A lubricantis the one which is capable of reducing the friction between two sliding or moving over each other.
- A lubricant is the substance which is introduced among two sliding surfaces to reduce the frictional resistance.
- The process of introducing lubricant is called lubrication.

TYPES OF LUBRICANT

- There are three types of lubricants -

1. Solid lubricant
2. Liquid lubricant
3. Semi solid lubricant

1. Solid lubricant

- The lubricants which are used basically in solid form or powdered form is known as **solid lubricant.**
- These solid lubricants fill up the lower spots in the surfaces of moving parts which forms a solid film which exhibits low frictional resistance.

Example

Graphaite, Molybdenum disulphide, wax etc.

2. Liquid lubricant

- It is a common type of lubricant which is neither powdered like structure nor solid type, rather it is a fluid like structure.
- This type of lubricant provides a uniform film form between the metal- metal points,by which it reduces friction.

Example

Petrolium oil, vegitable oil, animal oil etc.

3. Semi solid lubricant

- Semisolid lubricants are the lubricating substance which is neither solid nor fluid like at normal atmospheric temperation.
- It is paste like structure.

Example

Grease, silica gel , vaseline etc.

SPECIFIC USES OF SOME LUBRICANTS

1. Graphaite

- Graphaite is a good conductor of electricity so, it is used for making electrode in dry cell,electrolyte cell etc.

- It is very soft & slipperyso, it is used for lubricant & in grease.

- It has high melting point thus used in making graphaite crucibles for melting of metals.
- It is used for carbon brushes used in dynamo
- It is used for moderate the speed of the fast moving neutrons in nuclear reactors.
- It is used in making lead pencils.

2. Lubricating oil

- It prevents the metal surface corrosion.
- It helps in controlling the friction between load bearing surfaces.
- It helps in reducing the temp by carrying away heat from friction & combustion of fuel.
- It reduces operation noise.

3. Grease

- The function of grease is to remain in contact with and lubricate moving surfaces without leaking out under the force of gravity, centrifugal action or being squeezed out under pressure.
- Its major practical requirement is that it retains its **properties** under shear forces at all temperatures it experiences during use.

PURPOSE OF LUBRICATION

- The main purpose of lubrications are -

1. To save power consumption.
2. To prevent the wear & tear of sliding bodies.
3. To reduce the expansion of metallic bodies.
4. To remove the heat of friction.
5. To reduce the frictional resistance of the moving bodies.

SHORT TYPE QUESTIONS AND ANSWERS

Q-1) Define / What are lubricants ? Give examples of Solid lubricants.
[2020(W/N) ,

Ans. A lubricant is the one which is capable of reducing the friction between two sliding or moving over each other.

Example

Oil, grease ,wax etc..

Q-2) Write down the types of lubricant with examples .

Ans. There are three types of lubricants -

1) Solid lubricant (Ex-Graphaite,Molybdenum disulphide)
2) Liquid lubricant (Petroleum oil,Vegitable oil)
3) Semi solid lubricant (Grease,Vaseline)

Q-3) Write the functions of Lubricants .
[2018(W)(O),
Ans. The main functions of Lubricants are -

1. To save power consumption.
2. To prevent the wear & tear of sliding bodies.
3. To reduce the expansion of metallic bodies.
4. To remove the heat of friction.
5. To reduce the frictional resistance of the moving bodies.

LONG QUESTIONS

Q-1. What are lubricants ? Write down the purpose of lubrication .

[2018(W)(N/BP), 2019(W/1st)(N) , 2020(W/1st)(N),

Q-2) Write down the uses of the following lubricants .
i)Grease,ii)Graphaite ,iii) Oil

Q-3) What are greases? Write the Component of greases.
[2018(W/2nd)(N),

CHAPTER-12

FUEL

Learning Objectives :

- *Definiton and classification of fuel*
- *Definition of calorific value of fuel*
- *Choice of good fuel*
- *Liquid : Diesel , Petrol and Kerosene – Composition and uses*
- *Gaseous : Producer gas and Water gas (Composition and uses)*
- *Elementary idea about LPG ,CNG and Coal gas (Composition and uses only)*

Introduction

- A fuel is a source of energy. It may be chemical fuel or nuclear fuel.
- All the type of fuels are combustible substance.Generally carbon & hydrogen in the fuel produce carbon dioxide & water along with a large quantity of heat.

Definition

- A fuel may be defined as any substance which on combustion release a large amount of heat energy without producing excess residue or by-product.
- This energy can be used in various domestic as well as industrial purposes.
- The fuel commonly used contain carbon as the main constituents particle.

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

CLASSIFICATION OF FUEL

- Fuels are classified in two ways

(i) on the basis of occurence

(ii) on the basis of physical state

(i) On the basis of occurence

(a) Natural or Primary fuels

Example

Wood, Peat ,Coal, Natural gas.

(b) Artificial or Secondary fuels

- It is prepared from Primary fuels.

Example

Charcoal , Coke ,Kerosene ,Petrol ,Producer gas etc.

(ii) On the basis of physical state

(a) Solid fuel

Example

Wood, Peat ,Coal, Charcoal , Coke etc.

(b) Liquid fuel

Example

Kerosene ,Petrol , etc.

(c) Gas fuel

Example

Natural gas, Producer gas etc.

Calorific value of a fuel

- The chemical reactions used to produce heat are combustion reactions.
- The energy released when a fuel is burnt is known as its fuel value or calorific value.
- Calorific value of a fuel is defined as the amount of heat energy released by the complete combustion of one gram of the fuel at constant pressure.

Example

Wood, Peat ,Coal, Natural gas.

Units of calorific value

(i) In case of solid & liquid fuel the units of calorific values are calorie/gm or kcal/gm.

- It may be expressed in British thermal unit/pound or B.Th.U/lb

(ii)In gaseous fuel case it is expressed as kilocalorie/cubic meter or kcal/m^3.

- It may be expressed as B.Th.U/Ft^3.

Choice of a good fuel

- A good fuel is one which possess the following characteristics -

1. It should have high calorific value.

2. It should have controllable combustion rate.

3. The ignition temperature should be moderate.

4. It should contain minimum quantity of moisture.

5. It should leave only small amount of residue or ash when burnt.

6. Products of combustion should not be harmful.

7. It should be cheap & easy to transport.

COMPOSITION & USES OF SOME LIQUID FUEL

1) Diesel

- It is a fraction obtained between 250^0 –320^0C & is a mixture of $C_{15}H_{32}$(decapentane) to $C_{18}H_{38}$(decaoctane) .
- The average composition of diesel is -

C = 85%
H = 12%
Rest = 03 %

- It's calorific value is 11,000 kcal/kg
- It is used as a fuel in diesel engine.

2. Petrol

- It is obtained between 40 – 120^0 C& is a mixture of hydrocarbons such as C_5H_{12} (pentane) to C_8H_{18} (octane).
- The average composition is -

C = 84%
H = 15%
N + S +O = 1%

- It's calorific value is 11,250 kcal/kg.
- It is used as fuel for I C (internal combustion) engines of automobiles & aeroplane.

3. Kerosene

- It is the fraction obtained between 180^0-250^0 C & a mixture of hydrocarbon $C_{10}H_{22}$(decane) to $C_{16}H_{39}$(hexadecane) .
- The average composition is -

C = 84%

H = 16%

S ≤ 1%

- It's calorific value is 11,100 kcal/kg.
- It is used as domestic fuel & jet engines fuel for making oil gas.

COMPOSITION & USES OF SOME GASEOUS FUEL

1. Water gas

- Water gas is essentially a mixture of combustible gases ,CO & H_2 with a little non-combustible gases, CO_2 & N_2 .
- It is made by passing alternatively steam & little air through a bed of red hot coke or coal maintained at about 900^0C to 1000^0C.
- The average composition is -

H_2 = 51 %

CO = 41%

N_2 = 4%

CO_2 = 4%

- Its calorific value is 2800kcal/m^3

Uses. It is used as -

(i) a source of hydrogen gas

(ii) a fuel for welding purposes.

1. Producer gas

- Producer gas is essentially a mixture of combustible gas, carbon monoxide & hydrogen associated with large percentage of non-combustible gases, N_2, CO_2 etc.

- It is prepared by passing air mixed with a little steam over a red hot coal or coke bed maintained at about 1100^{0}C .
- The average composition is -

CO = 22 – 30%
H_2 = 8.12%
N_2 = 52 -55 %
CO_2 = 3%

- The calorific value of producer gas is 1300 kcal/m^3

Uses.
It is used as-
i) for heating open hearth furnace in steel and glass manufacture.

II) as a reducing agent in metallurgical operation.

2. LIQUIFIED PETROLEUM GAS(L.P.G.)

- L.P.G can be obtained as a by-product during cracking of heavy oils or from natural gas.
- The average composition is -

n-butane = 27%
iso-butane = 25%
Butene = 43%
Propene = 2.5%
Propane = 2.5 with little or no ethane.

Uses. It is mainly used as domestic fuel, industrial fuel & motor fuel etc.

3. COMPRESSED NATURAL GAS(C.N.G.)

- It is a natural colourless and odourless mixture of gases which is obtained from the upper portion of the petroleum deposition.
- Natural gas is formed under the earth by the decomposition of vegetable matter lying under water by anaerobic bacteria in the absence of oxygen.
- The average composition is -

Methane = 70-90%
Ethane = 4-9% with some traces of propane & butane.

Uses

i) It is used as domestic fuel, industrial fuel & fuel for vehicles.

ii) It is also used as a source of carbon in tyre industries.

iii) It is used for the production of hydrogen gas needed in fertilizer industries.

4 COAL GAS

- Coal gas is a mixture of a number of lower hydrocarbons along with N_2 , H_2 ,CO & CO_2.
- The average composition is -

Methane(CH_4) = 32%
Ethyne(C_2H_2) = 2%
Ethene(C_2H_4) = 3%
N_2 = 4%
H_2 = 4%
CO = 7%
CO_2 = 1%

Uses

i) Coal gas is used as a fuel

ii) It is a reducing agent in metallurgical operations.

SHORT TYPE QUESTIONS AND ANSWERS

Q-1) Define Primary and Secondary fuel with examples.
[2018(W/1st)(N) , 2019(S/2nd)(N) ,

Ans. Primary fuel

- Primary fuels are that which are found in nature and can be extracted ,captured, or graded without any sort of energy conversion or transformation process.

Example

Wood, Peat ,Coal, Natural gas.

- Secondary fuels are that which are derived from Primary fuels.

Example

- Charcoal , Coke ,Kerosene ,Petrol ,Producer gas etc.
-

Q-2) Define calorific value of a fuel .
[

Ans. Calorific value of a fuel is defined as the amount of heat energy released by the complete combustion of one gram of the fuel at constant pressure.

Q-2)Write the composition and calorific value of air dried wood.
[2018(W/2nd)(N) ,

Ans. The average composition of air dried wood is –

(i) Carbon = 50%

(ii) Oxygen = 35%

(iii) Nitrogen = 7%

(iv) Hydrogen = 6%

And (v) Ash = 2%

- The calorific value of air dried wood is in the range 3500-4500 Kcal/Kg.

Q-4) Write down the classification of fuel with example .
[

Ans. Fuels are classified in two ways

(i) on the basis of occurence
(ii) on the basis of physical state

(i) <u>On the basis of occurence</u>

(a) Natural or Primary fuels

<u>Example</u>

Wood, Peat ,Coal, Natural gas.

(b) Artificial or Secondary fuels

- It is prepared from Primary fuels.

<u>Example</u>

Charcoal , Coke ,Kerosene ,Petrol ,Producer gas etc.

(ii) <u>On the basis of physical state</u>

(a) Solid fuel

<u>Example</u>

Wood, Peat ,Coal, Charcoal , Coke etc.

(b) Liquid fuel

<u>Example</u>

Kerosene ,Petrol , etc.

(c) Gas fuel

<u>Example</u>

Natural gas, Producer gas etc.

Q-4) Write the important characteristics good of fuel .
[2018(W/2nd)(N) ,

Ans. A good fuel is one which possess the following characteristics -

1. It should have high calorific value.

2. It should have controllable combustion rate.

3. The ignition temperature should be moderate.

4. It should contain minimum quantity of moisture.

5. It should leave only small amount of residue or ash when burnt.

6. Products of combustion should not be harmful.

7. It should be cheap & easy to transport.

LONG TYPE QUESTIONS

Q-1)What are the basic characteristics belongs to be a good fuel ?

Q-2) Write the composition and uses of L.P.G and C.N.G.

[2017(W/2nd)(N) , 2019(S/2nd)(O) ,

Q-3) Write the compararison between of L.P.G and C.N.G.

[2018(S/1st)(N) , 2018(W/2nd)(N) ,

Q-2) Write down a note on the following

- **(i) Water gas**
- **(ii) producer gas**
- **(iii) C.N.G.**
- **(iv) L.P.G.**

CHAPTER-13

POLYMER

Learning Objectives :

- *Definition of Monomer,Polymer, Homo-polymer, Co-polymer, and*
- *Degree of polymerization,*
- *Difference between Thermosetting and Thermoplastic.*
- *Composition and uses of Polythene & Poly-vinyl chloride and Bakelite.*
- *Deefinition of Elastomer (Rubber) ,Natural Rubber (it's drawback)*
- *Vulcanisation of Rubber, Advantagesof Vulcanised rubber over rubber.*

MONOMER

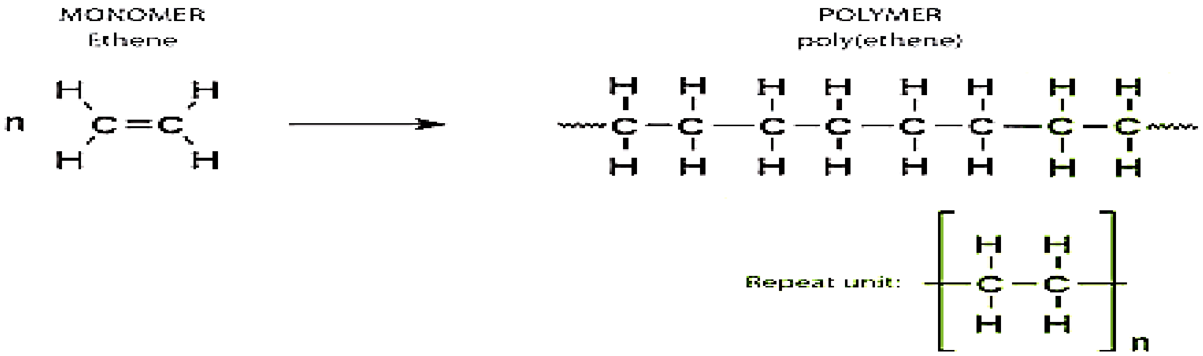
- It is defined as the small molecules of a substance which combine with each other as repeating units to form large molecular substance(polymer).

POLYMER

- "Poly" means "many" and "mer" means "units or parts".
- Polymer is defined as the MACROMOLECULES (giant molecules of higher molecular mass) obtained by joining together a large number of simple molecules through co-valent bonds

in a regular fashion.

Example



HOMOPOLYMER

- A homo polymer is one which is formed by the combination of identical monomer through covalent bonds in a regular fashion.

Example

Polyvinyl chloride.

- Polyvinyl chloride is the polymer in which vinyl chloride is the only monomer.

CO-POLYMER

- A copolymer is one which is formed from two or more different monomers through covalent bond in a regular fashion.

Example

Bakelite

- In Bakelite,phenol & formaldehyde are the two different monomers.

DEGREE OF POLYMERISATION

- The **degree of polymerization** (**DP**) is defined as the number of monomer units in the **polymer**.
- It is calculated as the ratio of molecular weight of a **polymer** and molecular weight of the repeat unit.
- Degree of polymerisation means the number of times a monomer unit repeats itself in one chain of the polymer molecule.

Difference between Thermosetting polymer & Thermoplastic polymer

Thermosetting polymer	Thermoplastic polymer
1. These are formed by addition Polymerisation.	1.These are formed by condensation Polymerisation.
2. These have usally linear structure.	2. These have three dimensional cross-linked structure.
3.These soften and melt on heating and harden again on cooling.	3.These do not soften on heating and rather becomes hard.
4.These are remoulded and reshaped.	4.These cannot be remoulded and reshaped.
5.These are less brittle and soluble in organic solvents.	5.These are more brittle and insoluble in organic solvents.
Examples Polythene, PVC, Nylon etc.	**Examples** Bakelite, Terylene, etc.

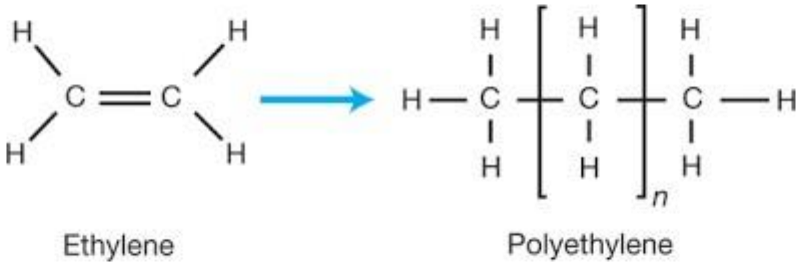
Composition & uses of Polythene, Poly-vinyle chloride & Bakelite

1. POLYTHENE

- A molecule of polyethylene is nothing more than a long chain of carbon atoms, with two hydrogen atoms attached to each carbon atom.

- It can be obtained by liquefying ethylene at 1500 atmospheric pressure and is pumped

into a heated pressure vessels maintained at about 150^0 to 250^0 C in presence of a traces of oxygen where it is polymerised in to a waxy solid substance.



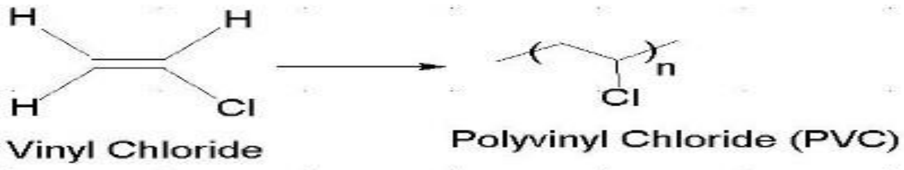
Uses

- It is used for making-

i) High frequency insulator parts.
ii) Packing materials in the form of thin films,bags etc.
iii)Flexible bottles,kitchen & domestic appliances.
iv)Toys,tubes,pipes,coated wires etc.

2. POLY-VINYL CHLORIDE

- Poly vinyl chloride(PVC) is obtained by heating water emulsions of vinyl chloride in presence of a small amount of Benzoyl peroxide$(C_6H_5CO)_2O_2$ or Hydrogen peroxide(H_2O_2) under high pressure.



Uses

- It is used for making-

i)sheets for tank lining.
ii)electrical insulators.
iii) refrigerator components,rain coats,plastic dolls etc.
iv)floor tiles,thermal insulators foams used in cinema halls.

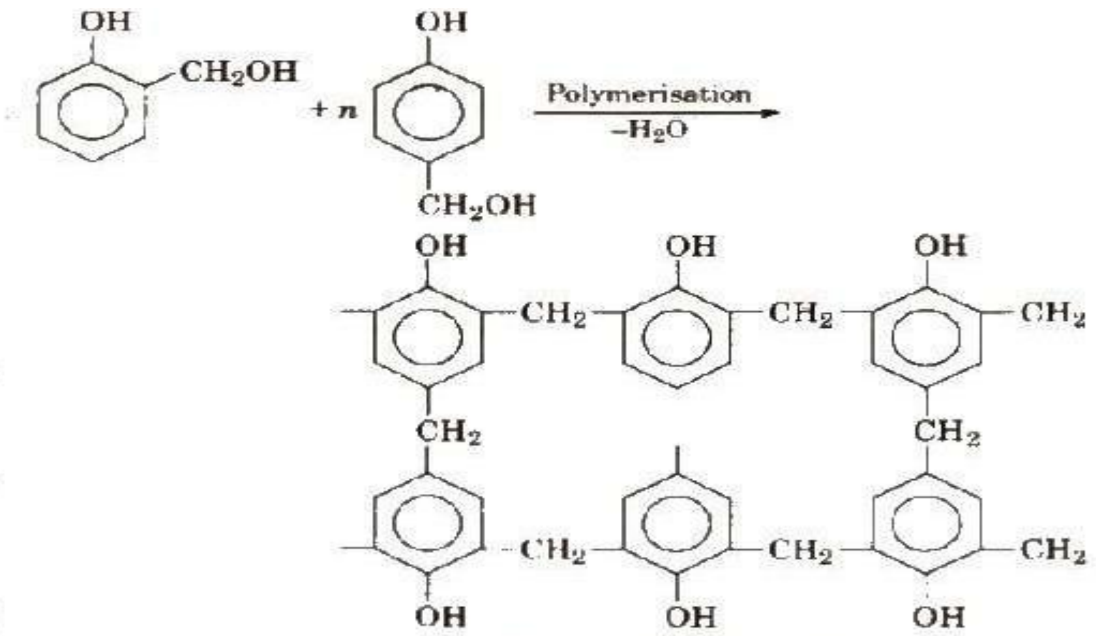
3. BAKELITE

- In the formation of Bakelite two monomers are used.

i)Phenol

ii)Formaldehyde.

- When phenol reacts with formaldehyde in presence of acid or dilute alkali as catalyst,a resinous polymer known as phenol-formaldehyde resin or Bakelite results. It is a dark brittle and cross-linked product.



cross linked polymer (bakelite)

USES

- It is used for making -

i) electrical insulation parts like switches,plugs,heated handles etc.

ii)for making telephone parts, television cabinets, radio parts etc.

iii)as an ion exchange in the softening of water.

ELASTOMER(RUBBER)

- Natural rubber is a polymer which monomer is isoprene with the formula $(C_5H_8)_n$
- Due to the elastic properties ,it is not a straight chain but in form of a coil so it can be stretched like spring.

NATURAL RUBBER

- The origin of Natural rubber is a plantcalled”HaveaBrasillians” which gives a white milky substance called “Latex”.
- Rubber latex is obtained from the tree is diluted to 15-20 %.Then it is filtered to remove the impurities.
- Now Acetic acid is added then lastly a white sticky mass is obtained which is called **Natural Rubber.**

Drawbacks of Natural Rubber

i)It can’t be used in high tempreture.

ii) It is too weak, can’t be used in heavy duty operation.

iii)It has low tensile strength.

iv) It is not resistance to mineral oils, organic solvents.

v)It has large water absorption capacity.

Vulcanisation of Rubber

- To improve the properties of Raw rubber or Natural rubber, it is compounded with some organic chemicals like sulphur,Hydrogen sulphide,Sulphur chloride etc.
- Among these sulphur is the most commonly used vulcanising agent.
- After vulcanisation the rubber gains high tensile strength and becomes resistance to oxidation.
- Vulcanisation is the process of heating raw rubber with amount of sulphur 3.5% to 140^0 C for some time.

Difference Between Raw Rubber & Vulcanised Rubber

Raw Rubber	Vulcanised Rubber
i) It is plastic in nature	i) It is less plastic.It is workable between -40^0 to 100^0 C.
ii) Water absorption tendency is high.	ii) Water absorption tendency is low.
iii) It is less durable	iii) It is more durable.
iv) It swells in organic solvents	Iv) It does not react with organic solvents.
v) It is attacked by oxidising agents	v) It is not attacked by oxidising agents like HNO_3,H_2SO_4 etc.

CHAPTER-14

CHEMICALS IN AGRICULTURE

Learning Objectives :

- *Pesticides , Insecticides, herbicides, fungicides, Examples and uses.*
- *Bio Fertilizers : Definition , examples and uses.*

Pesticides

- "Pesticides are chemical compounds that are used to kill pests , including insects,rodents,fungi, and unwanted plants(weeds). "
- The term pesticide includes all the following -

(i) Insecticides

(ii) Herbicides

(iii) Fungicides

(i)**Insecticides**

- Insecticides are substances used to like insects.

Examples

Chlorinated hydrocarbons like DDT, BHC (gammaxene) ,Aldrin, Dieldrin etc.

Uses

- Insecticides are used in agriculture, medicine, industry and by consumers.

(ii) Herbicides

- A herbicides is a chemical substance used to kill unwanted plants.
- These are commonly known as weedkillers.

Examples

Acetochlor, Amitrole ,Arsenic acid, dinitrophenol, dipyridyl, carbmate, Propanil, Paraquat, etc.

Uses

- Herbicides can be used to clear waste ground ,industrial and construction sites, railways, and railway embankments as they kill all plant material with which they come into contact.

- These areapplied in ponds and lakes to control algae & plants such as water grass that can interfere with activities like swimming and fishing.

Fungicides

- Fungicides are pesticides that prevent ,kill, mitigate, or inhibit the growth of fungi on plants.

Example

Bleaching powder, $CuSO_4$solution, aluminium phosphide, Copper oxychloride, Carbendazim, carboxin, Mancozeb, etc.

Uses

- These are used to control fungi that damage plants.

Bio-fertilizers

- Bio fertilizers are the substance that contains living microorganism.
- Bio fertilizers increase the nutrients of host plants when applied to their seeds, plant surface or soil by colonizing the rhizosphere of the plant.
- These are environment friendly substitute for harmful chemical fertilizers.
- Themicroorganism in Bio fertilizers restore the soil's natural nutrient cycle and build soil organic matter.
- These are extremely advantageous in enriching soil fertility & fulfilling plant nutrient requirements.

Example

Rhizobium, Azotobacter, Azospirillum, Biue green algae etc.

Uses

- Rhizobium inoculant is used for leguminous crops.
- Azotobacter can be used with crops like wheat, maize. mustard etc.
- Blue green algae is usedfor paddy crops.
- Azospirllum is used for maize, sugarcane, millets etc.

SHORT QUESTIONS WITH ANSWERS

Q-1)What are Pesticides ? Give examples.
[2017 (W/2nd) , 2018 (S/1st) (N) ,
Ans- Pesticides

- "Pesticides are chemical compounds that are used to kill pests , including insects, rodents, fungi, and unwanted plants (weeds). "

Examples
(i) Chlorinated hydrocarbons like DDT, BHC (gammaxene) , Aldrin, Dieldrin etc.

(ii) Bleaching powder, $CuSO_4$solution, aluminium phosphide, Copper oxychloride, Carbendazim, carboxin, Mancozeb, etc.

LONG TYPE QUESTIONS.

Q-1) What is pesticide ? Define herbicide and fungicides .Give at least two examples of each.
[2020(W/1st) (N) ,

Q-2) What are Bio fertilizers ? Give examples and their uses.