

# ATOMIC STRUCTURE

	Discovered	Named	charge	mass
Electron	J.J.Thomson	G.J.Stoney	$-1.602 \times 10^{-19}$ coul	$\frac{1}{1837}$ of H atom; $9.11 \times 10^{-28}$ gms
Proton	Rutherford	goldstein	$1.602 \times 10^{-19}$ esu	$0.000548$ amu; $9.1 \times 10^{-31}$ kgs
Neutron	chadwick	++	$1.672 \times 10^{-19}$ coul $0$	$1.672 \times 10^{-24}$ gms $1.672 \times 10^{-27}$ kgs

given by J.J.Thomson

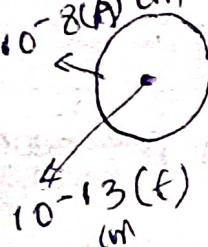
\* oil drop experiment - Milikan -  $\frac{e}{m}$  ratios =  $\frac{-1.6 \times 10^{-19}}{9.1 \times 10^{-31}} = -1.7 \times 10^{11} \text{ C/kg}$

→ Helps in finding charge of  $e^-$

for electron =  $\frac{e}{m} \uparrow v \uparrow$   
for proton = constant

→ J.J.Thomson - plum pudding model - watermelon model

\* Rutherford -  $\alpha$  ray experiment |  $\alpha = + + ve - {}^2_2 He^4$   
Nucleus -  $10^{-13}$  cm (fermi) |  $B = - ve$  (selection)  
Atom -  $10^{-8}$  cm (Angstrom) |  ${}^4_2 Be^9 + {}^2_2 He^4 \rightarrow {}^6_2 C^1 + {}^0_1 n^1$  [neutral]  
PLANETARY SYSTEM | phy - diffed  
chem - same



\*  $A = \text{mass no.} = \text{no. of neutrons} + \text{no. of protons}$  ↑  
proton, Deutonium, Tritium  
 $Z = \text{no. of protons}$   
Atomic No =  $\frac{Z}{A} = \text{no. of electrons}$  ↓  
 $A - Z = \text{no. of neutrons}$  Iso Bar  
 $Z - A$  - diffed - TOP - Isotopes  
 $Z - B$  - bottom diffed Possibility of mass in fractions

\* Isoelectronic - Same No. of electrons but different atomic no.

K - 1 -  $\frac{1}{2\pi}$  -  $\frac{1}{2}$  -  $\frac{1}{8}$  -  $\frac{1}{16}$  -  $\frac{1}{32}$  -  $\frac{1}{64}$  -  $\frac{1}{128}$  -  $\frac{1}{256}$  -  $\frac{1}{512}$  -  $\frac{1}{1024}$  -  $\frac{1}{2048}$  -  $\frac{1}{4096}$  -  $\frac{1}{8192}$  -  $\frac{1}{16384}$  -  $\frac{1}{32768}$  -  $\frac{1}{65536}$  -  $\frac{1}{131072}$  -  $\frac{1}{262144}$  -  $\frac{1}{524288}$  -  $\frac{1}{1048576}$  -  $\frac{1}{2097152}$  -  $\frac{1}{4194304}$  -  $\frac{1}{8388608}$  -  $\frac{1}{16777216}$  -  $\frac{1}{33554432}$  -  $\frac{1}{67108864}$  -  $\frac{1}{134217728}$  -  $\frac{1}{268435456}$  -  $\frac{1}{536870912}$  -  $\frac{1}{1073741824}$  -  $\frac{1}{2147483648}$  -  $\frac{1}{4294967344}$  -  $\frac{1}{8589934688}$  -  $\frac{1}{17179869376}$  -  $\frac{1}{34359738752}$  -  $\frac{1}{68719477504}$  -  $\frac{1}{13743895504}$  -  $\frac{1}{27487791008}$  -  $\frac{1}{54975582016}$  -  $\frac{1}{109951164032}$  -  $\frac{1}{219902328064}$  -  $\frac{1}{439804656128}$  - 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- Principal - Bohr
- Azimuthal - Sommerfeld
- Magnetic - Lande
- Spin - Wholenbeck & Goudsmith
- Size [atom] =  $n$
- Shape [atom] =  $l = n-1$  - fine spectrum
- Orientation =  $m = -l \text{ to } l$   $\rightarrow (2l+1)$   $\rightarrow$  Stark-Zeeman
- Orientation of orbital spin =  $\pm \frac{1}{2}$ ,  $\mp \frac{1}{2}$

$\rightarrow$  Max No. of  $e^-$  in orbit =  $2n^2$  - in subshell/orbital -  $2(2l+1)$

$$\begin{array}{ll} K = 2 & \text{no. of orbitals} = n^2 \\ L = 8 & 4 \\ M = 18 & 9 \\ N = 32 & 16 \end{array}$$

$$\begin{array}{ll} S = 2 & \\ P = 6 & \\ D = 10 & \\ F = 14 & \end{array}$$

$\rightarrow \Psi_{\max}^2$  - orbital (95%)  $\left| \begin{array}{l} \text{No probability of } e^- \text{ - radial plane} \\ (l) \end{array} \right.$

S - O spherical  $= 1$

$90^\circ$  - P - ~~∞~~  $p_x, p_y, p_z = 3$  (doumble)

$45^\circ$  - D - ~~∞~~  $d_{xy}, d_{yz}, d_{zx}$  - double double oriented on XY axis  
~~∞~~  $d_{x^2-y^2}$  ~~∞~~  $d_{z^2}$   $\rightarrow$  oriented on Z axis  
 Radial orbitals has perpendicular nodal plane

f - complex

$\rightarrow$  Aufbau's -  $e^-$  enters into least energy orbital  $[n+1, n]$

Hund's - Pairing of  $e^-$  (All deg orbitals filled with 1  $e^-$ )

Pauli's Exclusion - Spinning of  $e^-$  (4 Q.N are not same)

$\rightarrow$  Cr - [Ar]  $3d^5 4s^1$  Cu - [Ar]  $4s^1 3d^{10}$

$\rightarrow 1s < 2s < 2p < 3s < 3p < 4s < 3d < 4p < 5s < 4f < 5p < 6s < 4d < 5s < 6p < 7s$

+ - loss - cation

- - gain - Anion

$\rightarrow$  Atomic No was introduced by Mosley

$\rightarrow$  Hydrogen - no Neutron

$\rightarrow$  A  $e^-$  is a  $\beta$  particle (-ve)

$\rightarrow$  Isotope without neutron is protium

$\rightarrow$  shape of  $d_z^2$  double dumbell except  $d_z^2$

- Ferric ion  $[Ar] 3d^5$   $\xrightarrow[Fe^{+3}]{\text{stable}}$  Ferrous ion ( $Fe^{+2}$ ) -  $[Ar] 3d^6$

- The theory which proves Rutherford model wrong is Electromagnetic radiation theory

- In  $n$ th quantum level, no. of electronic subshell are  $\frac{1}{n}$

- Alpha particle is  $4$  times heavier than neutron

- Model of stationary states was proposed by Rutherford

- Particle having  $18$  electrons in valency shell

①  $A \approx$  ②  $K +$  ③  ~~$Cu^+$~~  ④  $Cu^{+2}$

- A atom has  $6$  neutrons  $5$  protons,  $y$  has  $5$  protons &  $6$  neutrons, they are isobars

are also isoelectronic species  
Protium, Deuterium, Tritium - Isotopes

$H^1$        $H^2$        $H^3$

- The lightest particle is proton
- Quantum No. not obtained from Schrodinger's equation is  $3$
- $n, l, m$  are the outcomes of Schrodinger's eqn
- Heisenberg uncertainty principle - momentum & position of electron can not be known simultaneously

If uncertainty is  $\Delta p$   $\Delta x$   
the certainty is  $\Delta p$   $\Delta x$

- First emission line of hydrogen atomic spectrum in balanced series appears at  $\left[ \frac{hR}{36} \text{ cm}^{-1} \right]$
- 3 quantum no.  $n, l, m$  required to designate an orbital

## OXIDATION

- normal oxide
- peroxide
- superoxide

$$F = -1$$

O = -2 (except peroxides -  $H_2O_2, H_2S_2O_8$ )

H = +1      Superoxides -  $KO_2$

$$K = +1$$

Sum of oxidation NO = charge on ion

In sulfur acid ( $H_2SO_4$ ) 3 atoms of O has -2 as O-N  
2 atoms of O has -1  
 $2(+1) + 1(+6) + 3(-2) + 2(-1) = 0$

$$7 = 6$$

Highest oxidation NO is +8 (for  $KUO_4, O_3O_4$ )

$\text{N}_x^{(n)}$  - group

Period

In  $H_2O$  due to repulsion of O (lone pairs) there is decrease  
in bond angle  
ref - 2 lone pairs



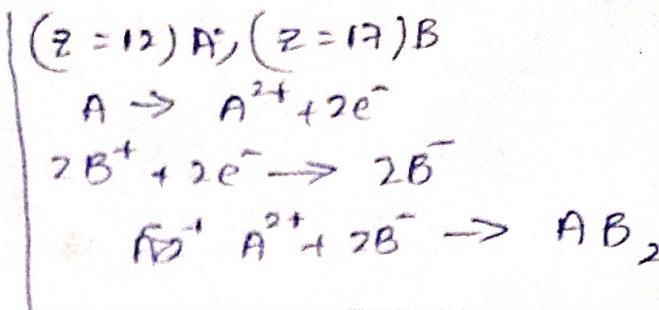
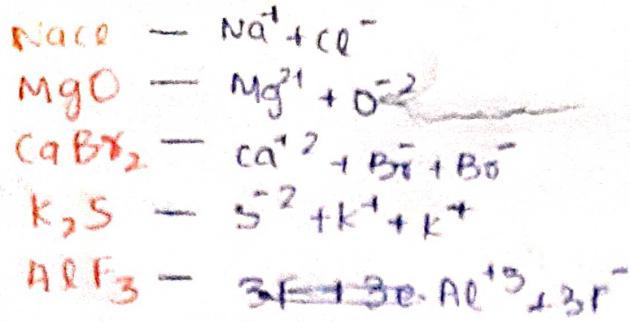
# CHEMICAL BONDING

- \* Electrovalency theory - Lewis & Kossel -  $ns^2 np^6$
- |  |   |
|--|---|
| <b>IONIC BOND</b> <ul style="list-style-type: none"> <li>1) Electrovalent bond - proposed by Kossel</li> <li>2) <math>E \cdot N &gt; 1.7</math></li> <li>3) complete transfer of electrons</li> <li>4) They exist in solids</li> <li>5) strong electrovalent forces</li> <li>6) Non directional bond do not exhibit isomerism</li> <li>7) soluble in polar solvents</li> <li>8) Bad conductors - solids<br/>good conductors - molten (or)<br/>liquid state</li> <li>9) <math>M \cdot P, B \cdot P \uparrow</math></li> <li>10) Reactions are fast</li> <li>11) Ex:- <math>\text{NaCl}, \text{KCl}, \text{Na}_2\text{O}, \text{K}_2\text{O}, \text{MgCl}_2, \text{MgF}_2, \text{AlF}_3, \text{CaF}_2, \text{KBr}, \text{Na}_2\text{S}</math></li> </ul> | <b>COVALENT BOND</b> <ul style="list-style-type: none"> <li>1) proposed by Lewis and named by Langmuir</li> <li>2) <math>E \cdot N \leq 1.7</math></li> <li>3) sharing of electrons</li> <li>4) All 3 states</li> <li>5) weak vanderwaal forces</li> <li>6) Directional bond, exhibit isomerism</li> <li>7) Soluble in non polar solvent except kerosene, benzene, diesel which are also soluble in polar solvents due to H bonds</li> <li>8) good conductors except graphite (due to Ti electrons)</li> <li>9) <math>M \cdot P, B \cdot P \downarrow</math></li> <li>10) Reactions are slow</li> <li>11) Homo - <math>\text{H}_2, \text{Cl}_2, \text{Br}_2, \text{I}_2, \text{O}_2, \text{N}_2, \text{O}_3</math><br/>Hetero - <math>\text{H}_2\text{O}, \text{HF}, \text{NH}_3, \text{CH}_4, \text{C}_2\text{H}_6, \text{H}_2\text{SO}_4, \text{HBr}, \text{Ac}_2</math></li> </ul> |
|--|---|

## Factors affecting Ionic Bond

- |   |  |
|---|--|
| <p>Cation</p> <ul style="list-style-type: none"> <li>1) Large atomic size <math>\text{H} &lt; \text{Li} &lt; \text{N} &lt; \text{K} &lt; \text{Rb} &lt; \text{Cs}</math></li> <li>2) less I<sub>o</sub>P <math>\text{Cs} &gt; \text{Rb} &gt; \text{K} &gt; \text{Li}</math></li> <li>3) cation with less charge <math>\text{Na}^+ &gt; \text{Mg}^{+2} &gt; \text{Al}^{+3}</math></li> </ul> | <p>Anion</p> <ul style="list-style-type: none"> <li>1) small atomic size <math>\text{F} &gt; \text{O} &gt; \text{N}</math></li> <li>2) More electron affinity <math>\text{Cl} &gt; \text{F}</math></li> <li>3) Anion with less charge</li> </ul> |
|---|--|

$E \cdot N$	Remember it it helps in determining ionic/covalent
$\text{F} - 4.0$	
$\text{O} - 3.5$	
$\text{N} - 3.0$	
$\text{Cl} - 3.0$	
$\text{C} - 2.2$	
$\text{H} - 2.1$	
$\text{Ne} - 0.9$	
$\text{Mg} - 1.0$	
$\text{Ca} - 0.8$	
$\text{Cs} - 0.07$	



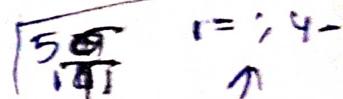
$\rightarrow$  If valency of a atom 'A' is x and 'B' is y



$\rightarrow \text{H}_2$	$\text{H}-\text{H}$	- linear ( $180^\circ$ )
$\cdot \text{Cl}_2$	$\text{Cl}-\text{Cl}$	- linear
$\text{O}_2$	$\text{O}=\text{O}$	- linear
* $\text{N}_2$	$\text{N} \equiv \text{N}$	- linear 3 bonds
diene $\text{H}_2\text{O}$		- Bent ( $104.5^\circ$ )
mono $\text{NH}_3$		- ( $107.3^\circ$ ) pyramidal
clone $\text{CH}_4$		- ( $109.28''$ ) tetrahedral
HCl	$\text{H}-\text{Cl}$	- linear

$\sigma > \pi$   
 $\sigma$  - end to end overlapping  
 $\pi$  - side to side overlapping

A multiple bond contains 1  $\sigma$  bond and others are  $\pi$  bonds



(Ethane)  $\text{C}_2\text{H}_6 \rightarrow$  7 electronic pairs ;  $\text{C}_2\text{H}_4$  (ethylene) - 6 pairs.  
 $\text{C}_2\text{H}_6 - \text{C}_2\text{H}_{2n+2}$  - tetrahedral -  $109.28''$  - Trigonal-bipyramidal

Acetylene. Ethyne  $\text{C}_2\text{H}_2$  - 5 pairs -  $180^\circ$

- \* covalent element with highest melting point is diamond
- \* EN - 0.0-0.5 - Nonpolar -  $\text{H}_2, \text{Cl}_2, \text{N}_2, \text{O}_2$  - No charge separation
- \* EN - 0.5-1.0 - polar (  $\text{H}_2\text{O}, \text{NH}_3$  ) - unequal e<sup>-</sup> sharing - soluble in water
- \* Alcohols and carboxylic acids soluble in water due to formation of H bonds

## Hydrogen Bond :- [Morse and Winniford]

partially charged positive H atom  
(+ weak electrostatic forces)

Most E-N element [F, N, O]

→ for formation of H bond

- atomic size should be less (in NaCl (some E-N) it does not form H bond because it's large atomic size)
- E-N↑

Intermolecular

→ H bond between the molecules

Intramolecular

→ H bond within the molecule

→ HF<sub>2</sub>, H<sub>2</sub>O, NH<sub>3</sub>, R-OH, R-NH<sub>2</sub> → sugar

ortho nitrophenol  
ortho benzaldehyde  
ortho hydroxy benzaldehyde

→ Para hydroxy benzaldehyde

Para nitrophenol Pd benzocoumarin

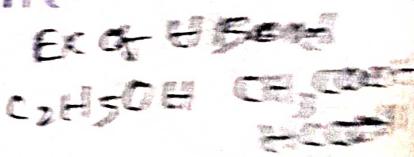
~~small chlorine~~

→ strength of H bond - 2 cal - 20 kJ/mol

HF, (00) KHF<sub>2</sub> - 27 cal (strongest bond)

→ H bond is a directional bond represented by dotted line (HF is in liquid phase)

- H Bond →
- ice is floated on water due to H bond
  - volume of ice is more than water
  - Acetic acid forms dimer in benzene
  - Anomalous expansion of water
  - H F, NH<sub>3</sub>, alcohols - B.P↑



## Co-ordinate covalent Bond :- (ative Bond)

Donor

- Lone pair of e<sup>-</sup> (H<sub>2</sub>O, NH<sub>3</sub>, ROH, PH<sub>3</sub>)
- Negative charge
- Multiple bond between same atom
- e<sup>-</sup>C, O<sub>2</sub>, N<sub>2</sub>

Acceptor

- e<sup>-</sup> deficient with vacant orbital (BF<sub>3</sub>, AlCl<sub>3</sub>, AlCl<sub>3</sub>, FeCl<sub>3</sub>)
- positive charge
- Multiple bond between different atom
- (O, SO<sub>2</sub>, NO<sub>2</sub>, N<sub>2</sub>)

KCN NaOH

- KOH contains both ionic & covalent bonds
- Most Ionic compounds are IA & VIIA
- H bond is absent in steam
- NH<sub>4</sub>Cl & K<sub>3</sub>SO<sub>4</sub>, K<sub>3</sub>[Fe(CN)<sub>6</sub>] - Ionic, covalent, coordinate covalent
- Nylon has H bond
- P & S - variable valency
- CCl<sub>4</sub> has no lone pairs in its central atom
- M.P  $\text{A}^{I\!F}_x \text{E} \cdot \text{Na}^+$  - NaF
- Ethane has large C-C distance
- Molecule of pyramidal shape
- ① PCl<sub>3</sub>    ② SO<sub>3</sub>  
③ CO<sub>3</sub><sup>2-</sup>    ④ NO<sub>3</sub>  
In NaCl, Na<sup>+</sup> is surrounded by 6 Cl<sup>-</sup> ions ns<sup>2</sup>np<sup>6</sup>  
- cubic structure

# SOLUTIONS

- $1\text{ mol g} = 6.023 \times 10^{23} \text{ molecules} = 2 \times 6.023 \times 10^{23} \text{ atoms} = 32 \text{ goms}$
- No. of moles =  $\frac{\text{weight of solute}}{\text{Gm. Molecular wt of solute}} = \frac{\text{no. of molecules}}{\text{Avagadro number}}$
- Charge of 1 mole of electrons is equal to 96500 coulombs. It is equal to FARADAY
- Reciprocal of avagadro's no. is avogram =  $1.66 \times 10^{-24}$
- No. of moles =  $\frac{\text{volume of gas}}{22.4 \text{ lit}} \quad (\text{or}) \quad \frac{V}{22400 \text{ ml}}$

$$\text{Molarity (M)} = \frac{\text{no. of moles of solute}}{\text{Volume of solution}} = \frac{\text{wt. of solute}}{\text{GMV of solute}} \times \frac{1}{V(\text{lit})}$$

$$\text{Formality} = d \times \% \text{w} \times \frac{10}{\text{Mol. wt}} = \frac{W}{\text{GMV}} \times \frac{1000}{V(\text{ml})}$$

UNITS - moles/lit = TT M.L.  $\%(\text{w/v}) = \frac{\text{goms}}{\text{in 100ml}}$

$$\rightarrow M_1 V_1 = M_2 V_2 ; \quad \frac{M_1 V_1}{V_1} = \frac{M_2 V_2}{V_2} \quad \begin{matrix} \text{decimole} = 0.1 \text{ mole} \\ \downarrow \end{matrix}$$

The volume of water to be added  $= V_2 - V_1$  titration

$$\rightarrow M = \frac{V_1 M_1 + V_2 M_2 + V_3 M_3 \dots V_n M_n}{\text{Total volume}}$$

$$\text{Normality} = \frac{\text{no. of gram Equivalent of solute}}{\text{Volume of solute in lit}}$$

$$= \frac{\text{wt. of solute}}{\text{Eq. wt. of solute}} \times \frac{1}{\text{Volume in lit}}$$

$$= \frac{W}{\text{GEW}} \times \frac{1000}{V(\text{ml})}$$

$$V_1 N_1 = V_2 N_2 ; \quad \begin{pmatrix} \text{volume of water to be added} & = \frac{V_1 N_1}{N_2} - V_1 \end{pmatrix}$$

$$N = d \times \% \text{w} \times \frac{10}{\text{EW}} = \frac{V_1 N_1 + V_2 N_2 \dots V_n N_n}{\text{Total volume}}$$

$$= \frac{V_A N_A - V_B N_B}{\text{Total V}} \quad \left( \text{If } V_A N_A > V_B N_B \right) = \frac{V_B N_B - V_A N_A}{\text{Total volume}} \quad \left( \frac{V_B N_B}{V_A N_A} \right)$$

$$N \times \text{eq. wt} = M \times \text{mol. wt}$$

$$N = \frac{M \times \text{mol. wt}}{\text{eq. wt}} ; M = \frac{N \times \text{eq. wt}}{\text{mol. wt}}$$

~~\*\*\*~~  $\Rightarrow N = M \times \text{valency} ; M = \frac{N}{\text{valency}}$

- Eq. wt is defined as the no. of parts weight of a substance that can react with or displace 1.008 parts by  $H_2$ , 8 by  $O_2$ , 35.5 by  $Cl_2$

$$HCl - 36.5$$

$$HNO_3 - 63$$

$$H_2SO_4 - \frac{98}{2} = 49$$

$$(CH_3COOH - \frac{60}{1} = 60) \text{ (acetic acid)}$$

$$H_3PO_4 - \frac{98}{3} = 32.66 \text{ (orthophosphoric acid)}$$

$$H_2C_2O_4 \cdot 2H_2O - \frac{126}{2} = 63 \text{ (oxalic acid)}$$

$$Na_2CO_3 - \frac{106}{2} = 53$$

$$\underline{\text{glucose} - 180}$$

$$NaOH - 40$$

$$KOH - 56$$

$$Ba(OH)_2 - \frac{171.3}{2} = 86.65$$

$$NH_4OH - \cancel{\frac{58}{2}} = 29 \quad \frac{35}{1} = 35$$

$$Ca(OH)_2 - \cancel{\frac{107.1}{3}} = 35 \rightarrow \frac{74}{2} = 37$$

$$Mg(OH)_2 - \frac{58}{2} = 29$$

$$Fe(OH)_3 - \frac{107.1}{3} = 35.7$$

$$NaCl - 58.5$$

$$Na_2CO_3 - \frac{106}{2} = 53 \quad KMnO_4 = \frac{158}{5} = 31.6$$

$$MgCl_2 - \frac{95}{2} = 47.5$$

$$MgSO_4 - \frac{120}{2} = 60 \quad K_2Cr_2O_7 = \frac{294}{6} = 49$$

$$CaCO_3 - \frac{100}{2} = 50$$

$$AgNO_3 - \frac{170}{1} = 170$$

$$CuSO_4 - \frac{159.5}{2} = 79.75$$

$$\text{Mole fraction} = \frac{n_A}{n_A + n_B} = \frac{\frac{w_A}{C_1 M_W A}}{\frac{w_A}{C_1 M_W A} + \frac{w_B}{C_2 M_W B}}$$

~~(Temp donot effects M-F)~~

mobility

$(X_A) = \frac{w_A}{w_A + w_B}$

$$\text{Molarity} = \frac{\text{No. of moles of solute}}{1 \text{ kg of solvent}}$$

$$= \frac{w \text{ of solute}}{m \cdot \text{wt}} \times \frac{1000}{\text{wt of solvent (kg)}}$$

$$= \frac{wt}{m \cdot wt} \times \frac{1000}{\text{wt of solvent (mt)}}$$

<u>H</u> - 1
<u>He</u> - 4
<u>Li</u> - 7
<u>Be</u> - 9
<u>B</u> - 11
<u>C</u> - 12
<u>N</u> - 14
<u>O</u> - 16
<u>F</u> - 19
<u>Ne</u> - 20
<u>Na</u> - 23
<u>Mg</u> - 24
<u>Al</u> - 27
<u>Si</u> - 28
<u>P</u> - 31

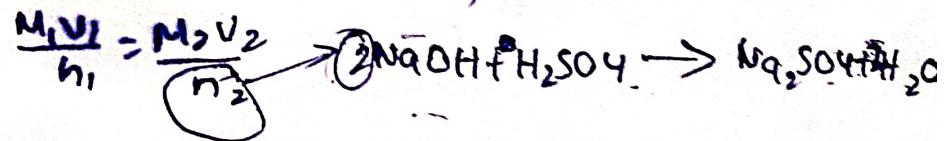
<u>S</u> - 32
<u>Cl</u> - 35.5
<u>Ar</u> - 40
<u>K</u> - 39
<u>Ca</u> - 40
<u>Sc</u> - 45
<u>Ti</u> - 48
<u>V</u> - 51
<u>Cr</u> - 52
<u>Mn</u> - 55
<u>Fe</u> - 56
<u>Co</u> - 59
<u>Ni</u> - 59
<u>Cu</u> - 63.5
<u>Zn</u> - 65

FROM 1 TO 20

for odd no - atomic no  $\times 2 + 1$   
even - atomic no  $\times 2$

1, 4, 7, 17, 18  
Except 4, Be, N & L & Ar  
Be - odd      N - even  
+ thick      + thick  
 $Cl = 35.5$   
 $Ar = 40 = Ca$

- For titrations / Reactions first write it in the form of equations & balance it to get its Molarity / Normality



- When non volatile substance is added to a solution its vapour pressure decreases
- Molarity of pure water is  $\frac{1000}{18} = 55.56$
- Valency of  $H_3PO_3$  is 2

Q) The volume of 0.2 M  $\text{H}_2\text{SO}_4$  solution containing 10 milli equivalents of solute is

$$N = 0.2 \times 2 = 0.4$$

$$10 = 0.4 \times V \Rightarrow V = 25 \text{ ml}$$

Q) The V of water that must be added to a mixture of 250ml of 6M & 750ml of 2M to obtain 2.5M

$$M_1V_1 + M_2V_2 = M_3V_3$$

$$6 \times 250 + 750 \times 2 = 2.5 \times V_3 \Rightarrow V_3 = 1200 \text{ ml}$$

$$1200 - 1000 = 200$$

Q) Eqv wt of trivalent metal is 9 then eqv mol wt of its oxide is ?

$$N = M \times V = 9 \times 3 = 27 \quad \text{at eqv oxide is } \text{M}_2\text{O}_3$$

$$2(27) + 3(16) = 102$$

$$\rightarrow \text{wt of solute} = d \times V$$

$$\underline{\underline{cM = \frac{102}{9}}}$$

# ELCTROCHEMISTRY

Electrolytic cell

- Electrical Energy  $\rightarrow$  chemical Energy

Electrochemical voltaic/galvanic

OLA

Faraday's

Positive

Cation

Anode

loss of  $e^-$

oxidation

Negative

Anion

cathode

CAR

+ attraction of  $e^-$   
Reduction

Theory of Electrolytic Dissociation - [Arrhenius]

[Degree of Ionisation]

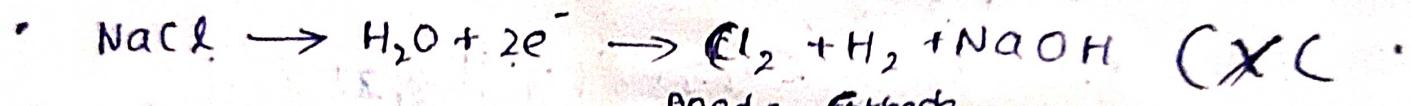
Ag - highest electro conductivity

High - strong Electrolytes  
Ex: Strong acids & bases

Low - Weak Electrolytes

Ex: weak acids & bases  
Barium salts

In weak electrolytes  $\alpha \uparrow$  by dilution because  
concentration  $\downarrow$   $\alpha \uparrow$  conductance  $\uparrow$



## FARADAY'S LAWS

1st law -  $w \propto Q$ .

$$w = ect$$

$e$  - electrochemical equivalent

$$w = \frac{E}{F} ct$$

$E$  - chemical equivalent

M - Atomic weight

$$w = \frac{MC}{ZF}$$

Z - Valency

$$\begin{aligned} e &= \frac{E}{F} \\ E &= \frac{M}{Z} \end{aligned}$$

1 Faraday  
= 96500 coulombs

$$= 1.6023 \times 10^{-19} \times 6.023 \times 10^{23}$$

2nd law

$$\frac{w_1}{E_1} = \frac{w_2}{E_2}$$

[when same current is passed

$$\frac{w_1}{w_2} = \frac{E_1}{E_2}$$

## VOLTAIC / GALVANIC CELL

CAR - cathode - attraction of  $e^-$  - Reduction

OLA - oxidation- loss of  $e^-$  - anode

Salt Bridge :- completes circuit for flow of e<sup>-</sup>

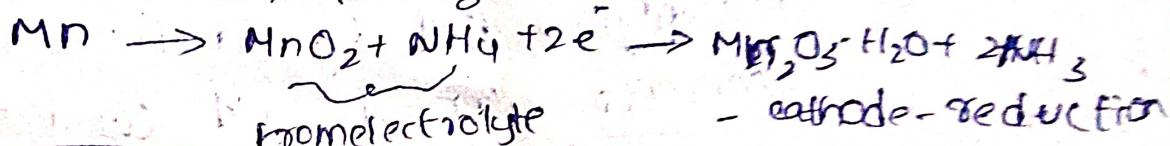
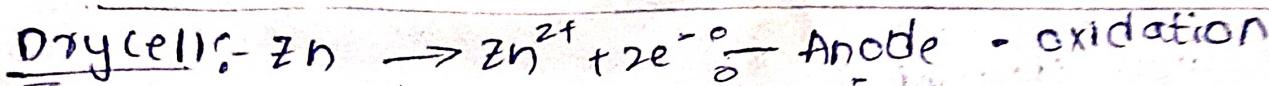
- Made with gel like substance, agar-agar gel
  - $\text{KCl}$ ,  $\text{NH}_4\text{NO}_3$ ,  $\text{KNO}_3$



anode      cathode: R R C P

→ primary cell :- without charge - Dry cell - irreversible

Secondary cell :- reusable - lead storage battery  
charged - reversible



EMF = 1.25V to 1.50V

concentration cell =  $Zn|Zn^{2+}(c_1)||Zn^{2+}(c_2)|Zn$

differ in concentrations

Electrode potential depends on

- concentration - electrolyte
- nature & purity - electrolyte
- Temp

(E)

standard electrode potential :- 1M, 25°C

SHE :- Standard hydrogen electrode potential :- 1 atm

$$(E^\circ) = 0.0V$$

Nearest equation :-  $AA + BB \rightarrow CC + DD$

$$\epsilon = \epsilon^\circ + \frac{20303RT}{nF} \log [Mn^+]_{(0)} \frac{(C)(D)^d}{(A)^a(B)^b}$$

$$= E^\circ + \frac{0.0592}{n} \log [mn^+]$$

## Electrochemical series

(Li)

Least SRP  
- 3.05 V

Cu < Mg < PF < Au < F<sub>2</sub>

Higher SRP  
+ 2.87 V

Reducing agent

[Anode]

Alkali & alkaline metals

Increasing order

Oxidising agent  
[cathode]

$$E_{cell} = E_{cathode} - E_{anode}$$

Flow of electrons :- A to C -ve to +ve  
Flow of electricity :- C to A +ve to -ve

Electrolytic  
Metallic  
conductors

- conductance due to ions
- conductivity ↑
- electrons

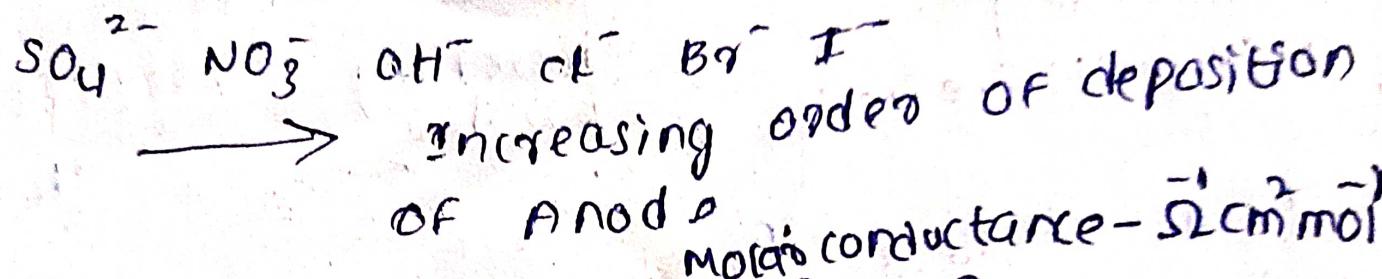
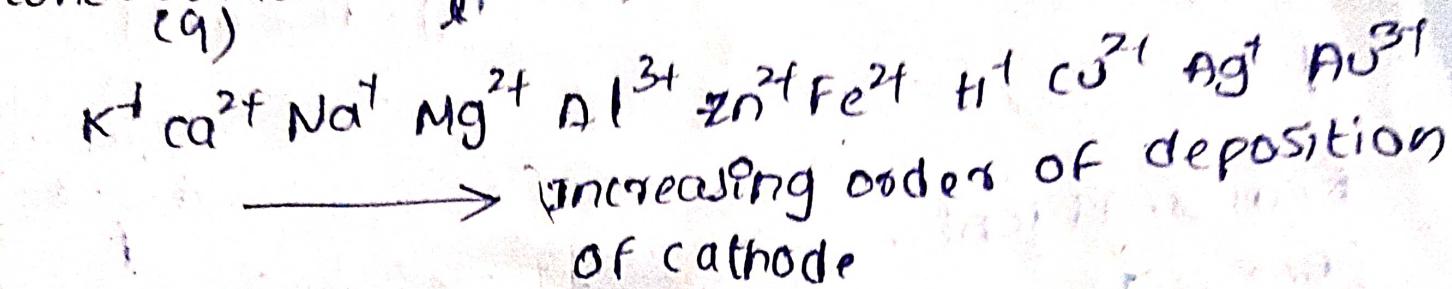
I.F.T.↑  
conductivity ↑  
conductivity ↓

## IMP Points

charge in 1g of ion is  $2.89 \times 10^5$  coulomb

$$\Delta G = -nFE = -2.303RT \log K$$

$$\text{conductance} = \frac{KA}{l} \rightarrow \text{specific conductivity } (\text{sm}^{-1}) (\Omega^{-1} \text{cm}^{-1})$$



Molar conductance -  $\Omega^{-1} \text{cm}^2 \text{mol}^{-1}$

$$\text{Molar conductivity} - \text{mol/L} \cdot \lambda_m = K \times \frac{1000}{m}$$

$$\text{Equivalent conductivity} - \text{eqV/L} \cdot \lambda_{eqv} = K \times \frac{1000}{N}$$

# WATER TREATMENT

- **Raw water** - Rust form of water [mostly dissolved salts, less organic matter]
  - **Lake water** - less dissolved salts, more organic matter
  - **Sea water** - 3.5% dissolved salts, 2.6% NaCl
  - **Softwater** - forms lather with soap
  - **Hard water** - forms precipitate with soap  $\text{CaHCO}_3, \text{MgHCO}_3$
  - { temporary Hardness : bicarbonate salts of Ca, Mg & Fe acidity  
Boiling removes | presence of  $\text{CO}_2$  causes temporary hardness & base
  - permanent Hardness : chloride & sulphate salts of Ca, Mg, Fe also by  $(\text{CaNO}_3)_2, \text{Mg(NO}_3)_2$
- Hardness<sub>calc-equiv</sub> =  $\frac{w \times 100}{\text{MW}} = \frac{w \times 50}{\text{Eqv}}$  ppm/gm  
 Ppm (os)  $\frac{\text{mg/l}}{\text{lit}}$  ( $1\text{gm} = 1000\text{cm}^3$ )

$$1\text{PPM} = 1\text{mg/litre} = 0.1^\circ\text{F} = 0.07\text{*} \\ 10^6 \text{ parts} \quad 10^5 \text{ parts} \quad 70,000 \text{ parts}$$

$$\text{TCL} = 1.43^\circ\text{F} = 14.3\text{PPM} = 14.3\text{mg/lit}$$

<del>Ca(HCO<sub>3</sub>)<sub>2</sub></del>	$\text{CaHCO}_3 - 62$	$\text{MgHCO}_3 - 62$
<del>CaSO<sub>4</sub></del>	$\text{MgSO}_4 - 120$	$\text{CO}_2 - 120$
<del>MgSO<sub>4</sub></del>	$\text{CaSO}_4 - 136$	$\text{MgCO}_3 - 95$
<del>CO<sub>2</sub></del>	$\text{HCO}_3 - 61$	$\text{MgCO}_3 - 84$
<del>NaCl</del>	$\text{CaCl}_2 - 111$	$\text{Mg(NO}_3)_2 - 148$

- sludge causes chocking of pipes and can be removed by blowdown operation
- $\text{CO}_2$  is removed by deaeration/  $\text{NH}_4\text{OH}$  (adding)
- To prevent caustic embrittlement instead of  $\text{Na}_2\text{CO}_3, \text{Na}_3\text{PO}_4$  is added

## Bubble Method :-

$$\text{Total hardness} = \frac{V_3 - V_1}{V_2 - V_1} \times 100$$

$V_1$  - Soap SO<sub>4</sub><sup>2-</sup>

$V_2$  - stand "

$V_3$  - unknown "

$V_4$  - Boiled "

$$\text{Temporary hardness} = \frac{V_3 - V_1}{V_2 - V_1} \times 100$$

$$\text{Permanent hardness} = \frac{V_3 - V_1}{V_2 - V_1} \times 100$$

EDTA (Ethylene Diamine Tetra acetic acid)

Complexometric titration

End point blue colour

(EBT) - indicator

NH<sub>4</sub>Cl + NH<sub>4</sub>OH (Basic Buffer)

$$T.H = \frac{V_2}{V_1} \times 1000$$

$$P.H = \frac{V_3}{V_1} \times 1000$$

1 ml of 0.01M EDTA = 1 mg CaCO<sub>3</sub>

Volume of XN EDTA =  $V \times N \times 100$

Lime Soda process :- Addition of Ca(OH)<sub>2</sub> + Na<sub>2</sub>CO<sub>3</sub> (lime) (soda)

→ coagulants used are Alum (K<sub>2</sub>SO<sub>4</sub> · Al<sub>2</sub>(SO<sub>4</sub>)<sub>3</sub> · 24H<sub>2</sub>O) Al<sub>2</sub>(SO<sub>4</sub>)<sub>3</sub>, NaAlO<sub>2</sub>

→ Hot lime Soda :- upto 15 ppm - accelerators required  
Cold lime soda :- upto 30 ppm - not required

Ca  $\xrightarrow{\text{lime}}$  CaCO<sub>3</sub> → only reacts with perm. hardness

Mg  $\xrightarrow{\text{lime}}$  Mg(OH)<sub>2</sub>

zeolite  $\left[ \begin{matrix} \text{Natural} - \text{natrolite} \\ \text{synthetic} - \text{permутite} \end{matrix} \right]$   $\xrightarrow{\text{Na}_2\text{O Al}_2\text{O}_5 \text{SiO}_2 \cdot y\text{H}_2\text{O}}$   
 $\downarrow$   $\approx 2 \text{ to } 10 \text{ g/m}^3$

Hydrated sodium aluminosilicate

→ Exhausted zeolite can be replaced by NaCl (10% brine)

→ Zeolite process can cause corrosion & caustic embrittlement

→ Acidic water can't be treated  $(\text{CO}_2)$   $(\text{Na}_2\text{CO}_3)$   $\text{NaOH}$

## Ion Exchange process & Demineralisation

cationic exchange -  $H^+$        $RH^+$

Anionic exchange -  $OH^-$        $ROH^-$

regenerated by  
 $HCl$  - copolymer

$NaOH$  - longchain cross  
linked



# ACIDS & BASES

1. Acids are substances which (1) are sour to taste and corrosive, (2) turn blue litmus red, (3) contain hydrogen which can be replaced by active metals ( $Zn$ ,  $Mg$ ), (4) react with bases to form salts, (5) react with carbonates and bicarbonates liberating  $CO_2$ , (6) conduct electricity in aqueous state.

Some common acids are  $HCl$ ,  $HNO_3$ ,  $H_2SO_4$

2. Bases are substances which (1) are bitter in taste, (2) soapy to touch (3) turn red litmus blue, (4) react with acids to form salts, (5) electrolytic conductors in aqueous states some common bases are  $NaOH$ ,  $KOH$ ,  $Ca(OH)_2$

3. According to Lavoiser all acids contain oxygen and it is responsible for acidic nature.

4. According to H. Davy all acids must contain hydrogen as its constituent.

5. Modern theories of acids and bases are :

1) Arrhenius theory of acids and bases

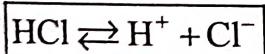
2) Bronsted - Lowry theory of acids and bases

3) Lewis theory of acids and bases

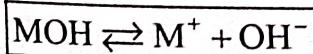
6. Arrhenius theory of acids and bases is based on Arrhenius theory of electrolytic dissociation.

7. According to Arrhenius, Acid is a substance, which produces  $H^+$  ions in aqueous solution. (or) Acid is a substance that increases the concentration of  $H^+$  ions in aqueous solution.

Ex :  $HCl$ ,  $HNO_3$ ,  $H_2SO_4$ ,  $H_3PO_4$ ,  $CH_3COOH$

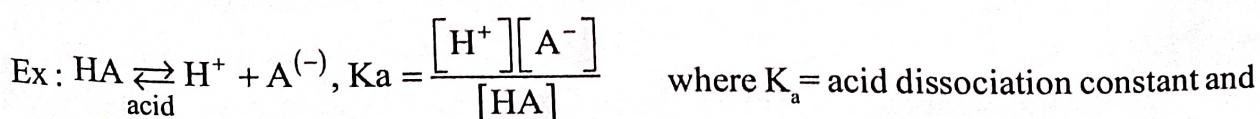


8. According to Arrhenius, base is a substance which produces  $OH^{(-)}$  ions (hydroxyl ions) in aqueous solution. (or) Base is a substance that increases the concentration of  $OH^-$  ions in aqueous solution :



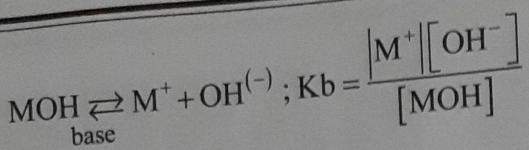
ex :  $NaOH$ ,  $KOH$ ,  $Ba(OH)_2$ ,  $NH_4OH$

9. Strength of acids and bases can be explained on the basis of ionisation constant (Extent of ionisation)



where  $K_a$  = acid dissociation constant and

$pH \uparrow K_a \downarrow$



$K_b$  = base dissociation constant

10. Strong acid ionises completely (high  $K_a$  value) to give more  $\text{H}^+$  ions.

Ex :  $\text{HCl}$ ,  $\text{HNO}_3$ ,  $\text{H}_2\text{SO}_4$ ,  $\text{H}_2\text{CrO}_4$ ,  $\text{HI}$

11. Strong base ionises completely (high  $K_b$  value) to give more  $\text{OH}^-$  ions.

Ex :  $\text{NaOH}$ ,  $\text{KOH}$

12. Weak acid does not ionise completely (low  $K_a$  value) to give less  $\text{H}^+$  ions

Ex :  $\text{CH}_3\text{COOH}$ , oxalic acid ( $\text{H}_2\text{C}_2\text{O}_4$ ),  $\text{HCN}$ ,  $\text{HCOOH}$ ,  $\text{H}_2\text{CO}_3$ ,  $\text{H}_3\text{BO}_3$ ,  $\text{H}_3\text{PO}_4$  etc.

13. Weak base does not ionise completely (low  $K_b$  value) to give less  $\text{OH}^-$  ions

Ex :  $\text{NH}_4\text{OH}$ ,  $\text{Be(OH)}_2$ ,  $\text{Ca(OH)}_2$ ,  $\text{Al(OH)}_3$ ,  $\text{Fe(OH)}_3$

14. Acid reacts with base to form salt and water (Neutralisation)

Ex :  $\text{HCl} + \text{NaOH} \rightarrow \text{NaCl} + \text{H}_2\text{O}$   
acid      base      salt      water

15. Limitations of Arrhenius theory of acids and bases :

1) It is applicable only to aqueous solution

2) It failed to explain acidic nature of carbondioxide ( $\text{CO}_2$ )

OXIDES

3) It failed to explain basic nature of  $\text{NH}_3$ ,  $\text{Na}_2\text{CO}_3$ ,  $\text{CaO}$ ,  $\text{Na}_2\text{O}$ ,  $\text{BaO}$  etc and  $M_g\text{O}$

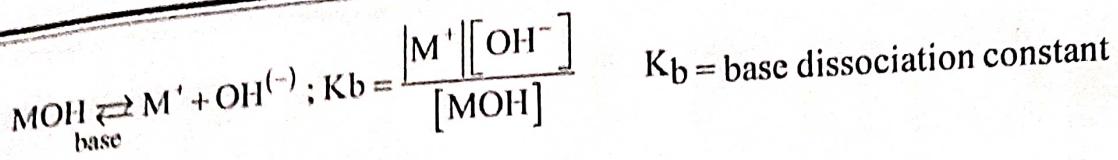
4) It failed to explain nonprotic acids like  $\text{SO}_2$ ,  $\text{NO}_2$ ,  $\text{P}_2\text{O}_5$  and  $\text{SO}_3$  etc.

5) The hydration of hydrogen ion in aqueous state was not explained.  $(\text{H}^+ + \text{H}_2\text{O} \rightarrow \text{H}_3\text{O}^+)$   
hydronium ion

6) The reactions between metal oxide and non-metal oxide are also neutralisations were not explained by Arrhenius.

16. According to Bronsted - Lowry, a substance which can donate a proton to other substance is an acid (or) proton donor is an acid. Ex :  $\text{HCl}$ ,  $\text{HNO}_3$ ,  $\text{H}_2\text{SO}_4$ ,  $\text{CH}_3\text{COOH}$

17. According to Bronsted - Lowry, a substance which can accept a proton from other substance is called a base (or) proton acceptor is a base. Ex :  $\text{NH}_3$ ,  $\text{H}_2\text{O}$ ,  $\text{HSO}_4^-$ ,  $\text{HCO}_3^-$ ,  $\text{Cl}^-$



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Ex :  $\text{HCl}$ ,  $\text{HNO}_3$ ,  $\text{H}_2\text{SO}_4$ ,  $\text{H}_2\text{CrO}_4$ ,  $\text{HI}$

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Ex :  $\text{NaOH}$ ,  $\text{KOH}$

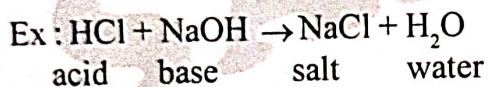
12. Weak acid does not ionise completely (low  $K_a$  value) to give less  $\text{H}^+$  ions

Ex :  $\text{CH}_3\text{COOH}$ , oxalic acid ( $\text{H}_2\text{C}_2\text{O}_4$ ),  $\text{HCN}$ ,  $\text{HCOOH}$ ,  $\text{H}_2\text{CO}_3$ ,  $\text{H}_3\text{BO}_3$ ,  $\text{H}_3\text{PO}_4$  etc.

13. Weak base does not ionise completely (low  $K_b$  value) to give less  $\text{OH}^-$  ions

Ex :  $\text{NH}_4\text{OH}$ ,  $\text{Be(OH)}_2$ ,  $\text{Ca(OH)}_2$ ,  $\text{Al(OH)}_3$ ,  $\text{Fe(OH)}_3$

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*Oxides*

3) It failed to explain basic nature of  $\text{NH}_3$ ,  $\text{Na}_2\text{CO}_3$ ,  $\text{CaO}$ ,  $\text{Na}_2\text{O}$ ,  $\text{BaO}$  etc and  $MgO$

4) It failed to explain nonprotic acids like  $\text{SO}_2$ ,  $\text{NO}_2$ ,  $\text{P}_2\text{O}_5$  and  $\text{SO}_3$  etc.

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17. According to Bronsted - Lowry, a substance which can accept a proton from other substance is called a base (or) proton acceptor is a base. Ex :  $\text{NH}_3$ ,  $\text{H}_2\text{O}$ ,  $\text{HSO}_4^-$ ,  $\text{HCO}_3^-$ ,  $\text{Cl}^-$

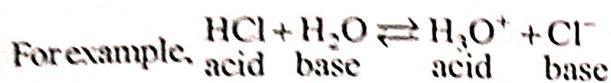
18. According to Bronsted-Lowry theory acid and base are interrelated by the equation



19. In the reaction,  $\text{HCl} + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{Cl}^-$ ,  $\text{HCl}$  is an acid since it donates a proton and  $\text{H}_2\text{O}$  is a base since it accepts a proton.

20. In the reaction,  $\text{NH}_3 + \text{H}_2\text{O} \rightleftharpoons \text{NH}_4^+ + \text{OH}^-$ ;  $\text{NH}_3$  is a base since it accepts a proton and  $\text{H}_2\text{O}$  is an acid since it donates a proton.

21. According to Bronsted-Lowry theory each acid-base involves two acids and two bases or acid-base pairs.



$\text{HCl}$  and  $\text{Cl}^-$  are one acid-base pair

$\text{H}_3\text{O}^+$  and  $\text{H}_2\text{O}$  are another acid-base pair

22. The acid-base pair which differ by a proton is called conjugate acid-base pair.

Ex:  $\text{HCl}$ ,  $\text{Cl}^-$  and  $\text{H}_2\text{O}$ ,  $\text{H}_3\text{O}^+$

23. An acid by donating a proton is converted into its conjugate base and a base by accepting a proton is converted into its conjugate acid

Acid - Proton ( $\text{H}^+$ ) = conjugate base

Base + Proton ( $\text{H}^+$ ) = conjugate acid

*add  
Acid  
Base  
subtract*

24. Some conjugate acid-base pairs are :

Acid	Base (conjugate)	Acid	Base (conjugate)
$\text{HCl}$	$\text{Cl}^-$	$\text{HClO}_4$	$\text{ClO}_4^{(-)}$
$\text{H}_3\text{O}^+$	$\text{H}_2\text{O}$	$\text{HNO}_3$	$\text{NO}_3^{(-)}$
$\text{NH}_4^+$	$\text{NH}_3$	$\text{H}_2\text{SO}_4$	$\text{HSO}_4^{(-)}$
$\text{H}_2\text{O}$	$\text{OH}^{(-)}$	$\text{HSO}_4^{(-)}$	$\text{SO}_4^{2-}$
$\text{CH}_3\text{COOH}$	$\text{CH}_3\text{COO}^{(-)}$	$\text{H}_2\text{S}$	$\text{HS}^{(-)}$
$\text{H}_2\text{CO}_3$	$\text{HCO}_3^{(-)}$	$\text{HS}^{(-)}$	$\text{S}^{2-}$
$\text{HCO}_3^-$	$\text{CO}_3^{2-}$		

- In a conjugate acid - base pair, if the acid is strong, its conjugate base is weak. Similarly if the base is strong, its conjugate acid is weak.
25. In a conjugate acid - base pair, if the acid is strong, its conjugate base is weak. Similarly if the base is strong, its conjugate acid is weak.

Ex : HCl is strong acid and hence its conjugate base  $\text{Cl}^-$  is weak base.

26. According to Bronsted - Lowry theory, the transfer of a proton from an acid to a base is called neutralisation.
27. An acid which has greater tendency to donate a proton is called strong acid.

Ex : HCl,  $\text{H}_2\text{SO}_4$ ,  $\text{HNO}_3$ ,  $\text{H}_2\text{CrO}_4$

28. An acid which has lesser tendency to donate a proton is called weak acid.

Ex : HCN,  $\text{CH}_3\text{COOH}$ ,  $\text{H}_2\text{CO}_3$ , HCOOH,  $\text{H}_2\text{CO}_3$ ,  $\text{H}_3\text{PO}_4$ ,  $\text{H}_3\text{BO}_3$  etc.

29. A base which has greater tendency to accept a proton is called strong base.

Ex :  $\text{OH}^{(-)}$ ,  $\text{CN}^{(-)}$ ,  $\text{CH}_3\text{COO}^{(-)}$ ,  $\text{HCOO}^{-}$

30. A base which has lesser tendency to accept a proton is called weak base.

Ex :  $\text{Cl}^{(-)}$ ,  $\text{HSO}_4^{(-)}$ ,  $\text{NO}_3^{(-)}$

31. Bronsted - Lowry classified solvents into four types :

1) Protophilic solvents - Bases

2) Protogenic solvents - Acids

3) Amphiprotic solvents and

4) Aprotic solvents

32. Solvents that have greater tendency to accept protons (i.e., bases) are called protophilic solvents.

Ex : Liquids ammonia, water, alcohol.

33. Solvents that have tendency to produce protons (i.e., acids) are called protonic solvents.

Ex : HCl (liquid), acetic acid, water,  $\text{H}_2\text{SO}_4$ ,  $\text{HNO}_3$ , etc.

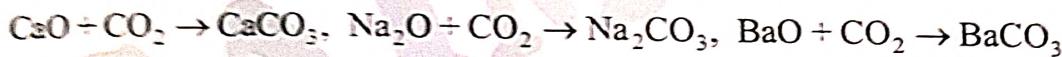
34. Amphiprotic solvents act either as protophilic or protonic solvents. They donate or accept proton depending upon the nature of other substance. Ex :  $\text{H}_2\text{O}$ , ROH

35. Solvents which neither donate nor accept protons are called aprotic solvents.

Ex : Benzene, carbon tetrachloride, carbondisulphide ( $\text{CS}_2$ ), Toluene etc.

36.  $\text{H}_3\text{O}^+$  is the strongest acid that can exist in water.

37.  $\text{OH}^{(-)}$  is the strongest base that can exist in water.
38. The levelling of the strength of all strong acids in water to the same level as that of  $\text{H}_3\text{O}^+$  (or) the levelling of the strengths of all strong bases in water to the same level as that of  $\text{OH}^{(-)}$  is known as levelling effect of water.
39. Bronsted - Lowry theory can explain the acid - base character of substances in non aqueous solutions. It can explain the basic nature of ammonia ( $\text{NH}_3$ )
40. Bronsted-Lowry theory is useful only when proton donor and proton acceptor are available together.
41. Bronsted - Lowry theory can not to explain the acidic character of electron deficient compounds like  $\text{BF}_3, \text{BCl}_3, \text{AlCl}_3, \text{FeCl}_3, \text{CO}_2, \text{SO}_2, \text{SO}_3, \text{P}_2\text{O}_5, \text{NO}_2$  etc. Oxides, deficient compou  
It can not explain basic character of substances like  $\text{CaO}, \text{Na}_2\text{O}, \text{K}_2\text{O}, \text{BaO}$  etc.
42. B.L. theory can not explain neutralisation reaction between  $\text{CaO}$  and  $\text{CO}_2$  with does not involve a proton transfer.



43. According to Lewis theory, a substance which accepts an electron pair and forms a co-ordinate covalent bond is known as an acid. (or) Electron pair acceptor is an acid.

Ex:  $\text{H}^-$ ,  $\text{FeCl}_3$ ,  $\text{BF}_3$ ,  $\text{AlCl}_3$ ,  $\text{PF}_3$ ,  $\text{SiCl}_4$ ,  $\text{SF}_4$

#### 44. Types of Lewis acids :

1) Cations with vacant orbitals. Ex :  $\text{H}^+$ ,  $\text{Na}^+$ ,  $\text{Mg}^{2+}$ ,  $\text{Fe}^{3+}$ ,  $\text{Fe}^{2+}$ ,  $\text{Zn}^{2+}$ ,  $\text{Ag}^+$

2) Electron deficient compounds (compounds in which the central atom does not possess eight electrons in valence shell) Ex :  $\text{BF}_3$ ,  $\text{BCl}_3$ ,  $\text{AlCl}_3$ ,  $\text{FeCl}_3$ ,  $\text{SO}_3$

3) Inorganic molecules containing double bonds between dissimilar atoms :

Ex:  $\text{CO}_2, \text{SO}_2, \text{NO}_2$

	A	B
B-L	d	a
L	a	d

45. According to Lewis theory, a substance which donates an electron pair and forms a co-ordinate covalent bond is called a base (or) Electron pair donor is a base.

Ex:  $\text{NH}_3, \text{H}_2\text{O}, \text{OH}^{(-)}, \text{Cl}^{(-)}$

#### 46. Types of Lewis bases :

1) All anions are negatively charged ions.

Ex:  $\text{Cl}^-, \text{F}^{(-)}, \text{OH}^{(-)}, \text{CN}^{(-)}$

2) Molecules containing lone pair of electrons.

Ex :  $\text{NH}_3$ ,  $\text{H}_2\text{O}$ ,  $\text{R}-\text{OH}$  (alcohol),  $\text{PH}_3$ ,  $\text{ASH}_3$

3) Molecules having multiple bonds between carbon atoms (*organic compounds*)

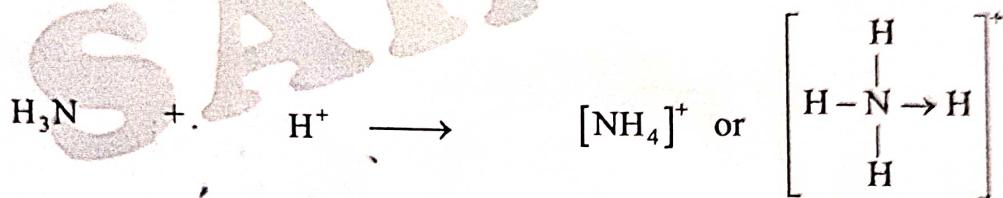
Ex :  $\text{C}_2\text{H}_4$  (ethylene),  $\text{C}_2\text{H}_2$  (acetylene) :  $\text{H}_2\text{C}=\text{CH}_2$ ,  $\text{HC}\equiv\text{CH}$

47. Neutralisation according to Lewis theory is the formation of *co-ordinate covalent bond between an acid and a base with transfer of electron pair.*

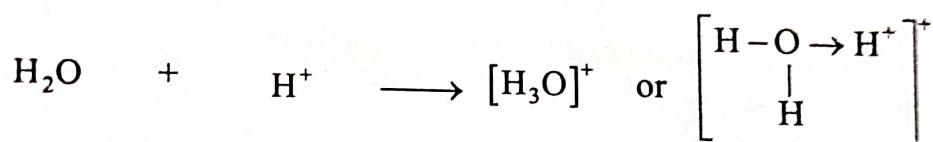
Ex : 1) Formation of Ammonia Boran trifloride



Ex : 2) Formation of Ammonium ion



Ex : 3) Formation of Hydronium ion  $[\text{H}_3\text{O}^+]$



48. Limitations of Lewis theory of acids and bases.

1) Lewis theory can not explain the strengths of acids and bases

2) Acids like  $\text{HCl}$ ,  $\text{H}_2\text{SO}_4$  can not form co-ordinate covalent bonds and can not accept electron pair.

3) Acid-base reactions are fast but Lewis acid - base reactions are slow.

4) Neutralisation of normal acids like  $\text{HCl}$ ,  $\text{H}_2\text{SO}_4$  and bases like  $\text{NaOH}$ ,  $\text{KOH}$  where dative bonds are not formed cannot be explained by Lewis theory.

5) The catalytic activity of  $\text{H}^+$  ion cannot be explained by Lewis theory.

6) It can not explain the basic nature of substances like  $\text{Ca}(\text{OH})_2$ ,  $\text{NaOH}$ ,  $\text{KOH}$  etc which can not donate electrons.

**Normal Bases**

49. The product of molar concentrations of  $\text{H}^+$  and  $\text{OH}^{(-)}$  ions in pure water or in aqueous solution at a given temperature is known as ionic product of water ( $K_w$ )

$$K_w = [\text{H}^+] [\text{OH}^-]$$

At  $25^\circ\text{C}$  the value of  $K_w = 1.0 \times 10^{-14}$  moles $^2/\text{lit}^2$

units of  $K_w = \text{moles}^2/\text{lit}^2$

50. In pure water,  $[\text{H}^+] = [\text{OH}^{(-)}] = 1.0 \times 10^{-7}$  moles/lit

51.  $[\text{H}^+] = \frac{K_w}{[\text{OH}^{(-)}]}$  and  $[\text{OH}^{(-)}] = \frac{K_w}{[\text{H}^+]}$

52. In neutral solutions,  $[\text{H}^+] = [\text{OH}^{(-)}] = 1.0 \times 10^{-7}$  moles/lit at  $25^\circ\text{C}$

In acidic solutions,  $[\text{H}^+] > [\text{OH}^{(-)}]$

i.e.,  $[\text{H}^+] > 1.0 \times 10^{-7}$  and  $[\text{OH}^{(-)}] < 1.0 \times 10^{-7}$

In basic solutions,  $[\text{OH}^{(-)}] > [\text{H}^+]$

i.e.,  $[\text{OH}^{(-)}] > 1.0 \times 10^{-7}$  and  $[\text{H}^+] < 1.0 \times 10^{-7}$

$\uparrow T \uparrow K_w \uparrow P_{\text{H}_2} \downarrow$

53. As the temperature increases  $[\text{H}^+]$  and  $[\text{OH}^-]$  increases and  $K_w$  increases.

54. In pure water and neutral solutions, the concentrations of  $[\text{H}^+]$  and  $[\text{OH}^{(-)}]$  ions are equal

$$\therefore [\text{H}^+] = [\text{OH}^{(-)}] = \sqrt{1.0 \times 10^{-14}} = 1.0 \times 10^{-7} \text{ mole/lit}$$

55. Soren sen introduced concept of pH      **Potenz of  $\text{H}_2$**

pH : The negative logarithm (base - 10) of the hydrogen ion concentration is known as pH of the solution

$$\text{Thus, } \text{pH} = -\log_{10} [\text{H}^+] = \log_{10} \frac{1}{[\text{H}^+]}.$$

56. Similarly  $\text{pOH} = -\log_{10} [\text{OH}^-] = \log_{10} \frac{1}{[\text{OH}^-]}$

57. In pure water at  $25^\circ\text{C}$   $[\text{H}^+] = [\text{OH}^-] = 1.0 \times 10^{-7}$  mole/lit

Thus in pure water:

$$\text{pH} = -\log_{10} (1 \times 10^{-7}) = -(-7) = +7$$

$$\text{and pOH} = -\log (1 \times 10^{-7}) = -(-7) = +7$$

$$\therefore \text{pH} + \text{pOH} = 7 + 7 = 14$$

58. For pure water and neutral solutions:

$$\text{pH} = \text{pOH} = 7 \text{ and } \text{pH} = 14 - \text{pOH}$$

59. For acidic solution  $\text{pH}$  is less than 7

For basic solution  $\text{pH}$  is greater than 7

$$\text{pH} = \begin{matrix} \text{O} & \xrightarrow{\quad} & 7 & \xrightarrow{\quad} & 14 \\ \leftarrow & & (\text{neutral}) & \rightarrow & \\ \text{Acidic} & & & & \text{basic} \end{matrix}$$

60. The lower the  $\text{pH}$ , more acidic is the solution, conversely the higher the  $\text{pH}$ , the more basic is the solution.

61. If  $[\text{H}^+]$  concentration increases by 10 times, the  $\text{pH}$  decreases by one unit and if the  $[\text{H}^+]$  can decrease by

10 times, the  $\text{pH}$  increases by one unit.

62.  $[\text{H}^+] = 10^{-\text{pH}}$

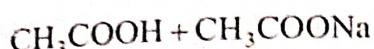
63. Human blood has specific  $\text{pH} 7.4$  (Slightly alkaline)

64. Buffer: A solution which resists change in its  $\text{pH}$  value by the addition of a small amount of an acid or a base is called Buffer solution.

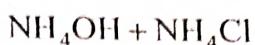
65. The property of resisting the change in  $\text{pH}$  value is known as Buffer action or Buffer capacity.

B. Chubbi

66. Examples of buffers are : Mixtures of



and



(Acetic acid) + (Sodium acetate)

(Amm hydroxide + Amm. Chloride)

67. Buffer solution are of two types :

1) Acidic buffers and

2) Basic buffers

68. Acidic Buffer : A mixture of weak acid and salt of its conjugate base is called Acidic buffer. The  $\text{pH}$  of this buffer will be less than 7.

Ex :  $\text{CH}_3\text{COOH} + \text{CH}_3\text{COONa}$ ,  $\text{H}_2\text{CO}_3 + \text{NaHCO}_3$ ,  $\text{HCN} + \text{NaCN}$ ,  $\text{HCOOH} + \text{HCOONa}$   
 $\text{H}_3\text{PO}_4 + \text{NaH}_2\text{PO}_4$

69. Basic buffer : A mixture of weak base and salt with its conjugate acid is called Basic buffer. Its  $\text{pH}$  will be more than 7.

Ex :  $\text{NH}_4\text{OH} + \text{NH}_4\text{Cl}$

70. Applications of buffer solutions are :

1) Buffer solutions are used in chemical analysis, in industrial synthetic processes and in enzyme catalysed reactions to control  $\text{pH}$

2) Buffers play an important role in biochemical reactions which occur at definite  $\text{pH}$ .

For example : Carbonate buffer keeps  $\text{pH}$  of blood at a constant value of 7.4.

3) Ammonia buffer (mixture of  $[\text{NH}_4\text{OH} + \text{NH}_4\text{Cl}]$ ) is used in the estimation of hardness of water by E.D.T.A method

complexometric Titration

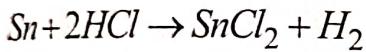
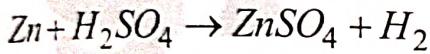
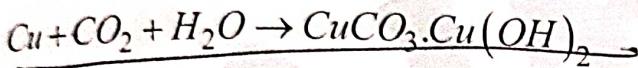
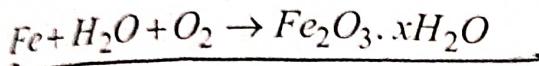
4) Buffers should be added to tonics and syrups

**Araise ! Awake ! And stop not till the goal  
is reached**



# CORROSION

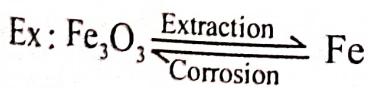
- Any process of deterioration of metallic materials with chemical (or) electrochemical attack by the environmental substance on the metal surface is called corrosion.
  - Corrosion is an unwanted reaction in which loss of metal takes place.
  - In corrosion metal reacts with environmental substance to form a metallic compound which is called corrosion product.
  - The corrosion product depends on the substance with which metal reacts
- Ex: Metal + Env. Substance → Corrosion product.



→ Metallic compound will be having lesser energy when compared to metal, so metallic compound is more stable than metal. Hence metals undergo corrosion to form metallic compounds in the environment i.e. Metal gets more stability when it undergoes corrosion.

→ Extraction of metal from its ore is a reduction process (i.e., gain of electrons takes place).

→ Corrosion is reverse to extraction of metal so corrosion is an oxidation process (i.e., loss of electrons takes place by metal)



→ Extraction is a non spontaneous process and corrosion is a spontaneous process.

→ Extraction of metal is a process from its ore in which energy is consumed, corrosion is a process in which energy is released. i.e. endothermic and exothermic processes respectively.

Noble metals Ag, Au, Pt can occur in their native state and they will not undergo corrosion in normal environment conditions.

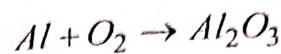
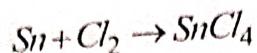
→ Corrosion can be broadly classified into two categories.

1. Dry corrosion (direct chemical corrosion)

2. Wet corrosion (electro chemical corrosion)

→ **Dry corrosion:** This corrosion takes place with the direct chemical action of environmental substance on the metal surface in the absence of conducting medium at low or high temperature. Conducting medium is any liquid, solution or moisture.

→ In the dry corrosion there should not be any conducting medium.



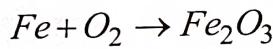
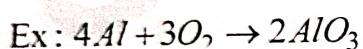
→ If a metal undergoes corrosion with the direct chemical action of oxygen in the absence of moisture, it is called oxidation corrosion.

→ Oxidation corrosion is a dry corrosion which takes place with oxygen.

→ In oxidation corrosion metal oxide is formed as a corrosion product.

→ In Oxidation corrosion metal atoms will loose electrons to form positively charged metal ions and oxygen atoms gain electrons to form oxide ions ( $\text{O}^{2-}$ )

→ Metallic ions and oxide ions join, together to form metallic oxide



→ When a metal undergoes oxidation corrosion a metaloxide layer is formed on the surface of the metal

→ Depending on the formed metal oxide layer further corrosion of metal can be continued or it can be prevented.

→ The metaloxide layers can be classified into four types

◆ **Unstable metaloxide layers :** If a metal forms an unstable metaloxide layer further corrosion of the metal can be prevented.

Unstable metaloxide will dissociate into metal and oxygen. So corrosion cannot be continued.

Noble metals like silver, gold, platinum (Ag, Au, Pt)

will form unstable metaloxide layer

◆ **Stable metaloxide:** If a metal forms stable metal oxide layer further corrosion of the metal can be stopped.

A stable metal oxide will prevent metal exposure to oxygen so corrosion can be prevented.

Metals like copper, tin, zinc, aluminium, lead can form stable metal oxide layers (Cu, Sn, Al, Pb, Ti, Cr etc).

**Porous metaloxide layers:** If the metal oxide layer is porous, oxygen will enter through the pores and attack fresh metal surface i.e. a porous oxide layer will allow the metal to undergo continuous corrosion.

Alkali and alkaline earth metals will form porous oxide layers.

**Volatile oxide layers:** Volatile oxide will continuously evaporate into the atmosphere. So metal will undergo corrosion continuously.

tungsten (W), molybdenum (Mo) can form volatile oxide layers.

### → PILLING - BEDWORTH RULE :

Pilling-Bedworth rule predict the nature of metal oxide. :

According to this rule, if the metal oxide volume is equal to or greater than the volume of a metal from which it is formed, then it is non-porous and protective.

If the volume of metal oxide layer is less than the volume of metal from which it is formed. Then that metal oxide is porous and non-protective.

Alkali and alkaline earth metals will form the metal oxide having less volume than the metal undergoes corrosion. So those are porous

Metals like Cu, Sn, Al, Pb, Ti, Cr will form a metal oxide with, more volume than the volume of the metal so those are non-porous and protective

### → WET CORROSION (OR) ELECTRO CHEMICAL CORROSION:

Electro chemical corrosion takes place when a metal is in contact with conducting medium (or) when two different metals are connected to each other in presence of conducting medium.

When a metal is in contact with conducting medium, then on the metal surface there will be anodic area and cathodic area formed and the corrosion takes place with the electro chemical reaction.

Anodic area undergoes oxidation process and it continuously undergoes corrosion.

From anodic area metal atoms will loose electrons to form positively charged metal ions

The released electrons will transfer from anodic to cathodic area through the metal and at cathodic area these are consumed i.e., at cathodic area reduction takes place.

Between anodic and cathodic area current flows.

In the electrochemical corrosion always anodic area undergoes corrosion and cathodic area will be protected

The metallic ions from anodic area and the non metallic ions from cathodic area will diffuse together and join with each other to form a corrosion product between anodic and cathodic area, i.e., at the cathodic area.

### → The characteristic features of electro chemical corrosion are :

⇒ The presence of conduction medium on the metal surface

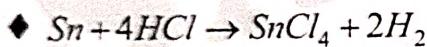
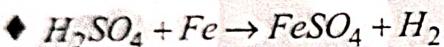
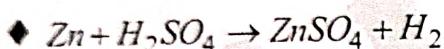
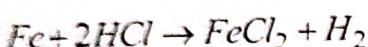
⇒ Formation of anodic and cathodic areas. Corrosion of anodic area only

Formation of corrosion product between anodic and cathodic areas. Electro chemical corrosion can take place either with evolution of hydrogen (or) with absorption of oxygen

### → EVOLUTION OF HYDROGEN TYPE E.C:

- When metals undergo corrosion in presence of acid, it takes place with evolution of hydrogen.
- Depending on the metal and acid, corrosion product will be formed.
- In presence of acid, on the metal surface a large anodic area and small cathodic area will be formed.
- From anodic area metal atoms will loose electron to form metallic ions.
- These electrons will be consumed by  $H^+$  ions of acid to form hydrogen gas.
- Metallic ions and non metallic ions of acid join together to form corrosion product.

Ex : ♦ If iron undergoes corrosion in presence of HCl ferrous chloride is corrosion product



- All the metals above the hydrogen in the electro chemical series undergo corrosion in the acidic medium.

### → OBSORPTION OF OXYGEN TYPE E.C:

- For the absorption of oxygen type electro chemical corrosion, rusting of iron in the neutral conducting medium can be taken as an example.
- In this type of corrosion a small anodic area and a large cathodic area will be produced on the metal surface.
- From anodic area metal atoms will loose electrons to form metallic ions  $[Fe^{2+}]$
- At cathodic area electrons will be gained by oxygen in presence of water to form  $OH^-$  ion.
- $Fe^{2+}$  and  $OH^-$  ions join together to form ferrous hydroxide.
- v.i.p In the sufficient amount of oxygen ferrous hydroxide will be converted into ferric hydroxide  $[Fe(OH)_3]$  which can be called hydrated ferric oxide  $[Fe_2O_3 \cdot xH_2O]$  and it is formed as a final corrosion product. (It is yellow rust)
- v.v.g In the limited supply of oxygen ferraso ferric oxide is the corrosion product  $(Fe_3O_4)$  (it is also called black magnatite)
- Electro chemical corrosion can be compared with electro chemical cell.

In the electro chemical cell chemical energy is converted into electrical energy

In the electrolytic cell electrical energy will be converted into chemical energy.

Electro chemical cell can also be considered as galvanic cell (or) voltaic cell.

In the electro chemical cell at anode electrons are released which is at higher potential i.e., oxidation takes place at anode.

At cathode electrons are consumed i.e., reduction takes place and cathode is at lower potential.

The tendency of loosing electrons (or) gaining electrons will be given by the electrode potential value of the metal

Electrode potential value of the metal can be expressed in two ways oxidation potential or reduction potential

The tendency of loosing electrons by a metal will be given by oxidation electrode potential.

Reduction electrode potential will indicate the tendency of gaining electron by a metal.

If the oxidation potential is +ve then its reduction potential is -ve and vice versa. ;

The metal with more oxidation potential or less reduction potential can loose electrons easily. It undergoes oxidation easily, it is more active and it can act as anode.

If a metal has less oxidation potential or more reduction potential can gain electrons easily, i.e., reduction takes place easily, it is less active or more noble and it can act as cathode.

If two metals are connected together, among them the metal with more oxidation potential can act as anode and it undergoes corrosion. And the metal with less oxidation potential value will act as cathode and it is protected.

A series of metals in which the metals are arranged according to their decreasing order of oxidation potential or increasing order of reduction potential is called as electro chemical series.

The electrode potential values of various metals can be calculated by comparing with standard hydrogen electrode which is having zero electrode potential.

In the electro chemical cell anode should be written left hand side and cathode should be written right hand side.

In the electro chemical cell connecting two half cells (i.e., anode and cathodes) there will be a salt bridge or porous diaphragm which allows only ions to move from one electrode to another electrode.

Anode and cathode are connected with an external wire through which the electrons will move from anode to cathode.

Danial cell is an example for electro chemical cell.

- In Daniell cell Zn in  $ZnSO_4$  will be taken as anode and Cu in  $CuSO_4$  will be taken as cathode. The cell representation or notation is  $Zn/ZnSO_4 // CuSO_4/Cu$
- The difference of potential between anode and cathode because of which the electrons will move from anode to cathode is called as electromotive force (emf)
- $EMF = E_{right} - E_{left}$
- In an electrochemical cell if anode is having -0.77 volts of potential and cathode is having +0.33 volts of potential what is the emf.

Sol :  $emf = 0.33 - (-0.77) = 1.1$  volts

- In electrochemical cell anode is indicated with -ve sign and cathode with +ve sign.
- In electrolytic cell anode is indicated with +ve sign and cathode with -ve sign.
- The potential development, when a metal is placed in its own solution of 1M conc. and at  $25^\circ C$  is called standard electrode potential.
- If standard electrode potential is known, the potential at same concentration at same temperature can be known with Nerust reaction.

Nerust equation is  $\epsilon = \epsilon^0 + \frac{2.303}{nF} \log [M^{+n}]$

- If a metal 'x' has potential -0.6 volts and 'y' has +0.8 volts, then what is anode and cathode among them? What is emf if they are connected together in an electrochemical cell?

Sol : X is anode and y is cathode  $emf = +0.8 - (-0.6) = 1.4$  volts

- Offering more corrosion resistance than expected is called as passivity.
- Passivity is offered by certain metals in specific environments only.
- In the oxidation atmosphere titanium, Al, Cr, stainless steels containing chromium will offer passivity.
- They form a very thin (i.e. upto 0.0004mm) protective layer which is self-healing.
- Even though oxidation potential of Al is more than iron, it undergoes less corrosion in oxidation atmosphere due to passivity.
- The corrosion resistance property of stainless steel is due to the Cr present in it. It forms a protective oxide layer over it.
- Due to oxidation nature of concentrated nitric acid Fe offers passivity in concentrated nitric acid. It forms a protective  $Fe_3O_4$
- In dilute nitric acid iron undergoes corrosion with evolution of hydrogen.
- By studying corrosion activity of various metals in a specific environment, they can be arranged in a series which is called as galvanic series.

- In galvanic series metals and alloys are arranged and it changes with corrosive medium.
- Galvanic series gives correct order of corrosion of metals and alloys in a specific corrosive medium.
- In electrochemical series metals and non-metals are arranged.
- In electrochemical series the position of elements are fixed.

Ex: For electrochemical series

Li - K - Ca - Na - Mg - Al - Zn - Cr - Fe - Ni - Sn - Pb - Cu - Ag - Pt - Au - F

for galvanic series in sea water

Mg - Mg alloys - Zn - Al - Cd - Al alloys - Fe - steel

Pb - Sn - Brass - Cu - Ni - Cr - Ag - Au - Pt

Corrosion fatigue : It is the reaction of fatigue strength of a metal in the corrosive medium.

The electrochemical corrosion takes place with electrochemical cell formation which are

- i) Composition cell
- ii) Concentration cell and
- iii) Stress cells

## ⇒ GALVANIC CORROSION : (Composition cell formation)

- When two different metals are connected together in the presence of a conducting medium, the more active metal (i.e, metal having more oxidation potential) will act as anode and noble metal or less active metal (metal having less oxidation potential) will act as cathode. It is called composition cell formation.
- Anodic metal undergoes oxidation and it will continuously undergo corrosion, less active metal will be protected.
- In galvanic corrosion in presence of acidic medium hydrogen evolution takes place.
- In presence of basic medium or neutral medium galvanic corrosion takes place with absorption of oxygen.
- Depending on the corrosive medium the corrosion product will be formed.
- Ex for this corrosion; Steel screws fitted in different machine parts. if metals or alloys are joined in a machine Cu screws fixed with steel screws.

## ⇒ CONCENTRATION CELL CORROSION: (Concentration cell formation)

- Metal surface partly exposed to more concentrated corrosive medium and partly less concentrated, then concentration cell will be formed.
- The area under more concentration will become anodic and less concentration becomes cathodic.
- When a metal is exposed to different air concentration then this type of corrosion takes place.
- The part of the metal surface which is exposed to more air (i.e, more oxygen) can act as cathodic area and remaining part of the metal surface which is exposed to less air / less oxygen can act as anodic area. (Differential aeration or oxygen concentration cell corrosion)

- If a metal part is covered with another metal (or) if some dust is present on the metal surface (or) if some dust is present on the metal surface (or) if drops of liquid present on the surface of the metal (or) if part of metal is covered with wooden block (or) mirror (or) asbestos etc. Then this type of corrosion takes place.

### ⇒ STRESS CORROSION (Stress cell Formation)

- Stress corrosion is a combined effect of stress and corrosive environment.
- Continuous stress on the metal will develop some strains which act as anodic areas and rest of the metal surface will act as cathodic area.
- Copper, brass, will undergo stress corrosion if ammonia is present as corrosive environment.
- Steel will undergo stress corrosion in presence of alkali or nitrate solutions. Stainless steel can undergo stress corrosion in acid chloride solution.

### ⇒ WATER LINE CORROSION

- If a metal is exposed to different oxygen concentration below and above the water level then this type of corrosion takes place.
- The metal surface which is under the water will not be exposed to air and it can act as anodic areas and metal surface which is above the water level will be exposed to air and it can act as cathodic areas.
- If a metal is partially immersed in water this corrosion takes place.
- This type of corrosion can be observed in water tanks, ship hulls.

### ⇒ PITTING CORROSION

- Pitting corrosion is a localised and fast corrosion resulting in the formation of pinholes or pits.
- It is due to the breakdown of protective film on a metal at specific points. That specific points will act as anodic areas.
- The developed cracks, pits will act as anodic areas and corrosion takes place very fastly.
- In this type of corrosion the anodic areas are very small and cathodic area is larger.
- Specific metals in the specific environments, undergo pitting corrosion.
- Pitting corrosion can also be due to surface roughness, non-uniform finish, cut edges, local stress, chemical attack, impurities on the surface of the metal etc.

Ex: Stainless steel and aluminium undergo pitting corrosion in the chloride solution

### ⇒ INTERGRANULAR CORROSION :

- This corrosion takes place along the grain boundaries of metals,
- This corrosion takes place internally and it cannot be seen externally until the metal piece breaks

This corrosion takes place due to the deposition of certain substances along the grain boundaries which can act as anodic areas and grain centre can act as cathodic area.

This corrosion can be observed in welded stainless steels.

In the welding process due to high temperature chromium carbide is formed in the stainless steel and it will be deposited along the grain boundaries which will act as anodic area.

With this intergranular corrosion the coordination to the grains will be lost and metal breaks.

#### → THERMO GALVANIC CORROSION

With the electricity leakage or with sudden heating and cooling if a metal undergoes corrosion then it is called thermo galvanic corrosion.

#### → SOIL CORROSION OR UNDER GROUND CORROSION :

- If the metals undergo corrosion in the soil or under ground then it is called as soil corrosion.
- The extent of soil corrosion depends on moisture in the soil, salt contents in soil, soil nature (acidic or basic) degree of aeration, soil texture, conductivity of soil etc. The pipes present in the soil, can undergo soil corrosion.

#### → MICRO BIOLOGICAL CORROSION :

- The corrosion that takes place with micro organism on the metal surface is called microbiological corrosion
- With the metabolic activities, the micro organisms will release certain substances on the metal surface which gives corrosion of the metal.

#### → CAUSTIC EMBRITTLEMENT :

- It is a type of boiler corrosion. It takes place with the basic substance like sodium carbonate  $\text{Na}_2\text{CO}_3$  present in the water
- $\text{Na}_2\text{CO}_3$  will react with water to form  $\text{NaOH}$  (sodium hydroxide) which will enter into the cracks or crevices or joints of the boiler where its concentration will be increased.
- The part of boiler material with more concentrated  $\text{NaOH}$  will act as anodic area and remaining part with less concentrated  $\text{NaOH}$  will act as cathodic area. And anodic area undergoes corrosion,
- Iron reacts with concentrated  $\text{NaOH}$  to form sodium ferroate ( $\text{Na}_2\text{FeO}_3$ ) which again reacts with water to form ferrasoferric oxide ( $\text{Fe}_3\text{O}_4$ ).

#### → SELECTIVE LEACHING :

- If a particular metal undergoes corrosion from an alloy or if a particular metal dissolves in an electrolyte from an alloy it is called selective leaching.
- If zinc dissolve in an electrolyte from an alloy it is called dezincification. If Al dissolves it is called deallumination.

## → EROSION CORROSION

- It is caused by the combined effect of the abrading action of flow of gases, or liquids and mechanical rubbing of solid over a metal surface.
- It takes place due to the breakdown of protective film on the metal surface.
- The areas on which protective film is broken can act as anodic areas and remaining part can act as cathodic area.

## → FACTORS EFFECTING CORROSION

- The factors which will effect corrosion can be classified into two types.
  - i) The factors which related to environment
  - ii) The factors which related to nature of metal

### → Nature of the metal :

- ◆ Position of the metal in galvanic series or emf series.
- ◆ Purity of metal : pure metals will not undergo corrosion easily when compare to impure metal.
- ◆ Physical state of metal
- ◆ Passivity of metal
- ◆ Nature of surface film
- ◆ Relative size of anodic and cathodic area.

v.t.Q If the anodic area is small and cathodic area is large corrosion takes place from anodic area very fastly because the electron supplying area is less and consuming area is more

If anodic area is large & cathodic area is small then corrosion takes place from anodic area slowly.

### → Environmental Factors :

- ◆ Presence of moisture in the atmosphere
- ◆ Presence of impurities and suspended particles in the air
- ◆ pH of the corrosive medium
- ◆ If oxidising agents are present in the environment those will increase-the rate of corrosion.
- ◆ Temperature of environment-: Temp may increase the corrosion or decrease the corrosion.
- ◆ The dissolved salts in the corrosive medium will increase the corrosion.
- ◆ The ability of corrosive medium to dissolve the corrosion product.
- ◆ Rate of corrosion can be expressed as loss of metal per area per time (mils per year - Milligrams of metal loss per year)
- ◆ In laboratory rate of corrosion can be expressed as mdd (milli gram. of metal loss per decimeter square area per day.)

## Corrosion controlling Methods :

### → Design of the equipment :

- ◆ Based on designing of the equipment corrosion can be controlled.
- ◆ In the designed instrument, sharp corners recessess must be avoided.
- ◆ Along with the metal, using of wood, cloth, asbestos mirrors etc must be avoided.
- ◆ The metal surface must not be covered with liquid drops, dust etc.
- ◆ Pure metals and alloys must be useful for designing the machines or instruments because pure metals or alloys offer more corrosion resistance.
- ◆ Metal surface should be smooth and uniformly exposed to air.

### → Cathodic protection:

- ◆ In this method the metal which is to be protected will be forced to act as cathode.
- ◆ There are two method with which a metal can be forced to act as cathode.

### → Sacrificial anodic protection :

- ◆ In this process the metal which is to be protected will be connected with a more active metal. More active metal will act as anode and the metal to be protected will act as cathode.
- ◆ More active metal will have more oxidation potential and it undergoes oxidation easily.
- ◆ The metals which are connected are called as sacrificial anodes or auxiliary anodes.
- ◆ The sacrificed anodes by undergoing corrosion themselves they protect the metals,
- ◆ This process can also be called as galvanic coupling. The sacrificial anodes will undergo galvanic corrosion.
- ◆ Mg, Zn, Al and their alloys-will generally act as sacrificial anodes.
- ◆ With this method underground pipelines, under ground cables, marine structures, ship hulls, water tanks, industrial boilers and transmission tower can be protected.

### → Impressed current cathodic protection :

- ◆ In this method the metal structure to be protected is made as cathode by passing direct current from a battery with an insoluble anode.
- ◆ As long as current passes through the metal it will not undergo corrosion.
- ◆ Inert electrodes like Pt, Pb graphite, stainless steel can be taken as anodes.
- ◆ This type of protection is used to water box coolers, water tanks, burried water or oil pipes, ship hulls and bridges, marine pipes, transmission tower, laid up ships, this method-is useful mainly for large structures in long operations.

## → MODIFYING THE ENVIRONMENT :

- The corrosive nature of the environment can be decreased by modifying the environment.
- Environment can be modified either by removing harmful substances or by adding certain substances,
- Corrosion due to oxygen can be decreased by removing oxygen with mechanical deairation process or by adding chemicals like  $\text{Na}_2\text{CO}_3$ ,  $\text{H}_2\text{N}-\text{NH}_2$  (hydrozine), sodium sulphite.
- Corrosion due to  $\text{CO}_2$  can be controlled by removing  $\text{CO}_2$  mechanically.
- Corrosion due to moisture can be controlled by adding dehumidification agents like  $\text{Al}_2\text{O}_3$ , silica gel.
- Acidic environment can be neutralised by releasing basic substance into the environment.;

## → BY ADDING INHIBITORS :

### **Use of Inhibitors:**

- ◆ A substance which when added in small quantities to the corrosion environment effectively decreases the corrosion of metal is called as inhibitor.
- ◆ Inhibitors are of two types- anodic inhibitors and cathodic inhibitors.
- ◆ Anodic inhibitors form protective film on the anodic area to reduce corrosion.
- ◆ Examples for anodic inhibitors are chromates, 'phosphates, tungstates and other ions of transition elements having oxygen content.
- ◆ If any break occurs in the protective film it forms a large cathodic and small anodic area which is dangerous.
- ◆ Inhibitors which reduces cathodic reaction is called cathodic inhibitor.
- ◆ Examples for cathodic inhibitors are oxides of arsenic (As) and Antimony (Sb) and organic compounds like amines, mercaptans, heterocyclic nitrogen compounds and substituted urea.
- In the design of the instrument two different metals contact must be avoided as *lit* as possible,
- If two different metals are in contact with each other it is better to have an insulation between them
- The chosen different metals be very close in the electro chemical series.
- When two different metals are in contact with each other then the anodic metals surface area must be large to decrease corrosion.
- Metals like Al,Zn,Pb are called as amphoteric metals because they undergo corrosion in acidic and basic medium.
- Caustic embrittlement which is a type of boiler corrosion can be taken as a stress corrosion.

## → APPLICATION OF PROTECTIVE COATINGS :

Protective coatings are of 3 types

- ◆ Metallic coatings

- ◆ Chemical conversion coatings or Inorganic Coatings

- ◆ Organic coatings

Metallic coatings: Applying a metal as a layer over another metal in order to protect it from corrosion is called metallic coating.

The metal which is used as coating is called coating metal and the metal over which it is applied is base metal.

Metallic coatings are of two types :      i) Anodic coatings      ii) Cathodic coatings

### → Anodic coatings: Sacrificial method

- ◆ Applying a metal as a coating which is more active than base metal is called anodic coating. That is coating metal is anodic to base metal, (coating metal is having more oxidation potential than base metal).
- ◆ Anodic coating will protect the base metal sacrificially.
- ◆ If any break occurs in the anodic coating a galvanic cell will be formed in which the coating metal acts as anode and base metal acts as cathode and coating metal only undergoes corrosion.

Ex: Coating of Zn, Mg, Al, Cadmium (Cd) on iron and steel.

● **Cathodic coating:** Coating a more noble metal than the base metal is called cathodic coating i.e., coating metal is less active than base metal.

● Coating metal will have less oxidation potential than base metal.

● Cathodic coating will protect the base metal because of its noble nature.

● If any break occurs in the cathodic coating, then base metal will act as anode and coating metal will act as cathode and a small anodic area and a large cathodic area will be developed and base metal undergoes faster corrosion.

Ex: Applying tin (Sn), silver ; (Ag), Chromium (Cr), Copper (Cu), Nickel (Ni) over iron and steel

### → Applications of metallic coating:

- |                                    |   |
|------------------------------------|---|
| ◆ Hot dipping                      | ◆ Metal cladding                          |
| ◆ Cementation or diffusion coating | ◆ Electro planting.      ◆ Metal spraying |

### → Hot dipping :

- ◆ In the process coating metal will be melted and in the molten coating metal the base metal will be dipped
- ◆ This is applicable for the coating metals having less melting point and base metal having high melting point.

Ex: Coating of Zn, Sn, Pb, Al on iron, steel or copper

- ◆ Coating of Zn over iron is called galvanising.
- ◆ Coating of Sn is called tinning.

♦ Food stuffs can't be stored in the galvanised containers because Zn is liable to react with food stuff. But tinned containers can be used

### → Metal cladding :

- ◆ In this process on the surface of the base metal thin sheets of coating placed and passed through hot rollers by pressing, then coating metal will be fixed to base metal. This process is called metal cladding.
- ◆ This process can be used for coating steel, Al, Cu, Ni, with, silver, (Ag), Pb, Cu, Ni alloys, Cu alloys and Pb alloys.
- ◆ Al cladding is used to make the bodies of aeroplanes, which are obtained by coating of duralumin sheets covered on both the sides of pure Al sheets. (Al Clad).

### → Cementation (or) diffusion coating:

- It is the process of coating a base metal with coating metal powder.
- Coating metal power is taken in large rotating drums and small base metal articles are taken in it and they will be rotated at high temperature, then coating metal powder will be diffused into base metal surface.
- This process will be used for coating small articles.
- As the coating metal is diffused into base metal at the junction of coating metal and base metal there will be formation of alloy of two metals. Above this alloy coating metal layer and below this alloy base metal will be present.
- This type of coating will be useful for the coating of Zn, Cr, Al on iron and steel.
- If Zn power is coated over iron or steel it is called sheradising this process will be used for small steel articles.
- Coating of Al powder on iron or steel is called clorising. This process can be used for coating of furnace parts.
- Coating of a mixture of Cr powder and Al oxide powder over iron and steel is called chromising. This can be used to protect turbine parts.
- Coating of silicate powder is called enamelling.

### → Electroplating:

- Coating of metal over another metal using electrolysis process is called electroplating.
- In this process coating metal will be taken as anode and base metal will be taken as cathode coating metal  
salt solution will be taken as electrolyte.
- In the electroplating anode dissolves in electrolyte, and it will be deposited over cathode.
- In the electroplating process a uniform coating of required thickness will be formed.

In this process coating will be fixed to the base metal strongly

In this process a bright and hard coating will be formed which will give decorative value to the article.

Electroplating depends on

i) Temperature of electrolytic path

ii) Composition of electrolytic path

iii) pH of electrolyte

iv) Agitation of electrolyte

v) Current density

v) Area of cathode

In the electroplating process anode undergoes oxidation and produced metallic ions come into the solution.

At cathode reduction takes place and the neutral metal will be deposited.

In electroplating electricity is used to carry out chemical reaction so it belongs to electrolytic cell. Hence electroplating can be considered as reverse to corrosion.

#### → Displacement by immersion technique :

- A more active metal will replace or displace a less active metal from its salt solution.
- The replaced metal can form as a loose coating over the base metal.
- These coatings can be useful as primary coatings.
- Example : Zn will replace Cu from  $\text{Cu}^{2+}$  solution



#### → Metal spraying :

- This process is useful for coating low melting metals over the base metal.
- In this process molten metal will be taken in the spraying guns and it will be sprayed over the base metal.
- With this process large structures can be coated uniformly.

Ex: Zn, Sn, Pb etc can be coated over iron, steel.

#### Chemical conversion coatings (or) Inorganic coatings :

- These coatings are inorganic compounds produced by chemical or electro chemical reactions brought at the surface of the base metal.
- This type of coatings are used as primary coatings.
- On the metal, if phosphoric acid ( $\text{H}_3\text{PO}_4$ ) solution is applied the metal phosphate formed as a coating.
- Phosphate coatings can be applied on iron, manganese (Mn), Zn, steel and in a lesser content it can be applied for Al, Cd, Sn.
- Phosphate coatings will be in gray colour.
- By applying chromic add chromate coatings can be formed. In places of chromic acid potassium chromate (acidic or neutral) can also be used.

- Chromate coating will give more corrosion resistance.
- Chromate coatings will be in yellow colour.
- Ex: On Zn, Cd, Al, Mg these coatings can be applied.

⇒ **Oxide coatings :**

- By applying alkaline (basic) oxidising agents, metal oxide coating can be formed over the metal.
- [alkaline oxidising agent like  $KMnO_4$ , (potassium permanganate),  $K_2Cr_2O_7$ ]
- Oxide coatings will give corrosion resistance and they act as primary coatings
- If a metal oxide layer is formed over the metal by using electrolysis it is called anodising.
- In anodising process the metal on which oxide coating is to be formed will be taken as anode and an inert electrode like platinum, graphite can be taken as cathode.
- In anodising the electrolyte is dilute acid like  $HCl$ ,  $H_2SO_4$ ,  $HNO_3$ , potassium permanganate or potassium chromate like oxidising agent can also be used.
- In the anodising the basic principle is protection of metal by the formation of its own oxide layer.
- Anodising process can be applied for the formation of aluminium oxide ( $Al_2O_3$ ) on Al,  $Fe_2O_4$  on iron or steel and it can also be used to form oxide layers on copper, Sn, Cr etc.
- Anodising can protect the metals which can form stable metal oxides.
- If any pores are present in  $Al_2O_3$  layer those will be covered by keeping the metal which is covered with aluminium oxide in boiling water in which  $Al_2O_3 \cdot 2H_2O$  will be formed.

⇒ **Organic coatings :**

- Paints, varnishes, lacquers, enamels are belonging to organic coatings.
- Organic coatings are useful for the protection of metal against corrosion and also for the decoration purpose.
- **Paint :** Paint is a mixture of one or more pigments in a Vehicle. Vehicle is nonvolatile film forming material which is called drying oil and a volatile solvents called thinner.
- Pigment will give a desirable colour to the paint, for example  $ZnO$  (zinc oxide) will give white colour  $Fe_2O_3$  will give red colour.  $Cr_2O_3$ , will give green colour.
- Drying oil is a non volatile oil which will form a paint film.
- Examples for drying oils are linseed oil, soyabean oil, dehydrated castor oil etc
- Thinner will reduce viscosity of paint and it dissolves pigment and drying oil.
- Thinner will increase penetration power of paint and it helps in drying.
- Examples for thinner are terpine oil,  $C_6H_6$  (benzene), dipentene, naptha, tolol, xylol, kerosene, methylated naphthalene.

Apart from the three main constituents, other substances like driers, extenders, plasticizers antiskinning agents etc can also be used.

Driers will help in drying the paints, these are oxygen carrier catalyst

Ex: Cobalt substances (Co), lead substances (Pb) and Mn substances can act as driers.

Extenders will increase toughness (or) hardness of paint.

Ex: Barium sulphate ( $BaSO_4$ ), gypsum, asbestos, magnesium silicate, silica and calcium sulphate can act as extenders.

Plasticizers will give elastic property to the paint.

Ex: Tricresyl phosphate, triphenyl phosphate, tributylphthalate ..

Anti skinning agents will decrease peeling of paint film.

Ex: Poly hydroxy phenols.

Varnish is a mixture of natural or synthetic resin with a drying oil or thinner or both.

Varnish can have decorative value along with corrosion protection property.

Varnish will give a hard transparent glossy, lustrous film.

Lacquers are a mixture of cellulose derivative resin, plasticizer and solvent

Enamels are mixture of varnish and pigment.

Rubber like resin in water with a dryinig oil pigment and extender is called emulsion paint.

Corrosion protection can be carried out by taking different alloys

For example by alloying iron with cromium (or) stainless steel can be produced which is corrosion resistant.

A stainless steel with 13% cromium can be used in cutlery, surgical instruments etc.

More than 13% to 26% Cr steels are called ferrite stainless steels. These are used in turbine brackets and heat resistant parts.

18/8 stainless steels is 18% chromium and 8% Nickel.

**SUCCESS IN LIFE  
Mostly depends on the  
Power of concentration  
Clear thinking and  
Intellectual Understanding  
are very easy for a  
Concentrated mind**

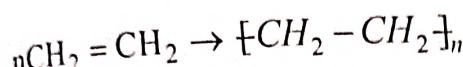
# POLYMERS



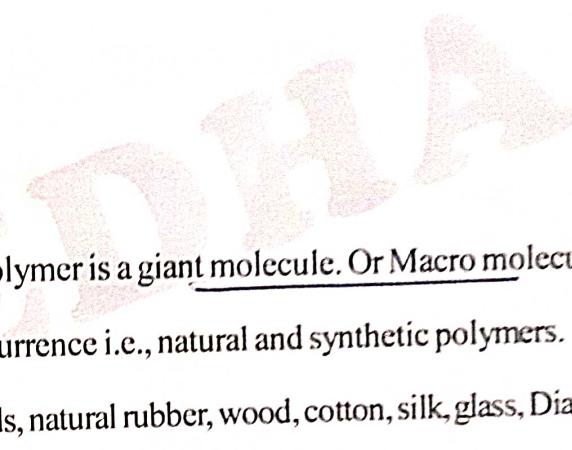
The process of joining many molecules to form a lengthy chain is called polymerisation.

The produced lengthy chain is called polymer and each molecule participating in polymerization is called monomer or basic unit.

Eg: Polymerisation of ethylene gives polyethylene or polyethene



Ethylene (ethene) (Polyethylene) Polyethene



In Latin language plastics means to mould.

Many monomers Join together to form a polymer and a polymer is a giant molecule. Or Macro molecule

Polymers are classified into 2 types according to their occurrence i.e., natural and synthetic polymers.

Natural polymers: Cellulose, proteins, Insuline, nucleic acids, natural rubber, wood, cotton, silk, glass, Diamond, Graphite.

Polyethene, PVC, Bakelite, Teflon, Nylon, Polystyrene are examples of synthetic polymers.

The no. of monomers which join together to give a polymer chain is called degree of polymerisation.

For polymerisation monomers should have unsaturation ( $\text{C}=\text{C}$  or  $\text{C}\equiv\text{C}$ ). To carry out polymerisation, high temperature and high pressure are required. Sometime catalysts and initiators are also required. Unsaturated monomers =  $\text{C}_n\text{H}_{2n}$  or  $\text{C}_n\text{H}_{2n-2}$ , saturated molecules ( $\text{C}_n\text{H}_{2n+2}$ ) can not undergo polymerisation.

Depending on the monomers which join together polymers can be; classified as

i) Homopolymers                    ii) Co-polymers

and also  
functionality <2

If same monomers join together, it is called homopolymer.

Eg: Polyethene, PVC, Teflon, polystyrene etc.

If different monomers join together, it is called a co-polymer.

Eg: Bakelite is produced from phenol & formaldehyde

Bakelite is produced from phenol & formaldehyde

Eg: Buna - S rubber (Butadiene + styrene) - peptide linkage

Nylon 6, 6 is produced by (Adpic acid + Hexa methylene diamine)

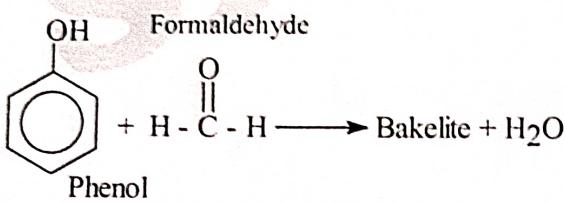
Polyester is produced by (ethylene glycol + Terephthalic acid) etc.

The number of reactive sites in a monomer is called functionality.

- Ethylene is a bifunctional molecule. Phenol and acetylene are trifunctional molecules
- bifunctional monomers give straight chain polymers with high flexibility LDPE
- Trifunctional monomers give branched chain polymers with less flexibility LDPE
- Polyfunctional monomers give cross-linked and network structured polymer with high strength
- If only carbon atoms are present in a basic polymeric chain, it is homochain polymer.
- If other atoms are present along with carbon atoms in a basic polymeric chain it is heterochain polymer.

### TYPES OF POLYMERISATION REACTIONS:

- Polymerisation reactions can be classified into 2 types, i) Addition polymerisation  
ii) Condensation polymerisation.
- Monomers add up together without the elimination of any by product is called addition polymerisation.  
Eg: Polyethene, PVC, Teflon, Polystyrene etc.
- If Monomers join together with the elimination of small molecules as by product, it is called condensation polymerization  
Eg: Formation of bakelite from phenol and formaldehyde



- When monomers join to form bakelite, water molecules are eliminated as byproduct.
- Other example for condensation polymerization are Nylon, Polyester, Urea – formaldehyde resin etc.
- Addition polymerisation is a slow process, and each time one monomer adds to the growing chain.
- Condensation polymerisation is a fast process and simultaneously many growing chains are possible
- In addition polymerisation molecular weight of produced polymer is equal to the sum of the molecular weights of monomers
- In condensation polymerisation, molecular weight of the polymer is less than sum of the molecular weights of monomers.

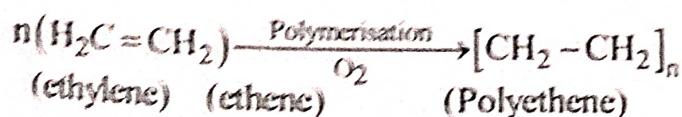
### CO-ORDINATION POLYMERISATION:

- It is a type of addition polymerisation but it takes place in presence of catalyst called “Zeigler-Natta”, catalyst so it is called Zeigler - Natta polymerisation.

- ▶ Zeigler-Natta catalyst is triethyl aluminum ( $C_2H_5Al$ ), Al mixed with transition metal halide like  $TiCl_4$
- ▶ Zeigler-Natta catalyst is organometallic compound with transition metal halide.
- ▶ In Zeigler-Natta polymerisation stereo-specific polymer is produced.
- ▶ The arrangement of monomers in a polymeric chain i.e., configuration of polymer is called tacticity.
- ▶ According to tacticity polymers are isotactic, syndiotactic and atactic polymers.
- ▶ Plastic is a polymer which is moulded into a desired shape. All the plastics are classified into 2 types. They are
  - i) Thermoplastics
  - ii) Thermosetting plastics

### THERMOPLASTICS

- ▶ These plastics will become soft upon heating and they regain their hard nature after cooling.
- ▶ These will undergo a temporary change upon heating (Physical change).
- ▶ These are produced from addition polymerisation.
- ▶ These are linear polymers.
- ▶ These are having weak intermolecular forces & soft in nature.
- ▶ These are soluble in organic solvents.
- ▶ These can be recycled and reused.
- ▶ All vinylic polymers like PVC (Polyvinyl chloride) Polymethyl Methacrylate, Teflon and Polyamide like nylon, Poly cellulose acetates are thermo plastics
- ▶ Polyethene (Polyethylene) : It is produced from the polymerisation of ethylene. It is homopolymer produced from addition polymerisation and is thermoplastic.



### THERMOSETTING PLASTICS

These plastics will become hard upon heating and they remain hard after cooling.

These will undergo permanent change upon heating & cooling (chemical change)

These are generally produced from condensation

polymerization,

These are branched polymer with network & three dimensional structure.

These are hard, rigid, brittle with strong intermolecular forces.

These are insoluble.

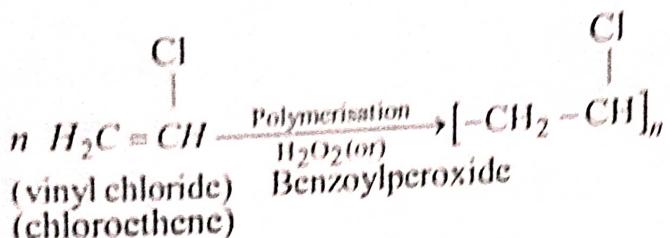
These cannot be recycled and reused.

Eg:- Polyester, Phenol formaldehyde

Resins i.e., bakelite, Urea formaldehyde resin, alkyl resins, Epoxy resins & silicone resins.

If high pressure is used, low density polythene is produced and in low pressure high density polythene is produced.

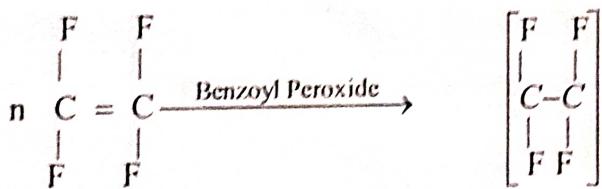
- Polyvinyl chloride (PVC)**: It is produced from the polymerisation of vinyl chloride. It is a homopolymer produced from addition polymerisation and is thermoplastic.



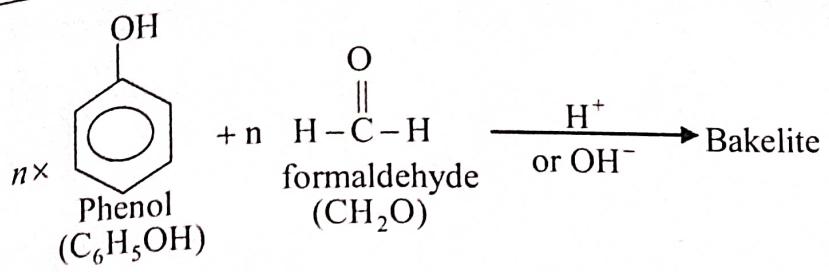
- **Uses:** It is used to produce pipes, electric insulators, tank linings, safety helmets, refrigerator components, tyres, cycle and motor cycle mudguards
  - PVC mixed with plasticizers like dibutyl phthalate tri cresyl phosphate, dioctylphthalate is used to make plastic curtains, rain coats, table cloths etc.

**Polystyrene**: Styrene upon polymerisation, it gives polystyrene. It is a homopolymer, thermoplastic and produced from addition polymerisation.

- **Uses :** It is transparent light stable moisture resistant polymer. It is used to produce toys, combs, buttons, buckets, radio and television parts, refrigerator components, battery cases, electric insulators and lenses.
  - **Teflon (fluon) :** Chemical name is polytetrafluoroethylene. It is homopolymer, thermoplastic produced from addition polymerisation.

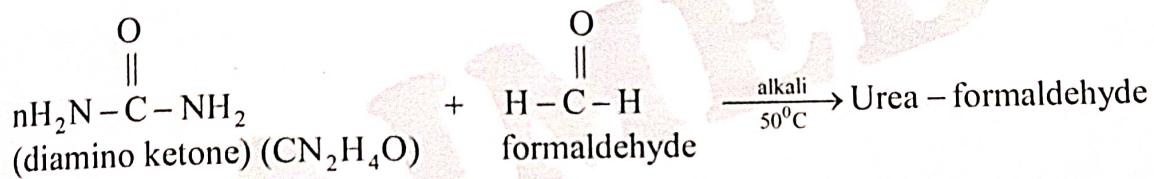


- Uses : Teflon is very hard having high softening point about  $350^{\circ}\text{C}$  and is highly chemical resistant except hot alkalis. Teflon is used in the production of insulating materials, gaskets, chemical carrying pipes, non-sticky kitchen ware and tank linings.
  - The above mentioned four polymers are belonging to vinylic group.
  - Polyvinyl acetate used to making chewing gums, surgical dressings paints adhesives
  - Polymethyl methacrylate (Perspex) is used to produce adhesives.
  - Bakelite : It is produced from the polymerisation of phenol and formaldehyde. It is a copolymer, thermosetting plastic and produced from condensation polymerisation, phenol and formaldehyde initially form a straight chain polymer which is called novalac resin, it changes into highly branched and network structure polymer called bakelite.



→ **Uses**: Bakelite is very hard rigid plastic resistant to acids, bases and many other chemicals. It is used in the production of electric insulator parts, switches, plugs, switch boards, heater handles, telephone parts, cabinets of T V and radio, bearings and to produce adhesives and paints.

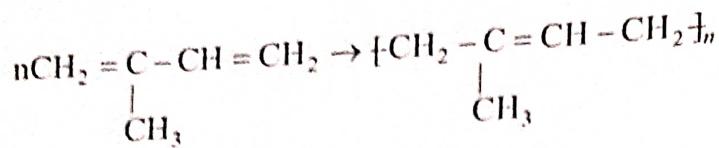
→ **Urea formaldehyde resin** : It is produced from the polymerisation of urea and formaldehyde in 2 : 1 ratio in presence of alkali. It is a copolymer, thermosetting plastic produced from condensation polymerisation. It is belonging to amino group of resins. Urea and formaldehyde initially form primary products monomethylol urea and dimethylol urea which undergo polymerisation to form urea formaldehyde resin.



# RUBBER

- Rubber is an elastomer having elastic property.
  - Its elastic property is in excess of 300%. A rubber band can be stretched 4 to 10 times of its original length.
  - Rubber is having coiled structure and in coiled structure it will have amorphous nature with weak inter molecular forces.
  - When stretched, it becomes crystalline with strong intermolecular force of attraction.
  - Rubbers are two types according to occurrence, they are (1) Natural Rubber (2) Synthetic Rubber
  - Natural rubber is produced from rubber plants Have a Brasilians and gaugule
  - Rubber plants are mainly grown in Indonesia, Malaysia, Thailand, Ceylon, India & South America
  - In India, rubber plants are mainly grown in Kerala. India occupies 5<sup>th</sup> rank in rubber production (2.7%)
  - Rubber plants will give Latex in which 26 to 35% of rubber is present, remaining is water, proteins, enzymes, nucleic acids, inorganic solids and other acids.
  - Latex must be diluted and treated with acetic acid or formic acid and subjected to coagulation, then rubber is produced. This phenomenon is processing of rubber (For 200 kg of rubber material, 1 kg of acetic acid or formic acid must be added).
  - Natural rubber is polymer of Isoprene units  $C_5H_8$ . Isoprene is Methyl 1,3 - butadiene – polycis-isoprene

→ Natural rubber is polymer of cis-polyisoprene



→ Transpolyisoprene is called Guttapercha.

→ It is produced from the leaves of *Dichopsis gutta* and *Palagub Gutta*.

### DRAW BACKS OF RAW RUBBER:

01. Low tensile strength (around 200 kg/cm<sup>2</sup>)
02. Plastic in nature
03. It is weak
04. It can be used in temp range of 10°C to 16°C
05. It has large water absorption capacity
06. It can be attacked by solvents and oxidizing agents
07. It swells in inorganic solvents and it dissolves in organic solvents
08. It will have tackiness
09. Little durability and it undergoes permanent deformation

### VULCANISATION :

- Heating rubber with sulphur is called vulcanisation. It was invented by Charles Good Year.
- For vulcanisation, H<sub>2</sub>S, S<sub>2</sub>Cl<sub>2</sub> or carbondisulphide (CS<sub>2</sub>) can also be used.
- In vulcanisation, the heating temperature may be 40°C to 140°C.
- In vulcanisation, rubber loses its elastic property and becomes hard.
- In vulcanisation, branched chains are formed with cross linking structure.
- A normal vulcanised rubber contains 3 to 10% sulphur
- Rubber containing 33 % of sulphur is ebonite rubber or vulcanite and it is used to produce battery cases.

### ADVANTAGES OF VULCANISED RUBBER :

- It has good tensile strength (5000 kg/cm<sup>2</sup>)
- It posses low water absorption capacity.
- It has excellent resilience.

- It is better electrical insulator
- It has higher resistance to oxidation or solvents
- It is useful in temp range 40 to 100°C
- Its tackiness is very less.

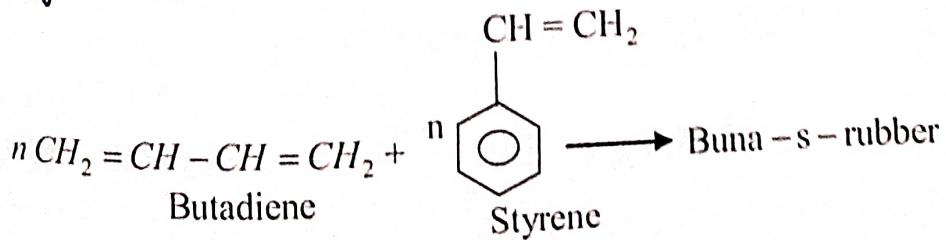
### COMPOUNDING OF RUBBER:

- Adding certain substances into the polymeric materials to have desired properties is called compounding.
- Common substances used in compounding of rubber are
  - 1) **Vulcanising agents** : These are added to increase hardness  
Eg :- Sulphur, Sulphurmonochloride ( $S_2Cl_2$ ),  $H_2S$ , Carbondisulphide, Benzoyl Chloride, Trinitro Benzene or certain other sulphides.
  - 2) **Plasticisers & Softners** : These are added to improve softness and plasticity  
Eg : Vegetable oils, waxes, stearic acid, resin etc.
  - 3) **Accelerators** : These materials will decrease the time for vulcanisation  
Eg ; 2-Mercaptol, Benzothiozole and Zinc - Alkylxanthate.
  - 4) **Antioxidants** : These are to resist oxidation.  
Eg :- Phosphites,  $\beta$  - napthal
  - 5) **Colouring agents** : These are added to get desired colour.  
Eg: Titanium oxide (white). Chromium oxide (green), Ferric oxide (Red), Antimony sulphide (Crimson), Lead chromate (Yellow).
  - 6) **Fillers (reinforcing fillers)** : These will increase strength & rigidity of rubber.  
Eg: Carbon black, Zinc oxide, calcium carbonate and magnesium carbonate.

### SYNTHETIC RUBBER:

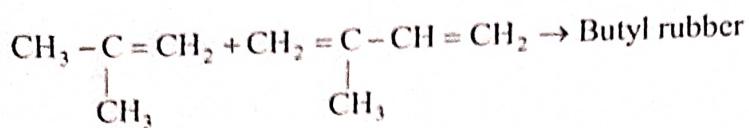
- Buna-S or (G.R.S) rubber: It is produced by mixing butadiene and styrene in 75% & 25% respectively

government rubber styrene



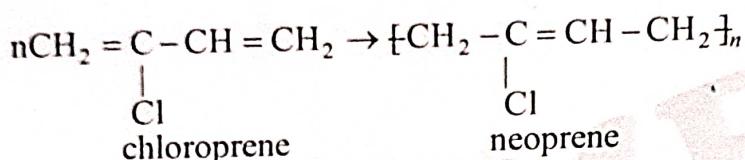
**Uses:** It has high load bearing capacity but it swells in oils and solvents and readily oxidised. It is used to produce tyres, floor tiles, shoes soles, foot wear components, gaskets, cable insulation, carpets, adhesives (gums) and tank linings.

→ **Butyl rubber:** It is produced in the polymerisation of isobutylene with 1 to 5% of isoprene

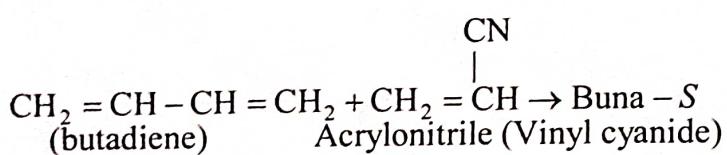


**Uses:** It has low permeability to air and other gasses, resistant to chemicals and solvents. It is used to make cycle and automobile tubes, automobile parts, conveyor belts, tank linings and insulation parts.

→ **Neoprene rubber:** It is produced in the polymerisation of chloroprene. It is a homopolymer.

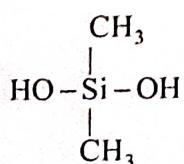


- It is related to natural rubber, resistant to oils, soluble in some solvents and it can be made hard by compounding with zinc oxide or magnesium oxide.
  - It is used to produce gaskets, tubes for oils and chemicals, sponges, conveyor belts and adhesives.
  - Thikol rubber: It can also be called polysulphide rubber or GR-P rubber. It is produced from sodium polysulphide ( $\text{Na}_2\text{S}_2$ ) and ethylene dicchloride ( $\text{Cl}-\text{CH}_2-\text{CH}_2-\text{Cl}$ ). It is used to produce cable coverings, oil tank linings and solid propellant for rocket fuels. - **Modern rubber**
  - Buna-S: It is produced from the polymerisation of butadiene and acrylonitrile



**Uses:** It is used to produce conveyor belts, air craft components, tank lining, gaskets, adhesives and automobile parts.

→ **Silicone rubber:** It is produced from the polymerisation of silicon hydroxide (dimethyl silicone hydroxide)



It is very hard and can withstand high temperature upto  $200^{\circ}\text{C}$ . It is used as sealing material and to produce tyres for aircrafts, insulating materials in various industries, paints and protective coatings, lubricants, artificial heart valves, transfusion tubings.

### **GENERAL USES OF RUBBER**

1. It is used as insulating coating on wires and cables electrical power transmission and in electrical equipment,
2. Used for making rubber bands, mechanical rubber goods, golf ball, printing rollers, tubes for automobiles, aeroplanes and bicycles etc.
3. In making rubber lined metal tanks, tyres, foot wear, conveyor belts, shock absorbers.
4. Rubber hoses are used for transfusion of petrol, oils etc.
5. For making storage battery cases, electrical switch board panels, plugs, sockets, telephone receivers, rubber fittings and valves.
6. Sponge rubber is used for shock absorption, thermal insulation and sound insulation.
7. Foam rubber is used for making pillows, mats, pads, etc.
8. Rubber can also be used for making gaskets, transfusion tubings, padding for plastic surgery etc.
9. Used to produce adhesives, sport goods and toys, polysulphide rubber is used as solid propellant in rocket fuels.

### **Properties of the plastics:**

01. Lighter in weight
02. Specific gravity varies from 1-1.4
03. Good thermal and electrical insulators
04. Resistant to corrosion
05. Casting, moulding, drilling etc is easy.
06. They have high adhesive properties.
07. Low fabrication cost.
08. Plastic surface will be shining and glassy appearance.
09. Not affected by insects and fungi.
10. They can expand and contract depending on temperature.
11. Chemically inert and they do not need any protective coatings so maintenance is easy.
12. Some plastics have transparent nature and have high refractive index.
13. Their colors will not fade and they have some shock absorption capacity.

14. Certain plastics like teflon are very hard, they do not absorb water.

### Compounding agents for plastics :

i. **Fillers** : To increase hardness, strength, capacity and to reduce brittleness and shrinkage. Eg : clay, paper pulp. Saw dust, wood flour, graphite, cottonfibre, marble floor, ground cork, cereal husk, carbon black.

Quartz , mica, carborundum or metallic oxide of zinc and lead are added to improve hardness.

Asbestos is added to increase heat resistance and corrosion resistance.

Fillers which enhance the mechanical strength are called reinforcing fillers. eg. Cotton fibre, rags or wood chips.

Barium salts are added to render the plastic impervious to X-rays.

**Plasticizer** : Improves the plasticity and flexibility of resin.

Eg : Non-drying vegetable oils, camphor, esters of oleic, stearic and phthalic acid, tributyl phthalate acid, tricetylphosphate, triphenylphosphate, triacetin etc.

**Lubricant** : Makes moulding easy gives flawless and glossy finish, prevent from sticking to moulding equipment.

Eg : oils, waxes and soaps

**Accelerator** : Accelerates the polymerisation process

Eg : Hydrogen peroxide, Benzoyl peroxide, metals such as

Ag, Cu, Pb, ZnO, Ammonia and its salts.

**Pigment** : Colouring agent.

**Stabilizer** : Increases thermal stability Eg : Salts of lead (white lead, lead chromate, red lead, litharge, lead silicate and lead naphthenate)

Transparent moulding compounds such as stearic acid salts of lead, cadmium or barium are also used as stabilizers.

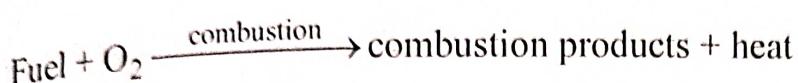
**THERE IS NO  
SUBSTITUTE TO  
HARDWORK**



# FUELS

Fuel: A substance which upon combustion releases heat energy is called fuel.

- ⇒ Combustion is a process of burning a substance in presence of air (oxygen).
- ⇒ A fuel upon combustion, It forms combustion products along with releasing heat.
- ⇒ Combustion is an exothermic reaction (heat releasing)



⇒ Main combustible elements of fuel are carbon and hydrogen. Sulphur and nitrogen if present as impurities also combustable.

⇒ CO<sub>2</sub>, H<sub>2</sub>O (water vapour) and SO<sub>2</sub>, NO<sub>2</sub> are produced as combustion products.

Moisture, volatile matter, ash content etc can be present as impurities in a fuel depending on its occurrence and nature.

⇒ According to the occurrence, fuels can be classified into two types :

⇒ 1. Primary (natural fuels) 2. Secondary fuels (derived fuels)

⇒ The fuels which are existing in the nature as they are called primary fuels. / Ex : wood, coal, dung, crude oil (petroleum oil) natural gas etc.

⇒ The fuels which are derived from primary fuels are called secondary fuels. Ex : coke, charcoal, tar kerosene, diesel, petrol, coal gas, bio gas etc.

⇒ According to the physical state, fuels are three types :

⇒ Solid, liquid and gases fuels. Ex : Primary solid fuels : wood, coal, peat, lignite, anthralite & Bituminous coals, dung etc.

⇒ Primary liquid fuel is crude oil (petroleum oil)

⇒ Primary gaseous fuel is natural gas.

⇒ Secondary solid fuels are coke, charcoal, briquette.

⇒ Secondary liquid fuels are kerosene, diesel, petrol, fuel oil and tar.

⇒ Secondary gases fuels are coal gas, water gas, oil gas, biogas, producer gas, blast furnace gas, coke oven gas. L.P.G (liquified petroleum gas).

⇒ The fuels which are stored and available in the earth crust are called fossil fuel. (conventional energy sources)

- ⇒ Conventional energy sources are non-renewable. Ex : coal, wood, petroleum fuels
- ⇒ Non conventional energy sources are renewable in nature. Eg : Solar energy, Wind, Geothermal, Hydel and tidal energy.
- ⇒ Charcoal is produced from the partial combustion of wood.
- ⇒ Nuclear energy sources are also non-renewable in nature.

conventional - non renewable  
Non conv - renewable

### Characteristics of a good fuel:

- ◆ It should have high calorific value.
- ◆ Moderate ignition temperature.
- ◆ Low moisture content.
- ◆ Low non-combustible matter
- ◆ Moderate velocity of combustion.
- ◆ Products of combustion should not be harmful.
- ◆ Low cost.
- ◆ Easy to transport.
- ◆ Combustion should be easily controllable.
- ◆ Should not undergo spontaneous combustion.
- ◆ Low storage cost.
- ◆ Should burn in air efficiently without much smoke.
- ◆ High carbon and hydrogen percentage.

SOLIDS	LIQUIDS	GASES
<ol style="list-style-type: none"> <li>1. Easily available and cheap</li> <li>2. Transport, storage and handling is easy with no risk of explosion</li> <li>3. Least danger of fire hazards</li> <li>4. Slow combustion process but controlling is not easy.</li> <li>5. More handling charges, i.e., labour is required for storage and supply.</li> </ol>	<p>Costly</p> <p>Transport, storage and handling will be difficult with some danger of explosion</p> <p>Some danger of fire hazard</p> <p>Combustion process is moderate and controlling is easy.</p> <p>Less handling charges</p>	<p>Costlier (except natural gas)</p> <p>Special measures must be taken for transport, storage and high danger of explosion</p> <p>Highest danger of fire</p> <p>Fast combustion and controlling is easy.</p> <p>Less handling charges</p>

<ul style="list-style-type: none"> <li>Gives more ash and smoke upon combustion</li> <li>This can't be used in internal combustion engines.</li> <li>Calorific value is less</li> <li>Least calorific intensity or sytometric effect</li> </ul>	<ul style="list-style-type: none"> <li>No ash is produced but some liquid fuels (aromatic) will give smoke</li> <li>Can be used</li> <li>High</li> <li>High</li> </ul>	<ul style="list-style-type: none"> <li>Neither ash nor smoke is produced</li> <li>Can be used</li> <li>Highest</li> <li>Highest</li> </ul>
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**Calorific Value :** The amount of heat released when unit mass of fuel is burnt completely in presence of oxygen is called calorific value.

- The amount of heat released when unit mass of fuel is completely combusted and the products of combustion are cooled to room temperature, it is called higher calorific value or gross calorific value.
- When unit mass of fuel is completely combusted and products of combustion are allowed to escape into atmosphere, then the released heat is called lower calorific value or net calorific value.
- When the products of combustion are cooled to room temperature then the latent heat of combustion products will be released. (i.e. latent heat of steam)

### Units for heat:

- Calories, kilo calories, centigrade heat unit and British thermal unit.
- Calorie :** The amount of heat required to raise the temperature of 1 gm of water by  $1^{\circ}\text{C}$  is called calorie.
- Kilocalorie :** The amount of heat required to raise the temperature of 1 kg of water by  $1^{\circ}\text{C}$  is called K.cal.
- Centigrade heat unit :** The amount of heat required to raise the temperature of 1 pound of water by  $1^{\circ}\text{C}$  is called centigrade heat unit (usually from  $15^{\circ}\text{C}$  to  $16^{\circ}\text{C}$ )
- British thermal unit :** The amount of heat required to raise the temperature of 1 pound (lb) of water by 1F heat is called British thermal unit. (B. Th. U)

$$1 \text{ K. Cal} = 1000 \text{ cal} = 3.968 \text{ B. Th. U} = 2.2 \text{ CHU}$$

### Units for calorific value :

$$1 \text{ K.cal/kg} = 1.8 \times \text{B. Th. U/lb}$$

$$1 \text{ K.cal/m}^2 = 0.1077 \times \text{B.Th. } U/\text{ft}^3$$

$$1 \text{ B.Th. } U/\text{ft}^3 = 9.3 \text{ K.cal/m}^3$$

**Solid Fuels :** Coal, coke, wood are solid fuels.

**Wood :** Freshly cut wood may contain 25% to 50% of moisture. Air dried wood may contain around 15% of moisture.

Average percentage of carbon in wood is 55%, and calorific value of wood may be 3500 to 4500 Kcal/kg. It is used mainly as a domestic fuel.

It burns with more smoke and leaves much ash.

**Coal:** Coal consists of carbon, hydrogen, nitrogen, oxygen, sulphur with some non combustable inorganic matter.

- ⇒ Coal is formed in the earth crust with the decomposition of vegetable matter especially wood.
- ⇒ To explain the formation of coal, two theories have been proposed.
  - i) insitue theory ii) Drift (transportation) theory.
- ⇒ According to insitue theory coal formation took place at the place of vegetation.
- ⇒ According to drift theory the trees were transported from one place to other place covered with soil and transformed into coal with the decomposition under high temperature and pressure in the absence of O<sub>2</sub> and presence of anaerobic bacteria (anaerobic decomposition)
- ⇒ During the decomposition, gases like CO<sub>2</sub>, methane may be released.

**Classification Coal:** The process of transformation of wood into coal is called coalification.

- ⇒ As the coalification process increases, moisture content decreases, hydrogen, oxygen, nitrogen, sulphur contents will decrease, volatile matter decreases and carbon content, calorific value and hardness will be increased.
- ⇒ According to the extent of caloification coal can be classified into peat, lignite, bituminous coals and anthracite coal.
- ⇒ Peat is the lowest rank coal and anthracite is highest rank coal.
- ⇒ Peat is a brown fibrous jelly like coal and it is produced in the first stage of coalification of wood.
- ⇒ Average composition of peat is C-57%, H<sub>2</sub> = 6%, O<sub>2</sub> = 35%, ash - 2.5 - 6%.
- ⇒ Calorific value is 5400 Kcal/kg.

⇒ Available in Nilgiri Hills.

Lignite : It is called brown coal.

⇒ Average composition is C - 60-70%, O - 20% remaining is H<sub>2</sub> and other compounds.

⇒ The calorific value is 6500 to 7100 Kcal/kg available in Assam, Kashmir, Rajasthan (at Palana) and Madras.

⇒ Lignite may be generally used for steam raising, house hold fuel, and for the manufacture of producer gas.

Bituminous : Bituminous coals are called common coals.

⇒ These are having laminated structure i.e., layered structure.

⇒ Bituminous coals can be again classified into Sub Bituminous, Bituminous and Semi Bituminous coals.

⇒ Sub-Bituminous coals will have carbon % of 75 to 80 and calorific value is 7000 Kcal/Kg to 7500 Kcal/Kg.

⇒ Bituminous coal will have carbon percentage 78 to 90 and calorific value is 8000 to 8500 Kcal/Kg.

⇒ Semi Bituminous coal will have carbon % from 90-95 with calorific value 8500 to 8600 Kcal/Kg.

⇒ Bituminous coals will be used to produce coke, coal gas and steam raising.

⇒ Bituminous coals are present in Bihar, Bengal, Madhya Pradesh and Orissa.

Anthracite coal: Anthracite coal is highest rank coal with carbon 92% - 98%

⇒ These are hardest coals with lustrous appearance.

⇒ Calorific value is 8650 to 8700 K. cal/kg.

⇒ These are available in Kashmir and Eastern Himalayas,

Peat Lignite Bituminous  
Anthracite

### Selection of Coal:

◆ High calorific value,

◆ Least moisture content.

◆ Low ash content.

◆ Fusion temperature of ash must be high.

◆ Calorific intensity must be maximum.

⇒ The maximum temperature reached when the coal is completely burnt is called calorific intensity.

⇒ Calorific intensity depends on quality, nature and specific heat of combustion products.

- ⇒ It must be uniform in size.
- ⇒ Less Sulphur, Nitrogen, Phosphorous contents.
- ⇒ Coking quality coal is required.
- ⇒ When coal is heated in the absence of air, it becomes soft plastic like fusible mass which are called coking coals. If that mass becomes hard, porous then it is called coke.
- ⇒ Coke is hard, porous with high percentage of carbon having highest calorific value and which is used for metallurgical purpose.
- ⇒ Process of heating in the absence of air is called destructive distillation. In this process coal is converted into coke, which is also called carbonisation process.
- ⇒ Upon destructive distillation, coal will not become a fusible mass, then it is called free burning coal or non-coking coal.
- ⇒ Percentage of moisture, ash content, volatile matter and fixed carbon can be determined with a process called proximate analysis.
- ⇒ Percentage of carbon, hydrogen, sulphur, nitrogen can be determined with a process called ultimate analysis.
- ⇒ In a good quality coal carbon, hydrogen and fixed carbon percentage must be more and remaining all other constituents (compounds) must be less.
- ⇒ If moisture content will increase the weight of coal will be increased and decreases calorific value.
- ⇒ Ash content increases weight of coal, gives more pollution, destroys furnace walls and interacts with metallurgical process. Volatile matter decreases the calorific intensity.
- ⇒ Sulphur and nitrogen gives corrosion of metals and pollution.
- ⇒ Powdered coal is called as pulverised coal.
- ⇒ Pulverised coal will give uniform combustion process. It requires less air, for combustion volatile matter will be expelled and easy controllability of combustion.
- ⇒ Carbonisation process can be carried out at low temperature or high temperature.
- ⇒ Coke produced from low temperature carbonisation ( $500-700^{\circ}\text{C}$ ) will have less carbon percentage and it is mechanically not strong, useful for domestic purpose.
- ⇒ In high temperature carbonisation less coke is produced but ( $900-1200^{\circ}\text{C}$ ) it will have more carbon percentage and very strong and useful for metallurgical process.

- Carbonisation can be carried out using Behive's oven or Ottohoffman's byproduct oven.
- When the coal is subjected to carbonisation process it gives byproducts, coke oven gas which contains Ammonia,  $H_2S$ , Naphthalene, Benzene, Tar, Moisture, Xylene, Toulene, anthracene

### Liquid Fuels:

- Petroleum oil (crude oil) is a dark greenish brown viscous oil found deep in the earth crust.
- Petroleum oil contains various hydrocarbons like Paraffins (Alkanes), Cyclo Paraffins, Naphthalene, Olefines (Alkenes), Aromatic compounds (like benzene) etc.
- Petroleum oil exists upon a layer of brine solution ( $NaCl$ ).
- Over the petroleum oil a layer of natural gas exists.
- Average composition of crude oil is carbon 79.5 to 87.1% hydrogen 11.5 to 14.8%, Sulphur 0.1 to 3.5%, Nitrogen + Oxygen 0.1 to 0.5%.
- In the earth crust petroleum oil was formed with the decomposition of animals, vegetable matter etc, by the Anaerobic bacterial decomposition under high pressure.

### Classification of Petroleum Oil :

- Depending on the chemical nature of petroleum oil, it can be classified into 3 types.
- Paraffinic Base Crude : It contains mainly saturated hydrocarbons from  $CH_4$  to  $C_{35}H_{72}$  with little naphthalene and aromatics.  $C_{18}H_{38}$  to  $C_{35}H_{72}$  are called waxes.
- Asphaltic Base Crude : It contains mainly cycloparaffins and naphthalene with little paraffins and aromatic compounds.

Mixed Base Crude : This contains both paraffinic and asphaltic hydrocarbons and it is very rich in waxes.

- Crude oil can be separated into various fractions by fractional distillation.
- Fractional distillation can be carried out in refineries and the process is called refining of crude oil.
- Refining of Petroleum Oil : Refining will be carried out in refineries, it is a process of separation of components of crude oil. This process can be carried out with fractional distillation.
- Before separating various fractions, water and sulphur compound must be removed from crude oil.
- Water can be removed with electrolysis process called Cottrell's Process.
- Sulphur compounds will be removed by treating with Copper Oxide ( $CuO$ ) by which sulphur will precipitated as Copper Sulphide.

- ⇒ Crude Oil will be heated to  $400^{\circ}\text{C}$  in which all the compounds will be vapourised.
- ⇒ The produced vapours will be passed into fractionating column, in which different fractions will be condensed at different temperature.
- ⇒ As the vapours move from bottom to top in the fractionating column, their temperature decreases.

Name of the Fraction	Temperature	Approximate Composition	Use
1. Uncondensed Gas	Below $30^{\circ}\text{C}$	$\text{C}_1$ to $\text{C}_4$	used as domestic and industrial fuel as L.P.G.
2. Petroleum Ether	$30^{\circ} - 70^{\circ}$	$\text{C}_5$ to $\text{C}_7$	Used as a Solvent
3. Gasoline (Motor Spirit or Petrol)	$40^{\circ} - 120^{\circ}$	$\text{C}_5$ to $\text{C}_9$	Used as a Motor Fuel and solvent in Dry Cleaning
4. Naphtha (or) Solvent Spirit	$120^{\circ} - 180^{\circ}$	$\text{C}_9$ to $\text{C}_{10}$	Used as solvent in Dry cleaning
5. Kerosene	$180^{\circ} - 250^{\circ}$	$\text{C}_{10}$ to $\text{C}_{16}$	Used as an illuminant, jet engine fuel and for preparing lab gas
6. Diesel (or) fuel oil (or) gas oil	$250^{\circ} - 320^{\circ}$	$\text{C}_{10}$ to $\text{C}_{18}$	Used as a diesel engine fuel
7. Heavy oil	$320^{\circ} - 400^{\circ}$	$\text{C}_{19}$ to $\text{C}_{30}$	to get synthetic petrol by cracking

- ⇒ Heavy oil is consisting of lubricating oils, petroleum gelly (vaseline), Grese and paraffin wax residue of crude oil remained after heating is called asphalt (or) petroleum coke. It can be used for water proofing of roofs and road making. Petroleum coke can be used as fuel.

→ Kerosene contains carbon 84% H-16%. Calorific value is 4000 Kcal/Kg.

PETROL	DIESEL
1. Costlier.	Less costly
2. Consumption for Unit Power production is more.	Less
3. Thermal efficiency is less	more
4. Combustion requires less complex device	Requires more complex and expensive device
5. It gives more pollution	Less air pollution

→ Petrol which is directly separated from crude oil is called straight run petrol.

→ Petrol can be produced with the cracking process of heavy oil.

→ Cracking is a process of heating a substance in the absence of air in which big molecules will be broken into small molecules.

Cracking can also be called "Pyrolysis".

With the cracking process heavy hydrocarbon of heavy oil will be broken into small hydrocarbons, resembling to petrol

Cracking process can be carried out thermally or catalytically.

In thermal cracking, high temperature and high pressure is used.

If the temperature is  $475^{\circ} - 530^{\circ}\text{C}$  with  $100 \text{ Kg/cm}^2$  - pressure, it is called Liquid Phase Thermal Cracking.

In vapour phase thermal cracking  $600 - 650^{\circ}\text{C}$  and  $10-20 \text{ kg/cm}^2$  pressure is used.

### Synthetic Petrol:

- Petrol can be produced synthetically with different processes (1) Polymerisation (2) Fischer - Tropsch process (3) Bergius process
- In polymerisation process, lower olefins (alkenes) and paraffins (alkanes) are polymerised in presence of high temperature and pressure with or without catalyst.
- In Fischer - Tropsch process, water gas and hydrogen mixture is passed through a catalyst in which petrol is produced.
- Water gas is a mixture of carbon monoxide and hydrogen gas,  $\text{CO} + \text{H}_2$
- Catalyst used in this process is cobalt, thoria, magnesia and Keiselguhar earth in  $100 : 5 : 8 : 200$  at  $200$  to  $300^{\circ}\text{C}$

- In Bergius process low ash coal and heavy oil are taken as raw material and passed through a catalysts tin or nickel oleate, at  $450^{\circ}\text{C}$  & 200 to 250 atmosphere.

### REFINING OF GASOLINE :

- Process of purification i.e. removal of undesirable substances is called refining.
- From petrol, sulphur compounds can be removed by alkaline (basic) sodium plumbite ( $\text{Na}_2\text{PbO}_2$ ) with controlled addition of sulphur and this process of removal of sulphur compounds as disulphide is called Doctor's Process or Sweetening process.
- Undesirable olefine and colouring matter are removed by percoating through Fuller's Earth.

### REFORMING PROCESS :

- Structural modification of the components of petrol is to be carried in reforming process to improve antiknock characteristics.
- Reforming process can be carried out thermally and catalytically.
- In catalytic process, 0.75% of platinum supported on alumina is used.
- In reforming process, isomerisation and Aromatization will be carried out.
- Isomerisation - Straight chain into branched chain, Aromatization - Straight Chain (or) branched chain into cyclic chain.

### KNOCKING OF ANTIKNOCKING PROPERTY :

- In the Internal combustion engines fuel and air must be mixed in an appropriate ratio.
- The ratio of the gaseous volume in the cylinder at the end of the suction stroke to the volume at the end of the compression stroke of the piston is known as compression ratio.
- Efficiency of internal combustion engine increases with increase in compression ratio.
- Compression ratio depends on the nature of the constituents present in the petrol.
- Ignition of fuel and air mixture instantaneously producing explosive sound is known as knocking.
- Knocking gives loss of efficiency.
- Knocking property increase in the following order, straight chain paraffins > branched chain paraffins > olefins > cyclo paraffins > aromatics.
- To increase antiknocking property. (TEL) Tetra Ethyl Lead (or) Tetraethyl Tellurium [ $(\text{C}_2\text{H}_5)_2\text{Te}$ ] can be used as anti knocking agent.

- In motor spirit 0.5 ml of tetra ethyl Lead per litre will be added.
- In aviation fuel, 1 to 1.5 ml/litre will be added.
- To remove lead oxide, ethylenedibromide is added. It removes lead oxide as Lead Bromide.
- Sulphur compounds will decrease the efficiency of tetraethyllead.

### OCTANE NUMBER :

- Normal heptane will have highest knocking property. Its antiknocking value is zero.
- Isooctane (2, 2, 4 trimethyl pentane) will have least knocking property, so its antiknocking value is 100.
- Octane number indicates the quality of petrol.
- Octane number is the percentage of iso octane in a mixture of iso octane and normal heptane.
- Iso octane is  $C_8H_{18}$  and heptane is  $C_7H_{16}$  which are branched and straight chain respectively.
- For example, if octane number of petrol is 60, it means that petrol will behave like a mixture in which 60% of iso octane and 40% of normal heptane are present.
- Antiknocking characteristics of a diesel fuel follows in the order normal alkanes > naphthalenes > alkenes > branched alkanes > aromatics.
- A poor gasoline fuel is a good diesel fuel.
- Quality of diesel will be indicated with cetane number.
- 2 Methyl napthalene (cyclic structured) will have least antiknocking property whose cetane number is zero and normal hexa decane (straight chain hydrocarbon) will have highest antiknocking property whose cetane number is 100.

→ n-Hexadecane ; ( $C_{16}H_{24}$ ) → cetane no. - 100

2-methyl naphthalene cetane no. is 0.

- Cetane number indicates the percentage of normal hexa decane in a mixture of 2-methyl napthalene and normal hexadecane.
- For example if cetane no. of diesel is 40, it behaves like a mixture in which 40% of normal hexadecane and 60% of 2-methyl napthalene are present.

<u>OCTANE</u>	<u>Antknoc</u>	<u>CETANE</u>	<u>Antknoc (C.N.)</u>
Heptane	0	2methylnapthalene	0
Isooctane	100%	hexadecane	100

⇒ More octane number and cetane number indicate more quality petrol and Diesel respectively.

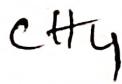
### ADDITIONAL POINTS :

- ⇒ For high speed diesel time lag in getting the diesel droplets heated to ignition point is very less.
- ⇒ They require cetane number 45 to 60.
- ⇒ For low speed diesel, time lag in getting diesel droplets heated to ignition point is high & the required cetane no. is around 25.
- ⇒ For medium speed diesel, cetane no. is around 35.
- ⇒ LPG is also called bottled gas (or) refinery gas.
- ⇒ LPG is a mixture of hydrocarbons in which normal butane is present as a major component.
- ⇒ Its calorific value is 27000 kcal/m<sup>3</sup>
- ⇒ In LPG Organic Sulphides (mercaptans) are added as smelling agents.
- ⇒ LPG is more advantageous than petrol.
- ⇒ Benzol and power alcohol are non petroleum fuels.
- ⇒ Benzol is a product of coal carbonization. It contains mainly benzene and it is used as a blending agent with gasoline.
- ⇒ Calorific value of benzol is 10000 cal/kg.
- ⇒ Power alcohol is ethyl alcohol and it is mixed with petrol.

### GASEOUS FUELS :

i) Natural Gas : It is obtained from petroleum oil wells.

- ⇒ It is mainly consisting of methane (75 to 90%)
- ⇒ Calorific value is 12000 to 14000 kcal/m<sup>3</sup>

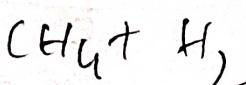


Uses : i) Used as domestic fuel, to produce various chemicals carbon black and hydrogen. Carbo black useful to produce printing ink.

ii) It is also used in synthesis of ammonia and proteins.

ii) Coal Gas : It is produced in the coal carbonization.

- ⇒ It has major components methane (32%) and hydrogen (40%)



Calorific value is 4900 kcal/m<sup>3</sup>

It is colorless with characteristic odour lighter than air, burns with smoky flame.

Uses : i) It is used as illuminant in cities and towns.

ii) Used as fuel in metallurgical operations.

iii) It is used to provide reducing atmosphere due to the presence of hydrogen.

Purified coal gas is stored over water in gas holders.

iii) Producer gas : It is a mixture of carbon monoxide and nitrogen associated with hydrogen and carbon dioxide.

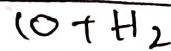
It is prepared by passing air and steam mixture over red hot coal or coke at 1100°C in a reactor called gas producer.

Composition: CO - 22.3%      N<sub>2</sub> - 52 - 55%      H - 8 - 12%      CO<sub>2</sub> - 3%

Calorific value is 1300 k.cal/m<sup>3</sup>

Uses : i) It is used for heating furnace and retorts and ii) It is used as reducing agent in metallurgical operations due to the presence of CO

iv) Water Gas : It is a mixture of carbon monoxide and hydrogen with little non combustable gases like carbon dioxide & nitrogen.



It is produced by passing steam and air mixture through red hot coal or coke maintained at 900 - 1000°C.

Hydrogen 14%, CO - 41 %, N<sub>2</sub> - 4% and CO<sub>2</sub> - 41 %

Calorific value is 2800 k cal/m<sup>3</sup>

Uses : i) It is used as fuel gas, illuminating gas, source of hydrogen

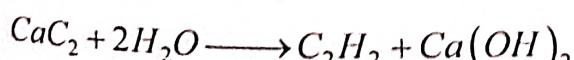
Water gas mixed with hydrocarbons is called carborated water gas and its calorific value will be around 4500 kcal/m<sup>3</sup>.

Bio Gas : It is produced by the decomposition of biological matter by anaerobic bacterial oxidation.

Bio gas is produced by decomposition of dung, organic waste matter and sewage etc. Gobar gas which is an example for biogas can be produced by anaerobic decomposition of cattle dung. It mainly consists of methane (55%) and CO<sub>2</sub> (35%) H (7.4%), N<sub>2</sub> (2.6%) and traces of H<sub>2</sub>S .

Its calorific value is 5300 kcal/m<sup>3</sup> used for cooking and Illumination purpose.

Acetylene (C<sub>2</sub>H<sub>2</sub>) : It is-produced by the hydrolysis of calcium carbide.



It is also produced with partial oxidation of methane or by passing carbon and hydrogen in an electric arc.

It burns in air to produce oxyacetylene flame, which will have around 3000C. So it is used in welding intensity. It is also used for illuminating purpose in hawkers lamp and light houses.

To produce substances like ethyl chloride, ethylalcohol, acetaldehyde and acetic acid etc.



# ENVIRONMENTAL

- The branch of chemistry which deals with the interaction of chemical substances with Air, water and soil in the environment is called environmental chemistry.
- Environment : The place surrounding us comprising of air, water, soil, plants, animals, etc., is called environment.
- Environment gives us favorable conditions to live.
- The earth summit took place on 3-14 June 1992 in "Rio - de- Janeiro" in Brazil.
- The Bhopal gas tragedy took place on 3rd December 1984.
- The World Earth days celebrated on April 22nd every year.
- The World Environment Day is celebrated on June 5th every year.
- The environment comprises of the following 4 segments. They are : 1. Atmosphere. 2. Hydrosphere 3. Lithosphere 4. Biosphere
- Atmosphere : The protective thick gaseous cover of air surrounding earth is called atmosphere.
- The atmosphere extends to a height of 1600 KM but 99% of atmosphere lies below 30 KM altitude.
- The pressure of atmospheric air on human body is 7Kgs/6 sq. cm. But of course we do not feel it.
- Atmosphere prevents
  - entry of cosmic rays from outer space on earth.
  - entry of U.V and I.R radiation from sun on earth.
  - Warming of earth and balances the heat
  - Atmosphere is classified into Troposphere (upto 8 km) stratosphere (upto 50 km), Mesosphere (upto 80km), and Ionosphere (80 km). *ozone layer is found*
- Hydrosphere is the 75% of earth's surface covered by water comprising oceans, seas, rivers etc.
- Lithosphere : The solid component of earth comprising soil, mountains, rocks etc. is called lithosphere.
- Biosphere : It is the space where living organism plants, animals etc. live in the environment comprising atmosphere, hydrosphere and lithosphere
- Pollution : The contamination of Air, water, soil, etc. with undesirable chemicals which spoil the natural quality of the environment is called pollution.
- The pollution is two types, natural and artificial or man made.
- Pollutant : The substance which causes pollution is called pollutant.

## POLLUTANTS

### Primary

Emitted directly from source

Ex : SO<sub>2</sub>, Oxides of Nitrogen etc.

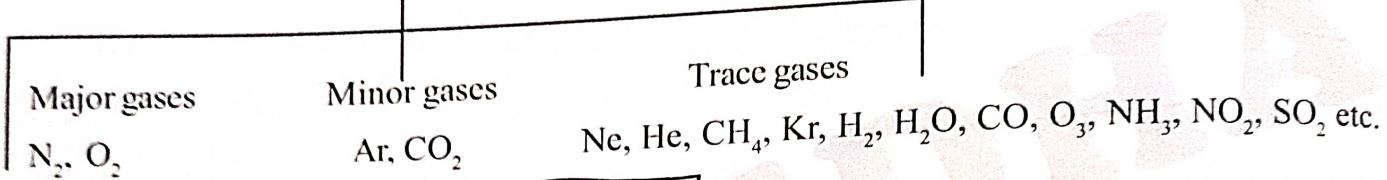
### Secondary

Derived from primary pollutants.

Ex : PAN produced from Nitrogen Oxides + Hydrocarbons

- ⇒ Air pollution : The excessive concentration of foreign matter in air which adversely affects the living organism and property on earth is called air pollution.
- ⇒ Composition of Air : The gases present in air are divided into 3 types.

### AIR



- ⇒ The air pollution is measured in parts per million.

ppm = No. of particles 1,000,000 particles

### ⇒ Major Gases :

- The most abundant gas in atmospheric air is N<sub>2</sub> (78.09% by volume)
- The second most abundant gas in atmospheric is O<sub>2</sub> (20.94% by volume)

### ⇒ Minor gases :

- The most abundance inert gas in atmospheric is Argon (0.93% by volume)
- The abundant of CO<sub>2</sub> in Air is (0.03% by volume)

<b>Gas</b>	<b>Abundance</b>	<b>Gas</b>	<b>Abundance</b>
Ne	-18ppm	CO	-0.10
He	-5.2	O <sub>3</sub>	-0.02
CH <sub>4</sub>	-1.3	NH <sub>3</sub>	-0.01
Kr	-1.0	NO <sub>2</sub>	-0.001
H <sub>2</sub>	- 0.5	SO <sub>2</sub>	-0.0002
H <sub>2</sub> O	-0.25		

- ⇒ The killer gas in Bhopal gas tragedy is Methyl isocyanate CH<sub>3</sub>NCO

- ⇒ The pesticide prepared by the union Carbide by using MIC is Carbyl Carbamate.

- ⇒ Environment means air, water, soil and other solid materials which are presence on the earth

- ⇒ The solid component of the earth is called as Lithosphere.

- ⇒ All the water component of the earth is called hydrosphere.

- Part of the earth in which, life exists is called as Biosphere.
  - Air on the earth is called as Atmosphere.
  - Portions of atmosphere, hydrosphere, lithosphere in which life exists is called as Biosphere
  - The upper portion of the atmosphere is called as stratosphere.
  - The average percentage composition of clean and dry air near the sea level in Nitrogen 78.9%, O<sub>2</sub> - 20.94%, Ar - 0.95%, CO<sub>2</sub> - 0.0318%, Ne-0.018%.
  - He + Kr + Xe + H<sub>2</sub> + CH<sub>4</sub> + O<sub>3</sub> + NO<sub>2</sub> + N<sub>2</sub>O + SO<sub>2</sub> = rest
  - Pollutions :** Air pollution is mainly concerned with troposphere.
  - Pollution is defined as the addition of any foreign materials like in organic, inorganic, biological, radio active substance (or) any physical change occur in nature which many effect the organisms directly or indirectly either immediately or after some time.
  - Pollution can be cause accidentally or naturally or man made.
- Examples for Natural pollutions are valcanos eruption, floods, Tsunamies forest fires, earth quakes, pollen grains. etc.
- Examples for Accidental pollution are oil slick, gas leakage, Radiation leakage etc.
- Man made pollutants are deforestation, population growth, industrialization, urbanisation, automobile pollution unscrupulous exploitation of nature, natural phenomenon like volcanic eruption, radio activity strong winds, forest fires floods, will give pollution.
  - A part from natural and man made pollution there are accidental pollutions oil.....leakage
  - Pollution can be classified in to various categories
- 1) Air pollution      2) Water pollution      3) Soil pollution      4) Noise pollution

CAUSES OF AIR POLLUTION	
<b>Natural sources</b> <ol style="list-style-type: none"> <li>1. Volcanic eruptions</li> <li>2. Pollen grains</li> <li>3. Forest fires</li> <li>4. Marsh gases</li> <li>5. Organic and inorganic decays</li> </ol>	<b>Man made sources</b> <ul style="list-style-type: none"> <li>Transportation services</li> <li>Rapid Industrialisation</li> <li>Increase of population</li> <li>Deforestation</li> </ul>

Transportation Service : About 75% of air pollution is due to automobile exhausts.

The incomplete combustion of motor fuels produce about 77% CO, 8% Nitrogen Oxides and 14% Hydrocarbons with lead particles.

- ⇒ The oxides of Nitrogen react with uncombustible petrol and diesel and form petrochemical Smog.
- ⇒ The mixture of the Smoke, and Fog is called Smog. -  $O_3 + PAN$
- ⇒ Rapid industrialisation is responsible for 20% of Air pollution.

Industry	Pollutant	Effect
Cotton Industry	Cotton dust	White lungs
Flour Mills	Flour	White lungs
Asbestos	Asbestos dust	Asbestosis
Glass	Silica dust	Silicosis
Petrol bunks	Petrol, Benzene	Headache.

- ⇒ Increase of population : Explosion of population leads to global warming, emission of green house gases, loss of forest and wild life.
- ⇒ Deforestation : plants maintain the balance of  $CO_2$  and  $O_2$  in atmosphere by the process of photosynthesis.
- ⇒ The gas absorbed in photosynthesis is  $CO_2$  and the gas liberated is  $O_2$
- ⇒ Deforestation cause decrease of conc. of  $O_2$  and produce respiratory problems.

### Air Pollutants

- ⇒ Pollen grains causes allergic diseases to individuals.
- ⇒ **Aerosol** : The solid or liquid, particles of microscopic size released under pressure dispersed in gaseous media are called Aerosols.  
Eg : Dust, Smoke, Mist, Fog, Fumes of jet planes.
- ⇒ **Dust** : The large solid particles dispersed in gaseous medium are called dust particles.
  - The size of dust particles of fly ash from chimneys is  $3 - 80 \mu$
  - The size of dust particles of cement industry is  $10 - 150 \mu$
- ⇒ **Smoke** : The fine particles produced by incomplete combustion for carbon or combustible materials is called smoke.
  - The size of smoke particles of coal is  $0.01$  to  $0.2 \mu$
  - The size of smoke particles of oil is  $0.03$  to  $1.0 \mu$
- ⇒ **Mist** : The dispersion of liquid particles of large size in low concentration in air is called mist.
  - The size of mist particles in atmosphere is  $40 - 50 \mu$
- ⇒ **Fog** : The visible aerosis in which the dispersed phase is a liquid is called fog.
  - The size of fog particles is  $1 - 40 \mu$

→ Fumes: The solid particles generated by condensation from the gaseous state after volatilisation from melted substances are called fumes.

### Gases and Vapours

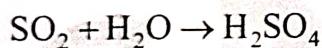
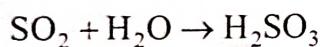
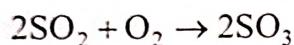
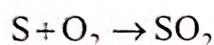
Type	Examples
S compounds	$\text{SO}_3$ , $\text{SO}_2$ , $\text{H}_2\text{S}$
O compounds	$\text{CO}_2$ , $\text{CO}$ , $\text{O}_3$
N compounds	$\text{NO}$ , $\text{NO}_2$ , $\text{NH}_3$
Halogens	$\text{HCl}$ , $\text{HF}$ etc.
Organic	Aldehydes, Hydrocarbons
Radioactive	Radioactive gases.

- CO forms a complex Carboxyl haemoglobin with iron of haemoglobin. Therefore the Oxygen carrying capacity of blood decreased.
- Aldehydes are produced by the consumption of gasoline, diesel oil and natural gas.

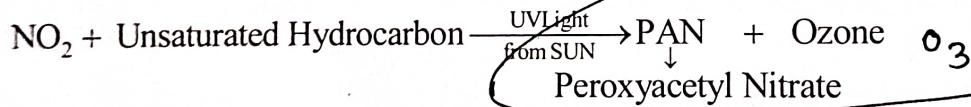
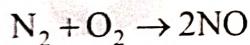
S.L.No	Air Pollutant	Source	Effect on Man
1.	$\text{SO}_2$	Combustion of coal and Petroleum Products, $\text{H}_2\text{SO}_4$ plants, paper mills	Death by respiratory disorders
2.	Nitrogen Oxides	Automobile exhausts, $\text{HNO}_3$ plants	Lung diseases
3.	$\text{H}_2\text{S}$	Refineries, Chemical Industries	Nausea, Irritation of eyes, Fatigue
4.	CO	Incomplete combustion of Coal, capacity of blood.	Heart attack, reduce $\text{CO}_2$ carrying
5.	Petrol products		
6.	HCN	Blast furnace, fumigation, metal	Dry throat, loss of vision, headache poisoning
7.	HF	Fluorine or fluoride plants Bone.	Tooth, respiratory diseases
8.	$\text{HCl}$ or $\text{Cl}_2$	$\text{HCl}$ plants, Chemical Industries	Respiratory diseases
9.	$\text{NH}_3$	Explosive Dye Making fertilizers plants	Respiratory diseases
10.	$\text{COCl}_2$	Chemical and Dye making	Caugh irritation and fatal
11.	Aldehydes	pulmonary Edema	
12.	Ozone	Oil, fat and glycerol Industry	Nasal and respiratory disorders
	Dust	Atmosphere, Transformers	Respiratory disorders
		Industries & Moto Vehicles	Silicosis Respiratory trances.

- ⇒ Formaldehyde causes irritation in eyes.
- ⇒ The London smog killed 5000 people in 1952
- ⇒ The London smog or sulphurous smog is a mixture of smoke, fog and  $\text{SO}_2$  formed from burning of coal
- ⇒ The sulphurous smog kills people due to bronchial irritation.
- ⇒ The components of photochemical smog are unsaturated Hydrocarbons, Nitrogen Oxides and sulphur compounds.
- ⇒ The effect of photochemical smog (or) Los Angeles smog is loss of vision, eye irritation and plant damage.
- ⇒ Formation of Photochemical smog

**From Industries :**



**From Motor Vehicles :**



- ⇒ The PAN is responsible for the pollution of photo chemical smog.
- ⇒ Green House Effect : The increase of atmospheric temperature due to accumulation of green house gases is called green house effect.
- ⇒ The important green house gases are  $\text{CO}_2$ ,  $\text{CH}_4$ ,  $\text{N}_2\text{O}$  and chlorofluorocarbons etc.
- ⇒ The green house gases prevent the escape of heat into upper atmosphere.
- ⇒ The Ozone layer is surrounding earth protects the entry of UV radiation from sun.
- ⇒ The Ozone layer is destroyed by chlorofluoro Carbons.
- ⇒ Important Chloro fluoro carbon are :

a) Difluorochloro methane  $\text{CF}_2\text{Cl}_2$  (Freon)

b) Flurotrichloro methane  $\text{CFCI}_3$

The chloro fluoro carbons are used in Airconditioning and refrigeration industry.

Reactions :



∴ Ozone is converted to Oxygen

⇒ Effect of Air pollution on Animals is a two step process. Air pollutants accumulate in vegetation. The spreading of disease from Vegetation to Animals.

⇒ **Air Pollutant                          Effect of Animals**

F	Lameness, Loss of weight Diarrhoea
As	Poison
Pb	Loss of appetite, paralysis and diarrhoea

⇒ **Effect of Air pollution on plants**

Air Pollutant	Effect on plants
SO <sub>2</sub>	Intervenial chlorotic bleaching of leaves.
O <sub>3</sub>	Collapse of leaf, necrosis and bleaching
Fluorides	Necrosis of leaf tip
NO <sub>2</sub>	Suppress growth leaf bleaching
HCl / Cl <sub>2</sub>	Damage to vegetation

⇒ **Control of Air Pollution :**

- Use of Non polluting energy sources
- Use of energy sources which cause less pollution.
- Control of air pollutants to safer limits.
- Cleaning of exhaust gases after combustion in Automobiles by using catalysts.

⇒ **Smoke in internal combustion energies is reduced by**

- correct method of firing
  - adding correct amount of air.
  - maintaining high temperature.
  - feeding fuel continuously
- ⇒ Smoke is a colloidal solution of negatively charged carbon particles in air.

- ⇒ Smoke is controlled by cottrell electrostatic precipitator by using + 30,000 volts. Therefore the smoke particles are settled at the bottom.
- ⇒ Zoning of residential and industrial places reduce air pollution.

### Air Pollution

- ⇒ Discharge of undesirable foreign substances in to the atmosphere air effecting the quality of air adversely causing damage to life is called as air pollution.
- ⇒ The air pollutants are gases like CO, CO<sub>2</sub>, Oxides of N<sub>2</sub>, F<sub>2</sub>, Cl<sub>2</sub>, NH<sub>3</sub>. Chemical compounds such as PH<sub>3</sub>, ASH<sub>3</sub>, HF detergents, phenol, benzene, acidic fumes toxic.....such as Cd, Hg, Pb, Fe, Zn etc.
- ⇒ Air pollution can also be caused by herbicide pesticides, fungicides, fertilizer reactions substances such as Ar-40, Co-60, I-131, Si-127.
- ⇒ Air pollution can be caused by dust, micro organisms etc. The pollutants are classified into two types
  - i) Primary pollutants
  - ii) Secondary pollutants.

- Substances which are released directly from the sources are called as Primary Pollutants.

Ex : SO<sub>2</sub>, NO, NO<sub>2</sub> etc.

- Substances which are produced in the reaction between primary pollutants are called as secondary pollutants.

Ex : Peroxy Acetyl Nitrate (PAN), SO<sub>3</sub>, O<sub>3</sub> etc.

- The pollutants are again 2 types

- a) Biodegradable      b) Non biodegradable

- Pollutants which can be decomposed by natural process with micro organisms are called as biodegradable.

Ex : Domestic sewage

- Pollutants which are non decomposed by micro organisms are called non biodegradable.

Ex. Phenolic compounds, metals like aluminium, iron mercury and ethylene etc.

Gases pollutants in air : Various gases which may given air pollutants are SO<sub>2</sub>, NO<sub>2</sub>, N<sub>2</sub>O, NO, CO<sub>2</sub>, H<sub>2</sub>S, HCN, O<sub>3</sub>, Br, HF. Organic gases like C<sub>2</sub>H<sub>6</sub>, C<sub>3</sub>H<sub>8</sub>, C<sub>2</sub>H<sub>2</sub>, CH<sub>4</sub>, C<sub>6</sub>H<sub>6</sub> formaldehyde etc can give air pollution.

SO<sub>2</sub> : Sulphur dioxide is released from thermal power plants in which sulphur containing coal and fuels are burnt. It can be released from petroleum industry, oil refineries, sulphuric acid plants. Sulphuric ore roasting plants.

### Bad Effects :

- SO<sub>2</sub> causes cardiac and respiratory problems. It causes asthma, bronchitis, it damages agriculture it gives corrosion of metals and also eye - irritation.

### SO<sub>3</sub>

- It is produced by the oxidation of sulphur dioxide.

acid rain

- $\text{SO}_2$  &  $\text{SO}_3$  can react with water to form  $\text{H}_2\text{SO}_3$  (Sulphurous acid),  $\text{H}_2\text{SO}_4$  (Sulphuric acid) which give acidic rains, damaging marble plants, cloth leather buildings and metals.

#### ⇒ Oxides of nitrogen :

- ⇒ It is produced from combustion of fuels, coal, petrol, diesel.
- ⇒ It can be released from explosive industries.

#### ⇒ Bad Effects :

- ⇒ It gives respiratory problem, irritation of eyes, lungs problems.
- ⇒ It sun light nitrogen oxides and hydrocarbons combined together to form smog which causes poor visibility and it cause eye irritation difficulty in breath in , Asthma, Bronchitis.
- ⇒ Oxides of nitrogen like  $\text{NO}_2$ ,  $\text{N}_2\text{O}_5$  etc dissolved in water to form acid range ( $\text{CO}_2$ , CO also can be observed by moisture to given acidic environment.)

#### ⇒ CO

- ⇒ It is released from the partial combustion offuels from automobiles and industries cigarettes and bedies.
- ⇒ It is released from domestic heat appliances.
- ⇒ Every year 290 million tons of CO is being released.
- ⇒ It is a colourless, non corrosive but very toxic gas
- ⇒ It cause headache, visual difficulty, paralysis, asphyxia (loss of consciousness) and even death
- ⇒ Carbon monoxide reacts with hemoglobin of blood to form carboxy haemoglobin which decreases oxygen carrying capacity of blood. This causes headache, giddiness, decrease in visual perception, damage of casdio-vascular system and at lastly death.

#### ⇒ $\text{CO}_2$

- It is released as smoke from burning fuels, it is released by the respiration of animals and plant
- The percentage of  $\text{CO}_2$  increases with deforestation and population growth.
- $\text{CO}_2$  gives respiratory disorders and suffocation
- $\text{CO}_2$  placed a major role in heating of atmosphere trapping of infra red radiation from the sun. This is called green house effect.
- Heating up of atmosphere is called global arming.
- Every year  $\text{CO}_2$  is increased by 0.75 ppm and every year temperature is raising by  $0.05^\circ\text{C}$ .
- Ozone can also given to see extent green house effect, some other gas which can also shown green house effect are  $\text{CH}_4$ ,  $\text{N}_2\text{O}$ ,  $\text{SO}_2$  and chloro, fluoro carbons.
- Green house effect can be prevented by growing more trees.

## ⇒ O<sub>3</sub>

- Ozone is an allotrope of oxygen and it is produced in the upper layer of atmosphere about 20 km above the earth surface (Stratosphere)
- Ozone absorbs UV radiation from the sun.
- Ozone destroys cloths rubber goods, crops etc.
- Chloro fluoro carbons which are released from refrigeration and air condition, exhausts of supersonic industries.
- With the depletion of ozone layer life effected with many problems like cancer, DNA replication, that leads to even death.

## ⇒ HF

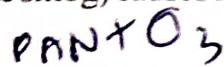
- It is released from phosphate fertilizer industry, aluminium industries, metallurgical industries and coal burning industries, it gives irritation, disorders of bone, tooth and skeleton and it also gives respiratory disorder and fluorosis in cattle.

## ⇒ Aerosols :

- There are certain chemicals released into the atmosphere with force as moist vapour
- There are released in the upper atmosphere from jet and aeroplane emissions
- Aerosols contains chloro fluoro carbons, sulful dioxide, and nitrogen dioxide deplete ozone layer.

## ⇒ Photochemical oxidants :

- Difference burnt hydro carbons react with oxides of nitrogen to a form peroxy acyl nitrates in presence of sun light (PAN) which are called as photo chemical oxidants.
- Photo chemical oxidants will cause respiratory problems, eye, nose, throat problems destroys plants, and rubber products.
- Photochemical oxidations form smog which is a mixer of smoke and fog
- Smog can be 2 types      i) London smog      ii) Los angle smog
  - i) London smog is a mixer of coal, smoke and fog in this the fog part is mainly SO<sub>2</sub>, SO<sub>3</sub>, humidity
  - ii) This London smog is very bad in early morning and become worst after sunrise.
  - iii) This photochemical smog (Los angle smog) causes irritation of lung, nose, throat, asthma and damaged of plants.



## ⇒ Hydro Carbons :

- Hydro carbons enter in to the atmosphere from incomplete combustion of fuels and also from oil refining
- Saturated hydro carbons are less harmful when compared to unsaturated hydro carbons.
- Aromatic hydro carbons are more danger (Benzene and benzene related)
- Hydro carbons causes cancer, respiratory problems, effects nervous system, DNA and cell growth.

### Particulars :

Dust : Sources of dust and mines, quarries, furnaces, power houses, vehicles traffic, house cleaning dust, and ceramic factories, forest fires, natural winds, earth moments, materials processing factories and engine exhausts

Dust causes allergy and respiratory proteins and it also causes corrosion, dust consisting of silica ( $\text{SiO}_2$ ) causes a disease called silicosis.

If the particle size is from 0.1 - 0.25 microns it is called dust.

Smoke : Smoke contains carbon particle ash, and oil droplets etc. These are released from incomplete combustion of fuels.

Smoke will be released into atmosphere from rails, road, locomotion, diesel engines, domestic wood and industrial power plants.

### Bad Effects :

- Smoke spoils cloths, buildings, loss of fuel value and increasing smoke may cause cancer.

- Smoke can also come from smog

### Asbestos :

- These are fibres silicate minerals and used for strength, resistant to heat, thermal insulation.

- Asbestos particles will cause a disease asbestos, This is a lungs disease it affects digestive track and also causes cancer.

### Lead :

- It is toxic to human metabolism.

- It enters into the air as  $\text{Pb}^{2+}$  or tetra ethyl lead.

- Tetra ethyl lead is more poisonous than  $\text{Pb}^{2+}$

- Lead should not exceed 40 ppm

- Tetra ethyl lead is used in the fuel to improve antiknocking property.

- Lead will be released into the air from the exhaust gases of vehicles.

- Lead causes brain damage, Anemia, it affects central nervous system and kidney function.

- Road side plants are more polluted by lead.

- The two most commonly used agents to remove lead are EDTA (or) 2,3 dimercapto propanol (British anti Lewisite)

### Mercury :

- Mercury is one more important pollutant.

- If mercury vapour is present in the air it is very dangerous causing irritation, and disturbance of lungs.

- Mercury in vapour state adversely affect neurological behaviour.

### ⇒ Split Mercury :

- Is impossible to recover and evaporates in the form of vapour.
- Split mercury is to be covered with sulphur powder which prevents evaporation and converts into mercuric sulphide  $HgS$ .
- Mercuric salts are generally soluble and toxic except  $HgCl_2$ .
- Mercuric chloride is not very toxic and it is used in medicine as purgative and to kill intestinal worms.
- Mercuric ions will be stored in kidneys and liver.
- Mercury causes sore gums and loose teeth.
- It dangerous brain in infants leading leads to a condition called as erethism.
- The most toxic of all mercuric compounds is dimethyl mercury and methyl mercuric ion. They separate blood from brain.
- Dimethyl mercury causes a disease minimata.
- In lakes and rivers contain bacteria and micro organisms convert mercury into mercuric ions and which form dimethyl mercury.
- The building up of any poison along a food chain is called as biomagnification.
- To reduce the poisoning of mercury EDTA is useful.
- Other metallic pollutants are Cr, Be, Mn, Cd, etc.
- Pesticides like DDT, benzene hexa chlorides, endosulphons can also give air pollution.
- DDT - dichloro diphenol and trichloro ethane.
- Deforestation gives more  $CO_2$  in air.
- Internal combustion will give more  $CO_2$  and to some extent CO, hydro carbons, oxides of sulphur and nitrogen.
- Combustion engines will decrease  $O_2$  concentration and increases  $CO_2$  concentration.
- Combustion, fermentation and respiration will give more  $CO_2$ .

## WATER POLLUTION

- ⇒ Water pollution : The contamination of water with undesirable substances to make it unfit for human, animal, aquatic animal and agricultural consumption is called water pollution.
- ⇒ The rain water is acidic in nature ( $pH < 7$ )
- ⇒ The distilled water is neutral in nature ( $pH = 7$ )
- ⇒ The ground water is basic in nature ( $pH > 7$ )
- ⇒ The rain water contains dissolved  $O_2$ ,  $N_2$ ,  $CO_2$  in it
- ⇒ The diseases caused by drinking water are called water born diseases.

- Cholera is caused by vibrio cholerae bacteria
- Typhoid is caused by salmonella typhi bacteria.
- ~~Amoebiasis is caused by the virous Hepatitis.~~
- ~~Jaundice is caused by the virous Hepatitis.~~
- Polio is caused by poliomyelitis virus.
- The pollutant which cause water pollution are : sewage, fertilizers, pesticides and industrial wastes.
- The type of water pollutants that are not degraded by microorganism of the water. Chemical pollutants.
- The main factors that cause water pollution because of industrialization are industrial effluents and hot water.
- The pollution due to letting of industrial hot water into water reservoirs is called. Thermal pollution.
- The type of pollution that influences the reproductive rate in some aquatic animals is : Thermal pollution.
- According to present rules the temperature of industrial waste water letting into water reservoirs should not exceed 67°C
- The toxic metals which cause water pollution are Mercury, Lead, Arsenic, Cadmium, Copper, Barium, Zinc, Selenium, Chromium, Cobalt etc.

#### Name of the Metal

#### Toxic Effect of Metal of Man

Mercury	Abdominal pain, headache, diarrhoea, hemolysis, chest pain
Lead and	Anaemia, Vomiting, loss of appetite, Convulsions, damage of brain, liver kidney
Arsenic	Mental disturbance, liver cirrhosis, lung cancer, kidney damage
Cadmium	Diarrhoea, Growth retardation, bone deformation, kidney damage
Copper	Hypertension, Coma, Sporadic fever
Barium	Excessive salivation, Vomiting, Paralysis, Colic pass
Zinc	Vomiting, renal damage, Cramps
Silver	Liver and lung disease
Selenium Low	Damage of liver, Kidney and sleeplessness, Fever, Nervousness, Vomiting, blood pressure, Blindness and death
Chromium	Nephritis, diseases in central nervous system
Cobalt	Diarrhoea, low BP, lung irritation paralysis
Manganese	Sterility, eye disease, loss of memory]
Sodium	Kidney disease

## ⇒ COMMON IMPURITIES AND THEIR CAUSES AND EFFECTS

Impurity	Cause	Effect
<b>A. INORGANIC</b>		
1. Suspended and Colloidal Impurities	a. Clay slit  b. Colloids  c. Colloids associated with bacteria	Turbidity
2. Dissolved impurities	a. Carbonates and Bicarbonates of Calcium and Magnesium  b. Chlorides and sulphates of Calcium, Magnesium  c. Carbonates and Bicarbonates of Sodium  d. Chlorides of sodium  e. Fluorides of 1mg/lit of sodium 1.5 mg/lit  f. Iron oxide  g. Manganese  h. Nitrates (excess over 50 mg/l) called "Blue baby" in children  i. Lead  j. Arsenic  k. Carbondioxide  l. Amonia  m. Hydrogen sulphide	Turbidity, colour Disease Temporary hardness  Permanent hardness  Alkalinity and softness  Brakish taste Dental caries Mottled enamel of teeth, Fluorosis Taste, colour hardness Taste, black and brown colour Mathemoglobinæma also  Lead poisoning Toxic Acidity, Corrosion Taste, Odour Rotten egg odour acidity
<b>B. ORGANIC</b>		
1. Suspended impurities and Colloidal impurities	a. Decayed leaves, Algae, Fungi  b. Bacteria	Turbidity, colour taste, Odour, acidity
2. Dissolved impurities	a. Large quantities of albuminoid Nitrogen with free Ammonia and Chlorides	Disease Disease producing bacteria water harmful

⇒ The Beauro of Indian standards has prescribed the following standards for domestic water supply

Sl.No	Impurity	Generally
1.	Turbidity of silica scale	2.5 mg/l
2.	Colour on platinum cobalt scale	5 mg/l
3.	Taste and odour	un objectionable
4.	Temperature	10° C
5.	pH value	7 to 8.5
6.	Total solids	500 mg/l
7.	Hardness as $\text{CaCO}_3$	200 mg/l
8.	Chlorides	200 mg/l
9.	Sulphates	200 mg/l
10.	Fluorides	1.0 mg/l
11.	Nitrates	45 mg/l
12.	Calcium	75 mg/l
13.	Magnesium	30 mg/l
14.	Iron	0.1 mg/l
15.	Zinc	5 mg/l
16.	Copper	0.05 mg/l
17.	Arsenic	0.05 mg/l
18.	Cadmium	0.01 mg/l
19.	Lead	0.1 mg/l
20.	Radium	$3 \times 10^{-12}$
21.	Phenolic Compounds	0.001 mg/l

#### → Water pollution :

- Any change on the physical or chemical or biological properties of water and also contamination with any foreign substances which gives health hazards decreasing the quality of water is called as water pollution.
- The sources of water pollution are domestic sewage, industrial wastes, suspended particles, pests and fertilizers (plant nutrients) radio active substances etc.
- Micro organisms presents in water will give many diseases like cholera, typhoid, dysentery, worm infection, viral and malarial diseases.
- Chemical industries like acid, alkaline acid, soaps etc. paper industries, distilleries, textiles refineries etc can give much water pollution.
- Fertilizers will give nitrates in water which can cause a disease methemoglobinemia in children.

### Causes of Water Pollution

- i. Faulty sewage system
- ii. Industrial effluents :
- iii. Unhygienic practices
- iv. Agricultural wastes
- v. Oil pollution
- vi. Radioactive Pollution

### ⇒ Effects of Water Pollution :

- Spreading up waterborne diseases to human beings and animals :
- Effect on aquatic and other life
- Effect on agriculture
  - i) The use of polluted ground water for irrigating agricultural fields severely damage crops and decreases grain production
  - ii) Polluted water actually effects soil fertility by killing bacteria and soil micro organisms
  - iii) Contaminated ground water increases alkalinity in the soils
  - iv) Water pollution affects plant metabolism severely and disturbs like whole ecosystem.
- Effect on Property

### ⇒ Water Pollution control methods :

- Recycling of water must be carried out with a suitable treatment.
- Recycling can be done using chemicals, removal of pollutants from water can also be done using technique like absorption ion exchange process electro dialysis reverse osmosis process etc.
- Proper drainage and treatment of drainage water for disposal.

### ⇒ Sewage treatment :

- Sewage is the liquid waste which contains human and house hold waste water, street washings and industrial waste which contains organic and inorganic matter in dissolved or suspended or colloidal state.
- Sewage contains both biodegradable and non biodegradable matter.
- Certain bacteria will decompose sewage matter in the presence of oxygen which are called as aerobic bacteria.
- Certain bacteria will decompose sewage matter in the absence of oxygen which are called as anaerobic bacteria.
- Aerobic decomposition will not give bad smell and it is non purifying.
- Products of aerobic decomposition are nitrates, nitrides, phosphates etc.
- Anaerobic decomposition will give a bad smell which gives purification. In this process  $\text{CH}_4$ ,  $\text{H}_2\text{S}$ , Ammonium sulphide  $(\text{NH}_4)_2\text{S}$  are the products.

The sewage which undergoes anaerobic decomposition is called as septic sewage.

The length of aerobic decomposition can be increased by increasing the percent of free oxygen in the sewage.

The amount of free oxygen required conditions is called biological oxygen demand (at 20°C) for a period of five days (BOD). *5 days* - for indicating water pollution

Units for BOD is PPM or mg/litre.

BOD determines the amount of organic matter decomposable in aerobic conditions.

An average sewage has biological oxygen demand of 100 to 150 mg/lit

Chemical oxygen demand is amount oxygen required to decompose both biodegradable matter and non-biodegradable matter.

Chemical oxygen demand determines total amount of decomposed matter in the sewage.

In sewage treatment the harmful compounds will be converted into harmless compounds.

Sewage treatment of sewage, removing harmful compounds and making it safe to discharge in natural water.

Artificial sewage treatment is called as sewerage.

Carbon of sewage is converted into  $\text{CO}_2$ , Nitrogen will be converted into  $\text{NH}_3$  and  $\text{NH}_2$  will be finally converted to nitrites and nitrates.

#### ⇒ Sewage Treatment serves the following purposes

- To render the sewage inoffensive as far as nuisances are concerned.
- To prevent destruction of aquatic life. e.g., fish and other wild life.
- To prevent the danger of contaminating water supplies, bathing areas etc.

The following methods are considered to be of potential importance in sewage treatment. They are

- a) broad irrigation in which sewage is disposed off on land
- b) sewage farming in which the water and fertilizing elements like nitrogen, phosphorus and potash are utilised for crops
- c) dilution in which sewage is discharged into large bodies of water like rivers, sea etc.

#### ⇒ The artificial sewage treatment process called sewage involves the following steps

- Primary treatment or Mechanical treatment
- Secondary treatment of Biological treatment
- Tertiary or Advanced Biological, chemical and physical treatment.

#### ⇒ Primary treatment involves :

- Preliminary process : This process causes removal of large and coarse solids, inorganic matter-suspended or floating in the sewage. This involves in passing the sewage through bar screens and mesh screens
- Settlement process : In this process greater portion of the suspended inorganic and organic solids are removed from the liquid sewage.

Chemical treatment is sometimes given to sewage, just before sedimentation. Chemical treatment precipitates the solids of flocculation or coagulation.

According to a report of American chemical society primary or mechanical treatment reduces about 60% of the total suspended solids, 35% BOD 30% COD (chemical oxygen demand), 20% total nitrogen and about 10% of the total phosphorus.

⇒ **Secondary of biological treatment :** After sedimentation tank treatment, the effluent is further oxidised by 'Aerobic chemical oxidation'. As a result, the carbon of the organic matter is converted into  $\text{CO}_2$  and nitrogen is converted into  $\text{NH}_3$  and finally into nitrites and nitrates. Bases present react with nitrites and nitrates to form nitrites and nitrates of calcium, potassium and ammonium.

- Biological treatment involves particularly the trickling filters and activated sludge processes.
- The normal trickling filter removes about 90% BOD.

⇒ **Activated sludge process :** This process is based on the principle that adequate amount of oxygen or air passes through sewage containing aerobes. Complete aerobic oxidation occurs, through slowly.

⇒ **Tertiary treatment :** The most important purpose of tertiary treatment is an effective and efficient removal of pollutants than in primary and secondary treatment and it can be applied any stage of the total treatment. The main function of tertiary treatment is to decrease the load of nitrogen and phosphorus compounds present in the effluents by the following processes.

- Precipitation : Calcium oxide is removed with phosphorus compounds in the form of calcium phosphate.
- Nitrogen strippling : It is removed in the form of ammonia gas
- Chlorination : It removes nitrogen and phosphorus with chlorine molecule

⇒ **Controlling measures for noise pollutions are :**

- Setting industries away from residential areas well designed industries and proper lubrications of machines.
- Using acoustic material which absorbed sound and planting trees.

⇒ **General Points :**

- Hot water from thermal nuclear reactors decreases dissolved oxygen in rivers which effect aquatic life.
- Soap and detergents from industrial wastes will give form in water.
- A typical analytical data of sewage is BOD (Biological Oxygen Demand) is 20 pm total solids 500 ppm. Suspended particles 100-150 ppm. Volatile matter 150 to 200 ppm. Grease 50-75 ppm.
- The world earth day April 22.
- World environment day June 5.
- PSI (Pollution Standard Index) upto 100 - Normal, Below 100 - Pollutants free, above > 400 Hazards to life.
- Atomic bomb for second world war was produced by transium nitrate.
- Methyl iso cyar ate  $\text{CH}_3\text{NCO}$  (Bhopal gas tragedy)

Rapid industrialization will give 20% of air pollution.

Air pollution is also due to pollen grain which gives Asthma and respiratory problems.

HCN is produced from blast furnace and other metallurgical process which causes throat problems loss of vision and headache.

Ammonia is released air from explosive and damaging plants and fertilizers which gives respiratory disorders.

The rain water as it enters into the atmosphere it gets acidic nature.

Ground water will have basic nature.

Distilled water pH is always 7.

Cholera will be caused by vibrio cholera.

Typhoid will be caused by salmonella typhi.

Amoebiasis caused by entamoeba palarites.

Jaundice caused by viral hepatitis.

Polio caused by Poliomyelitis.

The water temperature that is left in rivers must not cross  $67^{\circ}$  and optimum temperature is  $37^{\circ}$ .

The toxic metal for water pollution is Hg, As, Cu, Ba, Cd, Pb, Cr, Cl, Se, Cd.

Disease causing organisms in drinking water called as pathogens.

The plants in sewage which supply nitrogen to other plants is blue green algae.

Soil pollution will effect food value.

Osmoscope is used to know intensity of smell.

Turbidity is determined by using Jackson apparatus.

The scale used for measuring color of polluted water is Pt-Cobalt

Carbides in polluted water determined by Mohr's method using in  $\text{AgNO}_3$ .

The fluorides and nitrates in polluted water are determined by colorimetric method.

Dissolved oxygen in polluted water is determined by Winkler method.

The residual fluorine in polluted water is determined by Starch - iodide method.

The cotton and flour will give white lungs.

Smoke particles (Carbon particles) will give black lungs.

Radioactive inert gas is Radon.

$\text{H}_2\text{S}$  will be released from refineries.

Street dust contains silica

Sb - Abdominal pain, Diarrhea, Chest pain.

Po - Anemia, Vomiting, Loss of appetite, Convulsion, Damage to Brain & Liver, Kidney

As - Mental disturbance, Liver Cirrhosis, Lung Cancer, Kidney damage.

- Cd-Diarrhea, Growth retardation, Bone deficiency, Kidney damage.
- Accumulation of plant nutrients like Phosphates and Nitrates in the soil is called eutrophication.

#### ⇒ Types of Energy Sources

Phosphates  
Nitrates

- Renewable (non conventional) energy sources
  - a) Solar energy can be find by using 2 methods
    - 1) Thermal method
    - 2) Normal method
  - b) Tidal energy
  - c) wind mills
  - d) Hidro power
  - e) Geothermal energy
  - f) Bio gas
- Non renewable (or conventional) energy sources
  - a) coal
  - b) Oil (Petroleum)
  - c) Natural gas

#### ⇒ Advantages of using Alternative (Renewable) Energy Sources :

- Alternative energy sources are completely free from pollution.
- These sources are inexhaustable.
- The energy from these sources is replaced as we use them.
- These sources not only help in conservation of energy, but also contribute immesely to afforestation, improvement of the environment and also for the increase of health and hygiene.

#### ⇒ Limitations or Disadvantages of Renewable Energy Sources :

##### ● Solar energy :

- a. The main problem of solar energy is that it is only available during the day. It is less available in cloudy weather.
- b. Systems that use solar energy as a source must store with batteries or use supplementary sources of energy when sunlight is not available.

#### ⇒ Hydro Power :

- The initial capital investment is very high
- Construction work takes a long time.
- Due to construction of hydel projects, agriculture and forest lands are lost and large population are to be displaced.

### ⇒ Wind Energy :

- It is generally favourable in geographic locations which are far away from cities.
- Wind turbine design and installation is complex for varying atmospheric conditions.
- For large scale generation, wind power is not economical.

### ⇒ Geothermal Energy :

- The overall efficiency for power production is quite low.
- Drilling operations at geothermal sites cause noise pollution.
- Air pollution occurs in case of release of gases like  $H_2S$ ,  $NH_3$ ,  $CO_2$  present in the steam and the hot water coming out of the geothermal sources.

### ⇒ Biogas :

- Collection of human or animal wastes and storing is costly.
- In the beginning the supply is uncertain.
- The conversion efficiency in the production of gas is low.

### ⇒ ECOSYSTEM :

- Ecology : The branch of science which deals with plant and animal relationship with their environment is called ecology.

In other words, ecology is the science of inter-relation between living organisms and their environment.

The plants, animals and micro organisms together with the environment in which they live make up an independent unit, called Ecosystem.

Definition : The Ecosystem is defined as any unit that includes all the organisms i.e., communities in a given area which interact among themselves and with the physical environment, so that a flow of energy leads to clearly defined trophic (nourishing) structure, biodiversity and material cycle (exchange of materials) within the system.

### ⇒ Functional Component Soil Ecosystem :

An ecosystem consists of mainly two components. They are

- Abiotic components : The non living component examples.  
Sunlight, water, soil, temperature etc.
- Basic component : The living organisms of an ecosystem are known as biotic component.

### ⇒ The living organisms are of three types. They are

- Producers or Autotrophs
- Consumers or Heterotrophs
- Decomposers.

⇒ **Producers :**  
The living things that can manufacture their own food are called producers. Since all producers are synthesizing their own food, they are self sufficient in the nutrition and they are called

Autotrophic organisms :

Example : All the plants come under this category since all plants produce their own food by the process known as photosynthesis.

⇒ **Consumers :**  
These are the living things which obtain their food by eating plants or animals or both. Consumers can be classified into three types depending on their eating habits. They are

i) **Primary consumers** : These animals are known as Herbivores and they directly feed upon plants

Ex : Rabbits, Squirrels, Deers.

ii) **Secondary consumers (Carnivores)** : These are a group of (flesh eaters) lower level carnivores, that feed on primary consumers. Ex. Dogs, Cats, Wolves, etc

iii) **Tertiary consumers** : These are a group of higher level carnivores animals. These animals directly feed on secondary consumers.

Example : Larger Fishers, Tiger, Vulture etc.

⇒ **Decomposers** : These organisms like bacteria and fungi will attack the dead bodies of producers and consumers and bring about the decay. All the organisms and their wastes are finally decomposed and recycled by decomposers.

## **BIO DIVERSITY AND THREATS TO BIODIVERSITY**

⇒ **Biodiversity** : Biodiversity is the biological diversity that exists. In other words it means the existence of a large number of different kinds of living things (Plants and animals at micro and macro level) which make a balanced environment at a given place and time. It is the basis of human survival and economic well being.

⇒ **Biodiversity** : is defined as "the ensemble and interaction of genes, species and ecological diversity at a given place and time.

In simplest terms, biodiversity is the variety of life and its processes; and it includes the variety of living organisms, the genetic differences among them and the communities and ecosystem in which they occur.

## **THREATS OF BIODIVERSITY :**

⇒ **The various threats of Biodiversity are as given below :**

- Destruction of forests.
- Habitat loss, degradation and fragmentation.
- Over exploitation of resources.
- Urbanisation
- Industrialization

pollution

Soil degradation and erosion.

Climate change

Diminishing green cover.

Invasion of non-native species

Mining for ores, roads, and river valley projects.

Loss of land fertility

Poaching of wild animals

Natural factors like floods, drought, forest fires and desertification.

#### ⇒ Radio Active pollution :

Radio active pollutions takes place from nuclear explosion, discharge from nuclear reactor.

Radio active substances will not present for a long time in the air except transium 90 - (Sr-90) and Iodine 137 (I- 137) they undergo decay slowly.

The radiation on released by radio active substance is dangerous and giving long term hazards.

Radiation will disturb normal functioning of organisms and they cause genetic mutation and also cancer.

Radio active pollution can be stopped with the prevention of radiation leakage from the reactors.

Radio active substances must be buried in the ground or disposed in sea after making it harmless.

#### ⇒ Noise Pollution.

The unit for noise is db.

Another unit for noise is Bel.

1 dB is 1/10 of a bel.

A human can tolerate upto 120 dB of noise.

With the noise pollution various can be caused like disturbances in sleep, emotional behaviour, high blood pressure, fatigue, heating loss, increases the rate of heart beat, digestive problems, decreased perception, impairment of night vision, dilation of pupil of eyes.

## SOIL POLLUTION

⇒ Substances which negatively effect fertility of soil are called : Soil pollutants.

⇒ The soil pollution is mainly due to fertilizers, insecticides and pesticides, dead bodies of trees and animals, faecal matter of animals.

⇒ The type of pollution that cannot spread to other parts is soil pollution.

⇒ The soil becomes acidic due to acid rains.

⇒ The type of the pollution that effects food value is soil pollution.

## KNOW THESE POINTS

- ⇒ The insecticides commonly found in meat and eggs sold in Indian market are : DDT and BUC.
- ⇒ Highly polluted river in India is : Ganges
- ⇒ The project engaged in the pollution control of Ganges water is : Indo French Project.
- ⇒ Less air polluted city in India is : Chandigarh.
- ⇒ Highly polluted city in India is : Calcutta
- ⇒ Highly polluted country in the world is : America
- ⇒ The country which is more attentive in the control of pollution is : Russia
- ⇒ National Environmental Engineering Research Institute (NEERI) is located at Nagpur.
- ⇒ Deforestation leads to the increase of an air pollutant in the atmosphere is carbondioxide
- ⇒ The type of pollution that can be controlled by electric cremation of dead bodies is : Air pollution.
- ⇒ The presence of excess of fluorine in water causes a disease Fluorosis.
- ⇒ The absence of fluorine in drinking water (below 1 mg/lt) causes : Dental decay.
- ⇒ The disease which caused death to many Japanese after eating infections fish is Minimata.
- ⇒ The metal pollutant of water responsible for minimata disease mercury.
- ⇒ The deaths of marine animals in gulf region recently is due to : split of oil into sea.
- ⇒ The disease causing organism in drinking water is called Pathogens.
- ⇒ The most common method of destroying pathogen in drinking water is Chlorination.
- ⇒ Mercury pollutant in water is converted by bacteria into methyl mercury and dimethyl mercury.
- ⇒ The metal pollutant of water which brings about chromosomal mutations is mercury.
- ⇒ The oxygen used by bacteria in decomposing organic substance in water is referred as : Biochemical Oxygen Demand (B.O.D).
- ⇒ The potentials that cause genetic disorders are radio active materials.
- ⇒ The most stable pesticidal water pollutant is DDT.
- ⇒ The pollutant in the form of colloidal suspensions of the particles in gas Aerosols.
- ⇒ The non pollutant power plants are : Hydro electric power projects
- ⇒ Inhaling of asbestos particles cause, Emphasema. (difficulty in exhale)

- ⇒ The presence of excess amount of bleaching powder in water causes diarrhoea and lung disease.
- ⇒ The pollution caused by dumping of garbage, used tins package materials in water is called Third pollution.
- ⇒ The only way to control third pollution is recycling of biproducts and waste materials.
- ⇒ The plants present in sewage which supply nitrogen to plants is blue green algae.
- ⇒ The thermal pollution can be controlled by using Cooling towers.
- ⇒ Excess amount of bleaching in drinking water causes a disease called : Sphaerotilusnations.
- ⇒ The intensity of odour is measured by using Osmoscope.
- ⇒ The dilution ratio at which odour is just detectable is called Threshold Number.
- ⇒ By using osmoscope threshold number is calculated.
- ⇒ Turbidity is measured by using Jackson turbidimeter.
- ⇒ The colour of polluted water is measured in Hazen units.
- ⇒ The scale used for measuring colour pollution is Pt - cobalt scale.
- ⇒ The hardness of water is measured by EDTA method.
- ⇒ The carbides in polluted water are determined by Mohr's method by using  $\text{AgNO}_3$  solution
- ⇒ The fluorides Nitrates in polluted water are determined by colourimetric method.
- ⇒ The dissolved oxygen in polluted water is determined by Winkler method.
- ⇒ The residual chlorine in polluted water is determined by Starch Iodide method.

**SUCCESS IN LIFE  
Mostly depends on the  
Power of concentration  
Clear thinking and  
Intellectual Understanding  
are very easy for a  
Concentrated mind**

