

Chemistry

3 Atomic structure

| Electron | Proton | Neutron |
|---|--|---|
| <p>→ discovered by J.J. Thomson</p> <p>→ charge: $-1.602 \times 10^{-19} C$ $-4.8 \times 10^{-10} es.u$ -ve</p> <p>→ Mass: $\frac{1}{1837}$ of H $9.11 \times 10^{-28} g$ $9.11 \times 10^{-31} kg, 0.000548 amu$</p> <p>→ discovered in cathode rays, discharge tube experiments</p> <p>→ named by J. J. Stoney.</p> <p>→ charge was determined by Millikan oil drop experiment.</p> <p>→ mass is negligible.</p> <p>→ $\frac{e}{m}$ specific charge determined J.J. Thomson.</p> | <p>discovered by Rutherford.</p> <p>→ charge: +ve $+1.602 \times 10^{-19} C$ $+4.8 \times 10^{-10} es.u$</p> <p>→ Mass: 1 atom of H (1 unit), $1.672 \times 10^{-24} g$ $1.672 \times 10^{-27} kg, 1.00728 amu$</p> <p>→ discovered in Anode rays, discharge tube experiments</p> <p>Anode rays also called canal rays.</p> <p>→ Anode rays was discovered by Goldstein.</p> | <p>discovered by Chadwick</p> <p>→ charge = 0</p> <p>→ Mass: $1.674 \times 10^{-24} g$, $1.674 \times 10^{-27} kg$, $1.008665 amu$</p> |

Atomic number (Z)

Atomic mass (A)

$$A - Z = \text{No. of neutrons}$$

Ionice = $\frac{1}{12}$ th of carbon

Isotopes \Rightarrow Same element \rightarrow same atomic number \rightarrow different mass number.

Isobars \Rightarrow different elements \rightarrow different atomic numbers \rightarrow same mass number.

Isotones \Rightarrow different elements \rightarrow same neutrons.

→ Radius of any orbit in H atom
is equal to $0.529n^2 \text{ Å}$.

principal quantum number : (Bohr)

→ denoted by n →

n , energy ↑, radius of orbit ↑

No. no. of electrons in orbit $= 2n^2$

Azimuthal Quantum Number:

(Sommerfeld)

$l \Rightarrow 0 \text{ to } (n-1)$

No. of sublevels = principle Quantum number.

Max no. of electrons in subshell = $2(2l+1)$.

Magnetic Quantum number:

(Lande).

m values from $-l \text{ to } +l$

No. of values of m for given $l = (2l+1)$

Spin Quantum N

1 Aufbau principle:

lower energy orbitals filled first

with less $(n+l)$ value.

Pauli Exclusion principle:

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

"more than 2 electrons can't be accommodated".

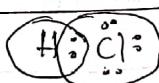
N molecule:



No. of bonds = 3 [1 is σ ; 2 is π]

shape: linear

HCl :



No. of bonds = 1

shape: linear

2. Chemical Bond : ★ in a chemical bond P-E↑; stability ↑

electrovalency → sharing/gaining/losing electrons

Ionic bond

Anion (-ve)

(Non metals).

cation (+ve)

(Metals)

For cation:

large atomic size

less ionization potential

cation with less charge.

For anion:

- less atomic size

- more electric affinity.

- Anion with less charge

- anion with net gas config.

Ionic Bond / Ionic compounds diff b/w Electro negativity < 1.7

→ mostly solids

→ non direction, do not exhibit Isomerism

→ Melting & Boiling points are high,

→ dissolves in polar solvents like water.

→ conduct electricity in aqueous solution/ molten state

→ Reactions are very fast

Covalent Bond:

→ formed b/w atoms having electronegativity < 1.7

→ introduced as electron pair bond by Lewis

→ named as covalent bond by Langmuir

→ formed due to covalency

① H₂ molecule



No. of bonds = 1

shape of molecule = linear

② Cl₂ molecule



No. of bonds/electropair = 1

shape: linear

③ O₂ molecule:



No. of bonds = 2 (1 → σ ; 1 → π)

shape: linear.

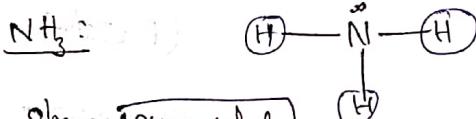
H₂O!

No. of bonds = 2



Shape : Bent / Angular

Angle : 104.5°



Shape : pyramidal

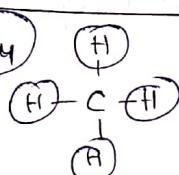
Angle : 107.3°

Methane (Alkanes) : (CH₄)

No. of bonds = 4

Shape : Tetrahedral

Angle : 109° 28"



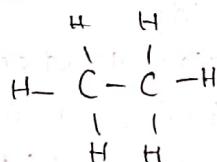
Methane

Ethane [C₂H₆]

No. of bonds = 7

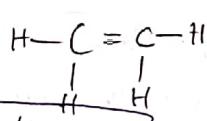
Shape : Tetrahedral

Angle : 109° 28"



C₂H₄ (Ethylene) / Ethene

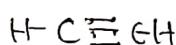
No. of bonds = 6



Shape : planar triangle / trigonal

bond angle : 120°

C₂H₂ (Acetylene / Ethyne molecule)



No. of bonds = 3 (b/w C atoms)

linear
- angle - 180°

For covalent

- less atomic size
- less electronegativity diff.

Properties of Covalent:

— solid → sugar (C₆H₁₂O₆)

— liquid → Benzene (C₆H₆)

— gas → methane (CH₄)

→ directional, exhibit Isomerism

→ M.P and B.P are less

→ covalent element with High M.P

[Diamond]

→ covalent element doesn't conduct electricity

→ graphite one only covalent element conduct electricity due to free π electrons

Hydrogen bond :

proposed by Moore and William

→ should have high electronegativity

→ should have less atomic size

→ Intermolecular H bond : Bond b/w atoms

HF, H₂O, NH₃, ROH, RCOOH, RNH₂,

P-Nitrophenol, para hydroxy benzyldehyde phenol, O-chlorophenol.

HF → strongest H bond

HF₂ → (27. k cal/mole).

Coordinate covalent bond :

Donor → -ve (anion)

Acceptor → +ve (cation).

Crystals of NaCl → cubic

Water — Universal solvent

Least electropositive metal → Au

3. Solutions

Molarity: moles/l.

$$\Rightarrow \frac{W}{G.W} \times \frac{1000}{V} \text{ (me)}$$

→ depends of temperature

→ temperature ↑, Molarity ↓ [concentration ↓]

→ For dilute solutions:

$$M_1 V_1 = M_2 V_2$$

→ For Volumetric titration:

$$\frac{M_1 V_1}{N_1} = \frac{M_2 V_2}{N_2}$$

→ solution whose concentration exactly known "standard solution".

→ prepared in [volumetric flasks]
[standard flasks.]

→ Wsolute in 1l = Molarity.

Molecular weight

$$\rightarrow M = \frac{P \times W\% \times 10}{Mol. wt}; P = \text{density}, W\% = \text{weight \%}.$$

Normality: gram equivalents of absolute present in 1l.

$$N = \frac{Wt}{\text{Equivalent weight of solute}} \times \frac{1000}{V \text{ (ml.)}}$$

$$N = \frac{P \times W\% \times 10}{\text{Eqw. wt.}}$$

Molarity of pure acetone = 55.5M

Normality of 10.6 (w/v) Na_2CO_3

Solvent is

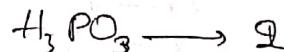
$$\frac{(W/v)\% \times 10}{\text{G. wt.}} = \frac{2}{106} \times \frac{10}{106.53}$$

$\frac{46}{12} \frac{12}{48} = 2 \text{ N. and } 1 \text{ M}$

Molar

Basicity of $(\text{C}_2\text{H}_5\text{O}_2)_2$ oxalic acid → 2

(phosphoric acid)



(phosphorous acid)

molarity

$$1M \uparrow > 1m > 1N > 1\% \uparrow \text{volume}$$

molarity

Normality

[Concentration]

Normality of Acid solution obtained by diluting 250 ml of 0.4N H_2SO_4 with 1000 ml of water

$$N_1 = 0.4N \quad N_2 = ?$$

$$V_1 = 250 \quad V_2 = 1000 + 250 = 1250 \text{ ml}$$

$$N_1 V_1 = N_2 V_2$$

$$N_2 = \frac{0.4 \times 250}{1250} = \frac{0.4}{5} = \frac{4}{10 \times 5} =$$

$$= \frac{4}{50} \rightarrow \frac{4}{50} \times 0.08 = 0.08 \text{ N}$$

↑ temperature; Normality ↑ [Concentration ↑]

more convenient method of expressing concentration is [molarity]

because it includes mass of liquid

Q. In 46% (w/w) aqueous solution of ethyl alcohol, the mole fraction of alcohol is

$$\text{no. of moles of Alcohol} = \frac{46}{46} = 1$$

$$\text{no. of moles of water} = \frac{54}{18} = 3 \quad (\text{C}_2\text{H}_5\text{OH})$$

$$\eta = \frac{1}{3+1} = \frac{1}{4} = 0.25$$

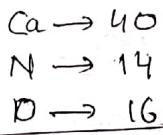
molarity is independent of temperature

pH is determined by using normality only

pH of solution is 8, then $\text{pOH} = 8$

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

→ The concentration of 10^{-3} solution of $\text{Ca}(\text{NO}_3)_2$ is



$$\text{Molar mass of } \text{Ca}(\text{NO}_3)_2 = 164$$

$$\boxed{\text{PPM} = \frac{\text{mass of solute}}{\text{mass of solution}} \times 10^6.}$$

$$M = \frac{w}{M.W} \times \frac{1}{V.}$$

$$\begin{aligned} w &= M \times M.W \\ &= 10^{-3} \times 164 = 0.164 \end{aligned}$$

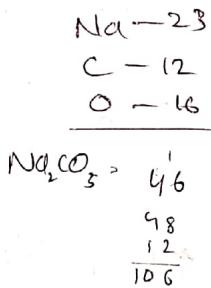
$$\begin{aligned} \text{PPM} &= \frac{0.164}{1000} \times 10^6 = 0.164 \times 10^3 \\ &= 164 \text{ PPM} \end{aligned}$$

The Normality of solution obtained by dissolving 5.3 g. of Na_2CO_3 in 1 l solution is

$$M = \frac{5.3}{106} \times \frac{1}{1}$$

$$M = \frac{1}{20}$$

$$\begin{aligned} N &= M \times 2 \\ &= \frac{1}{20} \times 2 \\ &= 0.1 \text{ N.} \end{aligned}$$



★ Acids and Bases

According to Leopold Kröger, all acids contain O_2 and it's responsible for acidic nature.

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

According to Arrhenius theory:

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

Strong Base: NaOH, KOH

Weak acid: CH_3COOH , oxalic acid, $(\text{C}_2\text{H}_2\text{O}_4)$, $\text{HCN}, \text{HCOOH}, \text{H}_2\text{CO}_3, \text{H}_3\text{BO}_3, \text{H}_3\text{PO}_4$

Weak base: $\text{NH}_3\text{OH}, \text{Be(OH)}_2, \text{Ca(OH)}_2, \text{Al(OH)}_3, \text{Fe(OH)}_3$.

Arrhenius theory applicable to only aqueous solution.

Hydroxonium ion is not explained

Bronsted Lowry Theory:

proton donor — acid (+ charge)
proton acceptor — base (- charge)



HCl — donate H^+ → acid

$\text{H}_2\text{O} \rightarrow$ accept H^+ → base

→ acid-base pair differ by a proton is called conjugate acid-base pair.

Acid — proton (H^+) = conjugate base

Base + proton (H^+) = conjugate acid

→ if acid is strong, its conjugate base is weak

→ if base is strong, its conjugate acid is weak

According to Bronsted Lowry theory:

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

Weak acids: $\text{HCN}, \text{CH}_3\text{COOH}, \text{H}_2\text{CO}_3, \text{HCOOH}, \text{H}_2\text{CO}_3, \text{H}_3\text{PO}_4, \text{H}_3\text{BO}_3$

Strong Base: $\text{OH}^-, \text{CN}^-, \text{CH}_3\text{COO}^-, \text{HCOO}^-$

Weak Base: $\text{Cl}^-, \text{HSO}_4^-, \text{NO}_3^-$

Protophilic solvents: greater tendency to accept protons. [Bases]

e.g.: liquid ammonia, water, alcohol

Protogenetic solvents: [Acids] to produce protons

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

Amphiprotic solvents: [donate or accept proton]

$\text{H}_2\text{O}, \text{ROH}$. depending upon nature

Aprotic solvents: neither donate nor accept proton

Benzene, carbon tetrachloride, carbon sulphide (CS_2), Toluene etc.

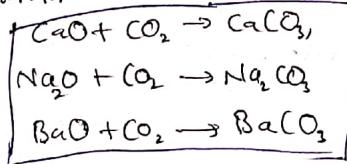
→ H_3O^+ strongest acid

→ OH^- strongest base

Non-protic & non polar solvent → Diethyl ether

Limits

- Can't explain acidic nature of electron deficient compounds.
- $\text{BF}_3, \text{BCl}_3, \text{AlCl}_3, \text{FeCl}_2, \text{CO}_2, \text{SO}_2, \text{SO}_3, \text{P}_2\text{O}_5, \text{NO}_2$ etc.
- also Basic character of substances. $\text{CaO}, \text{Na}_2\text{O}, \text{K}_2\text{O}, \text{BaO}$ etc
- can't explain neutralisation reaction b/w CaO and CO_2 with doesn't involve a proton transfer.



Lewis theory

- electron pair acceptor — acid
- All cations; H^+ , Na^+ , Mg^{2+} , Fe^{3+} , Fe^{2+} , Zn^{2+} , Ag^+
 - selection deficient compounds.
 - Eg: $\text{BF}_3, \text{BCl}_3, \text{AlCl}_3, \text{FeCl}_3, \text{SO}_2$
 - Inorganic molecules containing double bonds b/w dissimilar atoms : $\text{CO}_2, \text{SO}_2, \text{NO}_2$

Electron pair donor — Base

- All anions, $\text{Cl}^-, \text{F}^-, \text{OH}^-, \text{N}^-, \text{H}^-$
- Molecules containing lone pair of electrons. $\text{NH}_3, \text{H}_2\text{O}, \text{R-OH}, \text{PH}_3, \text{AsH}_3$
- Molecules having multiple bonds b/w carbon atoms (organic compounds) $\text{CH}_3(\text{ethylene}), \text{CH}_3(\text{acetylene})$

Neutralization Reactions:

- Eg: formation Ammonia Boron trifluoride
- Formation of Ammonium ion
- Formation of hydronium

Limitations:

- Can't explain strength of acids & bases
- Lewis acid-base reactions are very slow
- Catalytic activity of Ti^{4+} ion can't be explained by Lewis theory
- It can't explain about $\text{Ca}(\text{OH})_2, \text{NaOH}, \text{KOH}$

Ponic products factor (K_w) = $[\text{H}^+] \cdot [\text{OH}^-]$

At 25°C , $K_w = 1.0 \times 10^{-14}$ mole²/litre²

In pure water, $[\text{OH}^-] = [\text{H}^+] = 1 \times 10^{-7}$ mole/litre
Neutral solution

In acidic; $[\text{H}^+] > [\text{OH}^-] \Rightarrow [\text{H}^+] > 10^{-7}$

In basic; $[\text{OH}^-] > [\text{H}^+] \Rightarrow 10^{-7} > [\text{H}^+]$

As temperature ↑, $[\text{H}^+]$ and $[\text{OH}^-]$ increases, ★★

$K_w \uparrow$

Sorenson introduced pH

$$\text{pH} = -\log_{10}[\text{H}^+] \quad \text{pOH} = -\log_{10}[\text{OH}^-]$$

$\text{pH} + \text{pOH} = 14 \Rightarrow$ In pure water at 25°C

lower pH → more acidic in solution

higher pH → more basic in solution

* If $[\text{H}^+]$ concentration increased by 10 times, the pH decreases by one unit, and if $[\text{H}^+]$ concentration decreases by 10 times, pH increases by 1 unit.

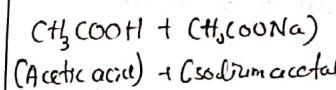
$$[\text{H}^+] = 10^{-\text{pH}}$$

$$[\text{OH}^-] = 10^{-\text{pOH}}$$

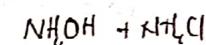
(at 25°C)

Human blood = pH = 7.4 (slightly alkaline)

Buffers: capacity to resist the change in pH



(Acetic acid) + (Sodium acetate)



(Amine Hydro) + Amine

Acidic Buffer: (weak acid + salt of conjugate base)

$$\text{pH} < 7$$

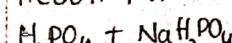
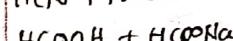
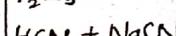
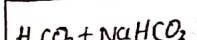
Basic Buffer: (weak base + salt of conjugate acid)

$$\text{pH} > 7$$

Carbonate buffer keeps pH of blood at a constant value of 7.4.

Ammonia buffer is used to estimate hardness in water.

Acidic Buffers:



Calculate pH of 0.01 M CH_3COOH ($K_a = 10^{-5}$)

For weak acids:

$$\begin{aligned} [\text{H}^+] &= \sqrt{K_a \cdot C} \\ [\text{OH}^-] &= \sqrt{K_b \cdot C} \end{aligned}$$

C - concentration

$$\begin{aligned} [\text{H}^+] &= \sqrt{10^{-5} \cdot 10^{-2}} \\ &= \sqrt{10^{-7}} \\ &= 10^{-3} \\ \text{pH} &= 3 \end{aligned}$$

pH of Buffers:

$$\text{pH} = p_{\text{Ka}} + \log \left[\frac{\text{Salt concentration}}{\text{Acid concentration}} \right]$$

$$\text{pH} = p_{\text{Kb}} + \log \left[\frac{\text{Salt concentration}}{\text{Base concentration}} \right]$$

If $[\text{salt}] = [\text{acid}]$, $\text{pH} = p_{\text{Ka}}$
 $\text{pH} = -\log(K_a)$.

Smaller the p_{Ka} , Higher the concentration

- presence of hydronium ions in an aqueous solution can't be explained by Arrhenius theory

acidic buffer

weak acid + salt of strong base

basic buffer

weak base + salt of strong acid.

pyridine ($\text{C}_5\text{H}_5\text{N}$) is a Lewis base

Conjugate acid of $\text{N}_3^- \rightarrow \text{N}_3\text{H}$

Conjugate acid of $\text{S}_2\text{O}_8^{2-} \rightarrow \text{H}_2\text{S}_2\text{O}_8^-$

According to Brønsted, the relative strengths of bases $\text{CH}_3\text{COO}^- > \text{OH}^- > \text{Cl}^-$

Buffer capacity = $\frac{[\text{salt}]}{\Delta \text{pH}}$

electrochemistry:

Electrolytic cell: Electricity \rightarrow chemical energy

Oxidative voltage cell: chemical energy \rightarrow electricity.
(electrochemical cells)

electrode
conductor
Inertial conductor

electrolyte (conducting)
Porous conductor

- conductivity due to electrons.
- no chemical change takes place
- no transfer of matter takes place
- conductivity \uparrow with \uparrow temperature

e.g. metal wires, graphite

- conductivity due to ions
- chemical change takes place at electrodes
- transfer of matter takes place.
- conductivity \uparrow with \uparrow temperature

Acids, Bases, & salts

Highest electrical conductivity \rightarrow Ag (silver)

Theory of electrolytic dissociation -

Frauenius

- Anions \rightarrow 阴 ions \rightarrow Anode (+ve)
- Cations \rightarrow 阳 ions \rightarrow cathode (-ve)
- charge on anion = charge on cations
- degree of ionisation = $\frac{\text{No. of ionised molecules}}{\text{Total no. of molecules}}$
- degree of ionisation \uparrow , dilution \uparrow , \uparrow in case of weak acids
- temperature \uparrow (Concentration \downarrow)

deg. of Ionisation high - strong electrolyte

- strong Acids, strong bases, salt
 $\text{HCl}, \text{H}_2\text{SO}_4, \text{HNO}_3, \text{HCrO}_4, \text{NaOH}, \text{KOH}, \text{NaCl}, \text{KCl}, \text{Na}_2\text{SO}_4, \text{K}_2\text{SO}_4$ etc

deg. of Ionisation is low - weak electrolyte

\rightarrow weak acids, bases, salts
 $\text{H}_2\text{CO}_3, \text{CH}_3\text{COOH}, \text{HCOOH}, \text{H}_2\text{BO}_3, \text{H}_2\text{PO}_4, \text{NH}_4\text{OH}, \text{Al(OH)}_3, \text{Al(OH)}_3, \text{Fe(OH)}_3$ etc., HF

F

reduction - cathode

Electrolysis.

- redox reaction

- a decomposition reaction
- an endoergic reaction.

cathode — Reduction process

anode — oxidation process

- electrode which do not react with electrolyte
inert electrodes (graphite, platinum).

when anode is same as in electrolyte:
anode dissolved and get deposited at cathode

when 2-diff. cations present in electrolyte,
cation with higher reduction potential, get deposited at cathode.

when 2 different anions present in electrolyte,
anion with lower reduction potential, get deposited at cathode.
released at anode.

conductance & deg. of dissociation

In weak electrolytes, deg. of dissociation ↑ with dilution, i.e., conductance increased ↑
[concentration ↓]

Faraday - 1st law:

$$n_1 \propto W$$

$$W \propto Q$$

$$W \propto It$$

$$W = ect$$

C - current (A)

t = time (s)

e = electrochemical equivalent

Faraday 2nd law:

$$\frac{W_1}{E_1} = \frac{W_2}{E_2} \quad (\text{when same current is passed through different electrolytes}).$$

$W_1, W_2 \rightarrow$ weight of substances deposited

$Ge_2 \rightarrow$ equivalent weight/eq. chemical equivalent

Units of e = g/coulomb or g/amp sec

1 Faraday = 96500 coulombs.

$$E = ex F$$

$$e = \frac{E}{F}$$

$$E = \frac{\text{At. wt}}{\text{valency}}$$

Amount of substance formed due to the passage of "n" no. of electrons 6.023×10^{23} is called E.

$$F = 96500 \times e$$

$$E = ect$$

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

$$W = \frac{Mct}{ZF}$$

Electrochemical cell

Chemical energy to electrical energy.

Anode → oxidation take place (-ve electrode)

Cathode → reduction take place (+ve electrode)

electrons flow from anode to cathode

Common electrolytes used in salt bridge are $\text{KCl}, \text{NH}_4\text{NO}_3$ and KNO_3 .

Cell Notation:

salt bridge — ||

porous pot — | (dotted) vertical

Daniel cell Eq. of galvanic cell

Nernst equation:

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

E° = standard electrode potential

comf = +ve (electricity will produce spontaneously)

comf = -ve (reverse action takes place)

comf = 0 (cell will not function)

• Teflon have min. conductance

• cell constant = Resistance × specific conductance
 $A = \text{area of electrode}$
 $L = \text{distance b/w electrodes}$

• PCl_3 is a covalent compound but its aqueous solution conducts electricity because of hydrolysis

• Mercury cell has constant voltage throughout its cell

• Chemical energy of $\text{H}_2 \rightarrow$ electrical energy
⇒ Fuel cell

Standard electrode potential of 0.1M solution of M^{2+} ion ($E^\circ = -2.36\text{V}$) is

$$E = E^\circ + \frac{0.0592 \log(10^2)}{F}$$

$$= -2.36 + 0.06$$

$$\frac{-2.36}{-0.06} = 2.30$$

When the cell reaction attains a state of equilibrium, the e.m.f. of cell is zero

rate of reaction ↑, time of reaction ↑

Hg metal displaces copper from copper sulphate solution. (Cu)

The R.P. ↑, ↑ concentration of ions, Temp ↑

e.m.f. of a cell is ≥ 0 when free energy change of reaction is ≤ 0 .

temperature coefficient of most of the reactions lies b/w 2 and 3

Dry cell consists:

- Zn sheet as anode
- carbon rod as cathode
- mixture of MnO_2 and NH_4Cl .

Dry cell → e.g. of primary cell

Lead storage cell → e.g. of secondary cell

Lead storage cell / reversible cell
Daniel cell

Dry cell → irreversible cell

e.m.f. of dry cell : 1.25V to 1.5V.

No. of faradays = no. of moles × valency

1F = 6.023×10^{23} electrons.

1F = 96500 coulombs.

$$x = [O.E.P = +0.2]$$

Zn - strong reducing agent

$$y = [O.E.P = -0.6]$$

O_2 - strong oxidising agent

$$z = [O.E.P = +0.5]$$

high oxidation potential \Rightarrow strong reducing agent

high reduction potential \Rightarrow strong oxidising agent

Water treatment

Hard water

Hard water
(does not form lather)

Hardness

Temporary hardness

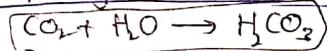
hardness
→ carbonate hardness
→ due to bicarbonates
salts of Mg and Ca

→ eliminated by boiling
water

→ bicarbonate salts
give basic nature to water.

→ if CO_2 present in water, it gives

Temporary hardness and acidic nature



units : mg/l/ ppm

→ CaCO_3 is insoluble in water.

→ hardness in CaCO_3 equivalents

weight of hardness causing substance \times mol. wt of CO_3
Mol weight

units of hardness : ppm, mg/l, °F, °cl

$$1 \text{ ppm} = 1 \text{ mg/l} = 0.1^\circ F = 0.07^\circ cl$$

$$1^\circ cl = 14.3 \text{ ppm}$$

Total hardness = Temporary hardness + permanent hardness

Molar mass of salts:

$$\text{Ca}(\text{HCO}_3)_2 = 162 \quad \text{CaCl}_2 = 111$$

$$\text{Mg}(\text{HCO}_3)_2 = 162 \quad \text{MgCl}_2 = 95$$

$$\text{CaSO}_4 = 136 \quad \text{Mg}(\text{NO}_3)_2 = 148$$

$$\text{MgSO}_4 = 120$$

$$\text{CO}_2 = 44$$

$$\text{HCO}_3 = 61$$

10^6 parts \rightarrow ppm

10^5 parts \rightarrow °F

70,000 parts \rightarrow °CP

0 to 70 ppm — soft water

70 to 150 ppm — moderate hard/moderate soft

150 to 300 ppm — hard water

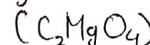
>300 ppm — very hard water

Kidney stones (caused due to drinking hard water)

\Downarrow calcium oxalate crystal



\rightarrow Magnesium oxalate crystal



Effect of hardness in boiler:

• Scale & sludge formation

• Priming and foaming

• Boiler corrosion

• caustic embrittlement

— Sludge is a loose and slimy precipitate
 $MgCO_3, MgCl_2, CaCl_2, MgSO_4$

— Sludge can be removed by blow down operation

— Scales are main source of boiler troubles

— Scales formed due to presence of
 $Ca(HCO_3)_2, CaSO_4, MgCl_2, Mg(HCO_3)_2, MgSiO_3,$
 $CaSiO_3$

— $CaSO_4$ scales will give many troubles in high pressure boiler

— Soft scales due to $\rightarrow Ca(HCO_3)_2, Mg(OH)_2, MgCl_2$

— Hard scales due to $\rightarrow CaSO_4, MgSiO_3, CaSiO_3$

Removal & prevention of scales:

— Scales formation can be prevented using certain chemicals called internal treatment.
Or Sequestration

— phosphate conditioning (high pressure boiler)

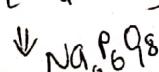
using $Na_3PO_4, Na_2HPO_4, Na_2HPO_4, Na_2P_2O_7$.

→ Na_2CO_3 (soda) causes caustic embrittlement

— Addition of calgon \rightarrow sodium hexameta phosphate

also called $\left[Na_2[Na_6(PO_4)_6]\right]$

graham salt



\rightarrow colloidal conditioning (adding chemicals like kerosene, tanin, lignin, agar-agar gel) used in low pressure boilers due to $NaOH$

\rightarrow To prevent caustic embrittlement

instead of Na_2CO_3, Na_3PO_4 is used

Boiler corrosion:

$O_2, CO_2 \rightarrow$ gives corrosion

$CO_2 \rightarrow$ produce carbonic acid (H_2CO_3) — gives corrosion.

\rightarrow corrosion with oxygen is prevented by mechanical deoxygenation, adding Na_2SO_3 , hydrazine (NH_2-NH_2)

\rightarrow corrosion with CO_2 can be prevented by mechanical deoxygenation, adding basic substance NH_4OH

Priming — wet steam production

Foaming — lather production (continuously)

\hookrightarrow water level can't be determined,

→ priming is stopped by fitting mech. steam purifier

→ foaming avoided by adding anti foaming agents castor oil, sodium aluminato

— $Na(HCO_3)_2, NaCO_3, K_2CO_3 \rightarrow$ give only basicity

— $Ca(HCO_3)_2, Mg(HCO_3)_2 \rightarrow$ gives temp, hardness and basicity

— Mn, iron salts give colour to water

— Arsenic, lead, mercury, antimony give toxic touch

EDTA (ethylene diamine tetraacetic acid)

\hookrightarrow Indicator used Eddochrome Black-T \rightarrow blue colour

\hookrightarrow Basic buffer is used which keeps pH at 10.

\hookrightarrow EB-T + Hardwater \Rightarrow wine coloured.

\hookrightarrow wine/red colour + EDTA \Rightarrow Blue colour.

Softening methods \rightarrow Removal of hardness.

① lime soda process

② zeolite (permutoh) process

③ Ion exchange process

Lime soda process: $Ca(OH)_2$ and Na_2CO_3 used.

Advantages:

\uparrow pH of treated water

Any kind of water can be treated.

Disadvantages:

\rightarrow More skill required

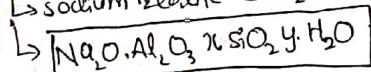
\rightarrow time consuming

\rightarrow accelerators needed

\rightarrow hardness removal upto 15ppm

Zeolite (permifit process):

↳ sodium zeolite (Na_2Ze)



$x \rightarrow 2 \text{ to } 10$

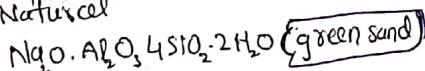
$y \rightarrow 2 \text{ to } 6$

$\rightarrow \text{Ca}^{2+}, \text{Mg}^{2+}$ exchanged with Na^+ of zeolite

$\rightarrow \text{Ca}, \text{Mg}$ are converted into sodium salts.

[Zeolites]

Natural



(Natrolite)

- Non-porous.

Synthetic

(permifit)

- high exchange capacity.

- porous

prepared by heating

mixture of [china clay + feldspar + soda ash]

- Zeolite can be regenerated by 10% NaCl (Brine) solution

Advantages

- removes hardness upto, 10 ppm

- less time, less space

- very clean, no sludge formation

Disadvantages

treated water contains more Na^+ salts

- won't remove acidic radical (anions)

- high turbidity of water can't be treated

- acidic water can't be treated

$\text{Na}_2\text{CO}_3 \cdot 2\text{H}_2\text{O} \rightarrow \text{CO}_2$ - cause corrosion

$\text{Na}_2\text{CO}_3 + \text{H}_2\text{O} \rightarrow \text{NaOH}$ (caustic embrittlement)

[Ion exchange (deionisation/demineralisation)]

- removes (+ve and -ve ions) from water

[zeocarb]

H^+ ions - exchanged in - cation resin

OH^- - exchanged in - Anion resin

- cation resin - regenerated by adding H_2SO_4 , HCl

anion resin - " " - dil. NaOH , dil. KOH

- treated zeocarb = distilled zeocarb / rainwater

Advantages

Used for acidic/basic water

- produce highly softened water, good for high pressure boiler

- residual hardness 2 ppm

Disadvantages

- costly method

- turbidity < 10 ppm

- In classic method, Ca(OH)_2 is used for softening.

- In modified lime-soda process BaCO_3 is used instead of Na_2CO_3

Drinking water requirements:

- must be clear and odourless

- turbidity < 10 ppm

- pH about 8.

- Total Dissolved Salts should be 500 ppm

- fluoride impurity < 1.5 ppm

- Dissolved oxygen > 4 ppm.

- conductivity $< 10 \mu\Omega$

Municipal water treatment:

sedimentation, filtration, sterilisation

- alum, sodium aluminate (NaAlO_2) and

coperas (FeSO_4), $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$ (green vitriol)

used as common coagulants used in sedimentation.

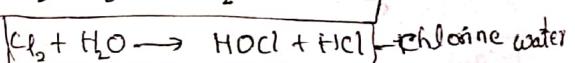
- sedimentation carried out 2 to 6 hrs

- After sedimentation, water becomes clear, transparent.

sterilisation: (removal of microorganisms)

- Germicides and disinfectants are used

- Bleaching powder [Ca(OCl)_2] calcium oxychloride



1000kl of water \rightarrow 1 kg of Bleaching powder added.

\rightarrow 35 to 38% of Cl_2

\rightarrow more effective at low pH values.

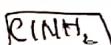
$\rightarrow \text{Cl}_2 \rightarrow 0.1$ to 0.2 ppm

Break point chlorination:

dosage of Cl_2 added to get free Cl_2 in water is called break point chlorination.

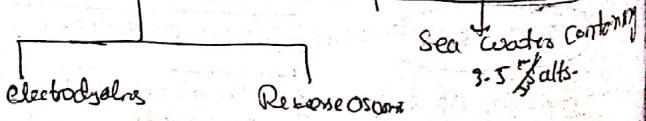
dechlorination \rightarrow by adding $\text{SO}_2, \text{Na}_2\text{SO}_3, \text{Na}_2\text{S}_2\text{O}_3, \text{NH}_3$.

Chloramine Treatment:



Nasutus pg 7.

B Desalination of Brackish water:



→ CaOCl_2 — Acidic salt
→ Rate of sedimentation $\propto \frac{1}{\text{Viscosity}}$

→ KMnO_4 — disinfectant → red med.
presence of CO_3^{2-} , HCO_3^- , OH^-

cause Alkalinity of water (basicity)

→ NH_3 in water estimated by Nessler's method

→ Fluorides in water detected by Zirconium - alizarin - S - dye

→ Hard water won't form lather due to formation of Ca and Mg salts of fatty acids

→ Municipal treatment of water doesn't involve softening

100 ml of a water sample contains 40 mg of cations. what is the hardness of water.

$$\text{Sol: mass of } \text{Ca}^{2+} = 40 \text{ mg} = 40 \times 10^{-3} \text{ g}$$

$$\text{no. of moles of Ca}^{2+} \text{ ions} = \frac{40 \times 10^{-3}}{40} \\ = 10^3 \text{ moles}$$

$$1 \text{ molar mass of } \text{CaCO}_3 = 100 \text{ g}$$

$$10^3 \text{ mole of } \text{CaCO}_3 = 10^1 \text{ g}$$

$$\rho_{\text{water}} = 1 \text{ g/ml}$$
$$\text{mass of 100 ml of water} = 100 \text{ g}$$

$$\text{hardness of water} = \left(\frac{10^{-1}}{100} \times 10^6 \right) = 10^3 \\ = 1000 \text{ ppm}$$

process removes ionic, non ionic, colloidal, organic matter from water

decrease osmosis

Turbidity caused due to suspended & colloidal particles

Ion exchange resins made with fatty acids

* CORROSION *

- corrosion product (metallic compound)
- Metallic compound will have ~~more~~ ^{less} energy than metal
- Metals get more stability, when it ~~not~~ undergoes corrosion
- Extraction of metal → reduction process
- corrosion → oxidation process.
(reverse to extraction)
- extraction → Non spontaneous process
- corrosion → spontaneous process.
↓ exothermic.
- Noble metals [Ag, Au, Pt] will not undergo corrosion.

Corrosion

- dry corrosion
[direct chemical corrosion]
- takes place in absence of conducting medium
- corrosion with O₂
↳ Oxidation corrosion
↳ forms metal oxides

- wet corrosion
[electrochemical corrosion]
- takes place in presence of conducting medium

Types of metal oxides:

unstable metal oxide layers:

- further corrosion can be prevented.
- Noble metals (Ag, Au, Pt) forms this layers

stable metal oxide layers:

- further corrosion can be stopped
- metals like (Cu, Sn, Al, Pb, Ti, Cr) forms this layers

Porous metal oxide layers:

- allows the metal to undergo continuous corrosion
- Alkaline and Alkaline earth metals forms this.

Volatile oxide layers:

oxide layer continuously evaporate into the atmosphere. so metal will undergo corrosion continuously.

- Tungsten (W), Molybdenum (Mo)

* CORROSION *

pilling Bedworth Rule:

→ used to predict the nature of metal oxide

• volume of metal oxide ≥ volume of metal
→ non-porous and protective

• volume of metal oxide < volume of metal
→ porous and non-protective

Alkali and Alkaline oxides → porous and non-protective

Cu, Sn, Al, Pb, Ti, Cr → non-porous, protective

wet corrosion: [Electrochemical corrosion]

- similar / dissimilar metals connected to each other in conducting medium. is called wet corrosion:

→ Anodic / cathodic areas formed on the surface of metal.

→ Anodic area → oxidation (continuously undergoes corrosion)

→ cathodic area → Reduction (protected one).

- electrons move from anode to cathode.

current flow

→ electrochemical corrosion can take place either with evolution of hydrogen or with absorption of O₂.

i) evolution of hydrogen:

→ When metal undergoes corrosion in presence of acid, then H₂ is evolved

→ Large anodic area & small cathodic area is formed on surface

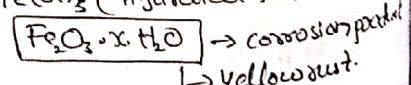
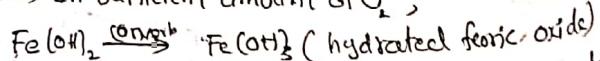
→ All the metals above hydrogen in electrochemical series undergo corrosion in acetic medium

ii) absorption O₂ type:

Eg: Rusting of Fe in the Neutral conducting medium.

→ Small anodic area, large cathodic area is formed

→ In sufficient amount of O₂;



→ In limited supply of O₂, ferric oxide (Fe₂O₃) [Black magnetite] is formed

Anode: metal with more oxidation potential
less reduction potential

Undergoes Oxidation
more active

Cathode: metal with less O.P.

more R.P.

less active

Undergoes Reduction

Electrochemical cell:

Anode - ve

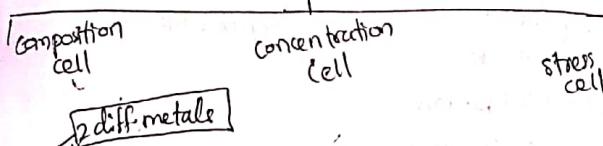
Cathode + ve

Electrolytic cell:

Anode + ve

Cathode - ve

Electrochemical corrosion



Composition cell: (Galvanic corrosion)

more oxidation metal → anode

less oxidation potential → cathode

- more active metal will be corroded

- less active metal will be protected

Eg: steel screws fitted in diff. machine parts

Cu Screws fixed with steel screws

Concentration cell: [concentration]

- Metal surface partly exposed to more concentrated corrosive medium and partly less concentrated corrosive medium.

[concentration cell is formed]



Anodic — area under more concentration

Cathodic — area under less concentration

↳ More catr, more oxygen

Eg: metal covered with another metal

liquid drops on metal surface

dust present on metal surface

Stress corrosion:

more stress — anodic

less stress — cathodic

→ stainless steel & stainless steel undergo stress corrosion in acid chloride solution.

Water line corrosion

- if a metal is partially immersed in H₂O

- observed in water tanks, ship hulls

Pitting corrosion:

- localised and fast corrosion resulting in formation of pinholes or pits.

- it due to breakdown of protective film at specific points. These points acts as anode.

- anodic area is small

Cathodic area is large

- It can also be due to Surface roughness, non-uniform finish, cut edges, local stress, chemical attack, impurities on the surface of metal

Eg: stainless steel, & aluminium will undergo pitting corrosion in chloride solution

Intergranular Corrosion:

- takes place along the grain boundaries of metals

- corrosion takes place internally, can't be seen externally until the metal piece breaks

- deposition of certain substances — anodic grain boundary acts as — cathodic

- observed in welded stainless steels

- In welding process due to high temperatures, chromium carbide is formed in the stainless steel and act as anodic area.

- with this coordination to the grains is lost and metal breaks.

Thermogalvanic corrosion:

with electricity leakage or with sudden heating & cooling if a metal undergoes corrosion then it's called thermo galvanic corrosion.

Soil erosion (underground corrosion)

pipes present in soil

Microbiological corrosion due to substance released by the microorganisms.

Caustic embrittlement: (Boiler corrosion)

due to addition of Na_2CO_3

due to formation of NaOHT

more NaOHT areas — anodic

less NaOHT areas — cathodic

Selective leaching: metal undergoes corrosion

~~dis~~ form an alloy / or metal dissolves in electrolyte from an alloy.

— Zn dissolves in electrolyte from an alloy is called dezincification

— Al dissolves " "
" → de aluminization

Erosion corrosion:

due to combined effect of a dragging action of flow of gases, liquids and mechanical rubbing of solids over a metal surface.

more anodic area }
less cathodic area } corrosion is slowly

less anodic area }
more cathodic area } corrosion is fastly

Temp. may increase / decrease corrosion.

dissolved salts in corrosive medium,

↑ corrosion.

(Rate of corrosion)

(expressed)

loss of metal per area
per time

[mils per year - mg of metal
lost per year]

In laboratory,

M.d.

mg. of metal
loss per
decimeter sq.
area. per day

pure metals offer more corrosion resistance

Impurity in metals ↑; corrosion. ↑

Cathodic protection

→ forced the metal to act as cathode

Types:

1) Sacrificial Anodic protection:

→ metal which is to be protected will be connected to more active metal

→ metals which are connected are called sacrificial anodes / auxiliary anodes

— sacrificial anodes will undergo galvanic corrosion.

— Mg, Zn, Al and their alloys act as sacrificial anodes

— underground pipelines

underground cables

marine structures

ship hulls,

water tanks

industrial boilers

transmission tower

} can be protected by this method

2) Impressed current cathodic protection:

→ metal to be protected is made cathode by passing DC from a battery with an insoluble anode

→ inert electrodes Pt, Pb, graphite, stainless steel can be taken as anodes

— water box coolers
water tanks

buried water/oil pipes

ship hulls, bridges

marine pipes.

transmission towers

load ship ships

} can be protected by this method.

→ mainly used for large structures in long operations.

Anodic Inhibitors: Chromates, phosphates, tungstates and other ions of transition elements having oxygen content.

Cathodic Inhibitors:

Oxides of Arsenic, Antimony(Sb), amines mercaptans, heterocyclic nitrogen compounds and substituted urea.

$\text{Al}, \text{Zn}, \text{Pb} \rightarrow$ called amphoteric elements metals — undergo corrosion in acidic and basic medium.

Metallic Coatings

Anodic

- Coated metal is more active than base metal
- protect the base metal sacrificially.
- coating metal have more oxidation potential than base.
- If break occurs, Coating metal only undergoes corrosion

Cathodic

- Coated metal is less active than base metal.
- coating metal is less oxidation potential than base
- if break occurs base metal under goes corrosion.

Anodic coatings:

Coating of $\text{Zn}, \text{Mg}, \text{Al}, \text{Cd}$ on iron and steel.

Cathodic coatings:

Applying tin on silver, chromium, copper, Nickel over iron and steel

Applications:

- Hot dipping: Base metal is dipped in molten coating metal
- coating metals have less melting points than base metal.
 - Zn over Fe \rightarrow Galvanising
 - Sn Coating of tin \rightarrow tinning

Food stuff's can't be stored in galvanized containers due to reaction of food with Zn.

They stored in tinned containers

Metal cladding:

- Coating sheets placed on base metal and passed through hot rollers
- used for coating steel, Al, Cu, Ni with Ag, Pb, Cu, Ni alloys, Cu alloys, Pb & alloys
- Al-cladding: used to make Aeroplane bodies [duralumin on Al] on both sides

Cementation / diffusion coating:

- base metal is coated with metal powders
- process used for coating small articles
- Coating of $\text{Zn}, \text{Cr}, \text{Al}$ on Fe and steel

Sheradising:

[Zn powder on Fe and steel]

- used for small steel articles

Cladding:

[Al powder on Fe and steel]

- used for coating of furnace parts.

Chromising:

[Coating Cr powder + Al oxide powder over Fe and steel]

- used to protect turbine parts.

Enamelling:

[Coating of Silicate powder]

Electroplating:

- coating of metal using electrolysis process

- coating metal — anode
base metal — cathode

[anodic salt]
Coating metal salt solution — electrolyte

- a uniform coating of required thickness will be formed
- can be considered as barrier to corrosion.

Metal spraying:

- coating low melting points than base metal.
- large structures can be coated uniformly.

Inorganic coatings:

Used as primary coatings
phosphate coatings \rightarrow grey colour
(H_2PO_4^- - acid)

chromate coating (yellow colour)

- more corrosion resistance

Oxide Coatings:

- By applying alkaline oxidising agents (potassium permanganate ($KMnO_4$))
- act as primary coatings
- metal oxide layer formed by electrolysis
⇒ Anodising
- Basic principle: protection of metal by formation of its own oxide layer.
- Anodising can protect metals which can form stable metal oxides.

Organic Coatings:

- paints, varnishes, lacquers, enamels.
- pigment will give colour to paint
 - Eg: ZnO → white colour
 - Fe_2O_3 → red colour
 - Cu_2O_3 → green colour
- Thinner reduce viscosity of paint and increase power of penetration of paint.
 - Eg: C_6H_6 , terpine oil, dipentene, naptha, toluol, xylol, kerosene, methylated naphthalene
- Drier helps in drying of paints
 - Eg: cobalt substances
 - lead ..
 - Mn ..
- Extenders will ↑ toughness, hardness of paint
 - Eg: $BaSO_4$, gypsum, asbestos, Mg silicate, $CaSO_4$
- plasticizers will give elastic property.
- Varnish will give hard transparent glossy lusturous film
- enamels: $\boxed{\text{varnish} + \text{pigment}}$

pure metals are less corroded

rate of corrosion of Al is less

If copper is exposed to air, protective layer formed on it is $\underline{\underline{CuCO_3}}$

Conditions to cause corrosion

$\boxed{O_2, CO_2, \text{moisture}}$

In nail, the part corroded is both head and tail

High O.P. → reducing agent
low reduction potential

high R.P. → strong oxidising agent
low O.P.

Tarnishing of Ag:

Silvers become black in sulphur compounds

The method of protection base (Inert) metal from corrosion by attaching a small anode metal is known as Passive method

- Zn will displace Cu from $(Cu\text{ solution})$
- Hg will displace Zn from $(Zn\text{ solution})$

Polymers

Sum of monomers = polymer

Polymer: Macro molecule

polymers

Natural

Eg: cellulose, proteins, insulin, nucleic acid, natural rubber, wood, cotton, silk, glass, diamond, graphite

Synthetic

Polyethane, PVC, Bakelite, Teflon, Nylon, polystyrene

No. of monomers required to give a single polymer \Rightarrow degree of polymerisation

$$\text{deg. of polymerisation} = \frac{\text{Mol. wt of polymer}}{\text{Mol. wt of monomer}}$$

polymers

Homopolymers

(same monomer)

Eg: Polyethene, PVC, Teflon, polystyrene

Co-polymers

(diff monomer)

Eg: Bakelite, Buna-S, Nylon-6, Polyester.

No. of reactive sites in a monomer

functionality:

Ethylene \rightarrow is a bifunctional molecule

phenols & Acetylene \rightarrow trifunctional molecule

Bifunctional molecule: gives straight chain polymers with high flexibility

Trifunctional molecule: give branched chain polymers with less flexibility.

Polyfunctional monomer: give cross linked structure with high strength

only carbon atoms present in chain = homo chain polymer

other atoms present = heterochain polymer.

Polymers

Polymerisation

Addition / chain

Condensation / step

Coordination polymer

① Addition / chain polymerisation:

without elimination of any by product.

Eg: polyethene, PVC, Teflon, polystyrene

- exothermic process

- monomer having $= \text{O}=\text{C}-\text{C}=\text{O}$

- No biproducts formed

- require Initiator - gives linear polymers

② Condensation / step polymerisation:

with elimination of products

- Bi products are formed

- endothermic process

- Branched / cross-linked polymers.

- Eg: Bakelite [pheno + formaldehyde] + H₂O.

- Nylon, polyester, Urea + formaldehyde

③ Coordination polymerisation:

\rightarrow Type of Addition polymerisation, takes place in presence of "Zeigler-Natta" catalyst

\rightarrow also called "Zeigler Natta - polymerisation".

Tetraethyl aluminium
 $(\text{C}_2\text{H}_5)_3\text{Al}$

Titanium tetrachloride

\rightarrow This gives stereo regular polymers

Isotactic: - same function group.

Syndiotactic: - diff. function group

atactic:

[Tacticity] \rightarrow config. of monomer

preparation of polymer \rightarrow min. functionality requires = 2

Thermo plastic

- produced by Addn. polymerisation.
- physical change occurs
- linear polymers
- weak Intermolecular forces, soft
- soluble in organic solvents
- recycled and used
- Vinyllic polymers → PVC, poly methyl Methacryl Teflon.
- polyamide → nylon, poly cellulose acetate,

Thermosetting

- produced by condensation.
- chemical change occurs
- 3D structures cross linked polymer.
- strong Inter molecular forces, Hard, rigid, brittle
- Insoluble in organic solvents
- can't be recycled and reused.
- polyester, phenol formaldehyde, Resins, bakelite, Urea-formaldehyde, alkyd, epoxy resin, silicone resin

Thermosetting:

Thermoplastics:

- ① Polyethene (polyethylene): polymerisation of ethylene. (CH_2)
 → homopolymer
 $n [\text{CH}_2 = \text{CH}_2] \xrightarrow{\text{O}_2} -[\text{CH}_2 - \text{CH}_2]_n -$

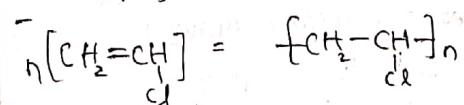
high pressure used → low density Polyethylene

low pressure used → high density polyethylene

Uses: insulating parts, flexible bottle caps, kitchen & domestic appliances, toys, sheets for packing materials, tubes & pipes, coated wires, cables and bags.

P.V.C.: polymerisation of vinyl chloride

→ homo polymer.



Uses: pipes, electric insulators, tank linings, safety helmets, refrigerator component, tyres, cycle and motor cycle mudguards.

(3) polystyrene: polymerisation of styrene

→ homopolymer.

Uses: produce toys, combs, buttons, buckets, radio & television parts, refrigerator components, battery cases, electric insulators & lenses.

Light stable moisture resistant polymer

Bakelite

- polymerisation of phenol & formaldehyde
- copolymer
- $\text{C}_6\text{H}_5\text{OH} + \text{CH}_2\text{O} \xrightarrow[\text{OH}^-]{\text{H}^+}$ Bakelite
 (phenol) (formaldehyde)
- very hard rigid plastic resistant to acids, bases
- 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

- Urea : formaldehyde = 2:1

- presence of alkali



Nylons:

→ Diamine + dicarboxylic acids

Nylon - 6,6

Nylon - 6,10 } copolymer

Nylon - 6,11

Nylon - 6 → Homopolymer.

Fibres

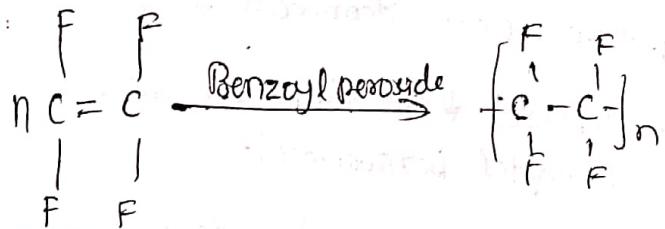
→ Polyester
 - Terylene

Q) Teflon : [polytetrafluoroethylene]

(fluor)

monomer: tetrafluoroethylene

- homopolymers



Uses: Very hard having high softening point
[about 350°C]

- highly chemical resistant
- production of insulating materials, gaskets, chemical carrying pipes, non-sticky kitchen ware and tank linings

Vinyl group polymers:

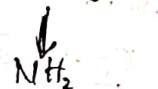
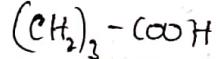
- polyethene (polyethylene)
- P.V.C
- polystyrene
- Teflon
- polyvinyl acetate used to make chewing gums, surgical dressings, paint adhesives
- polymethyl methacrylate (perspex) used to produce adhesives.

Nylon 6-6 :

Condensation polymerisation of hexamethylene diamine and adipic acid.

Nylon - 6 :

- caprolactum (monomer)



Polyesters:

Condensation polymerisation of dihydric alcohols with dicarboxylic acids

Eg: Terylene.

Rubber:

- elastomer having elastic property.
- excess of 30%.
- produced from Beta-silicons and gumule.
- Natural rubber — polymer of Isoprene (C_5H_8)
Methyl 1,3-butadiene
- Trans polyisoprene \rightarrow (gutta percha)
produced from leaves of Pithecellobium
gutta and palauan gutta

drawbacks of Raw Rubber:

- low T.S
 - plastic in nature
 - weak
 - used in temp. $10^{\circ}C$ to $16^{\circ}C$
 - large water absorption capacity
 - can be attacked by solvents and oxidising agents
 - swell in inorganic solvents and dissolve in organic solvents
 - will have tackiness
 - little durability & undergoes permanent deformation
- } due to =

drawbacks of vulcanised Rubber:

- \Rightarrow good T.S
- low water absorption capacity
- excellent resilience
- better electrical insulator
- high resistance to oxidation / solvents
- useful in temp range $40^{\circ}C$ to $100^{\circ}C$
- tackiness very less.

Vulcanisation: heating rubber with Sulphur.

- invented by Charles Goodyear.
- H_2S , SCH_3 , CS_2 , can also be used.
- $160^{\circ}C$ to $140^{\circ}C$
- Branched chains are formed with crosslinking structure.
- Consists of 3 to 10% sulphur
- Rubber containing 33% of sulphur is Ebonite
Rubber \rightarrow used for battery cases.

Compounding of Rubber:

- ① vulcanising agents — \uparrow hardness.
- ② plasticisers & softeners — \uparrow softness and pliability.
Eg: Veg.oils, waxes, stearic acid, resin.
- ③ accelerators: \downarrow time for vulcanisation
Eg: 2-Mercaptol, benzothiazole
- ④ Antioxidants: To resist oxidation.
Eg: polysulfides, β -naphthol.
- ⑤ colouring agents: To give colour.
Titanium oxide — white
Chromium oxide — green
Ferric oxide — red.
Antimony sulphide — crimson.
Lead chromate — yellow.
- ⑥ fillers: \uparrow strength & rigidity of rubber.
Eg: Carbon black, ZnO , $CaCO_3$, $MgCO_3$

Synthetic Rubbers:

BUNA-S: (G.R.S. Rubber)

Butadiene + styrene in presence of Na.
high load bearing capacity
- tyres, floor tiles, shoe soles, footwear, gaskets, cable insulations, carpets, gumb & tank linings.

BUNA-N:

Butadiene + nitrile compound
(Acrylonitrile)

- used to produce conveyor belts, aircraft components, tank lining gaskets, adhesives, automobile parts.

Butyl [most commonly used]

[polymerisation of Isobutene with 1 to 5% Isoprene.]

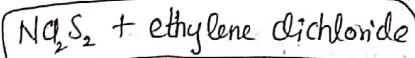
- low permeability to air and other gases
- resistant chemicals & solvents.
- used in cycle and automobile tubes, automobile parts, conveyor belts, tank linings, insulation parts.

Neoprene Rubber:

- polymerisation of chloroprene.
- homo polymer.

Thiokol Rubber { non-vulcanised }

- GRP, rubber or polysulphide rubber.

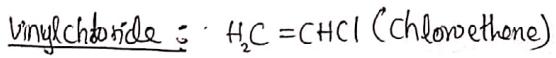
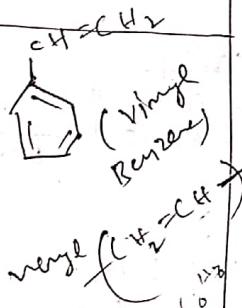
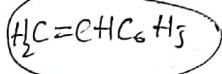
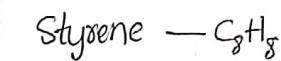


- solid propellant for rocket fuels

Silicon Rubber:

- polymerisation of silicon hydroxide

- very hard, and withstand upto 200°C



Diphenylamine added to rubber to protect it from deterioration on exposure to air

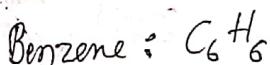
Formaldehyde manufactured by hydrolysis

of urea by addition

phenol is manufactured by oxidation

of cumene to its hydroperoxide and

followed by hydrolysis



Polystyrene is a polymer of

Styrene (vinyl benzene)



Fuels: \rightarrow releases heat energy

Combustion: exothermic reaction

$\text{CO}_2, \text{H}_2\text{O}, \text{SO}_2, \text{NO}$ \rightarrow combustion products.

Primary fuels: wood, coal, dung, cattle oil, petroleum oil, natural gas.

Secondary fuels: coke, charcoal, gas, kerosene, diesel, petro, coal gas, bio-gases etc.

| primary solid | primary liquid | primary gases |
|--|----------------------|---------------|
| wood, coal, peat, lignite, anthracite, Bituminous. | Crude oil, petroleum | natural gas |

Fuels are stored and available in earth crust

- fossil fuels.

Formation of coal

Plastic stage

brown coal (monomer of polymers)

Drift theory

[Transported]

peat \rightarrow lignite \rightarrow bituminous \rightarrow anthracite

brown fibrous jelly coal

5400 kcal/kg

Nilgiri

Bituminous: (Common coals)

\rightarrow used to produce coke, coal gas.

\rightarrow laminated structure, i.e. layered structure

Anthracite coal: C - 92% - 98%

- hardest coal with lustrous

- 8650 to 8700 kcal/kg -

Natural gas:

$\rightarrow \text{CH}_4$ (75 to 100%)

$\rightarrow 12000$ to 14000 kcal/m^3

\rightarrow used in synthesis of NH_3 & proteins

Coke gas:

methane (CH_4) \rightarrow 32%

H_2 \rightarrow 40%

4900 kcal/m^3

used as fuel in metallurgical process.

producer gas:

2nd $\text{CO} \rightarrow$ 1st

1st $\leftarrow \text{N}_2 \rightarrow$

$\text{H}_2 \rightarrow$

$\text{CO}_2 \rightarrow$

1300 kcal/m^3

- used for heating houses
- used as reducing agent in
metallurgical operations due to CO

Liquified gas:

$\text{CO} \rightarrow$ 1st

$\text{H}_2 \rightarrow$ 2nd

Source of H_2

4900 kcal/m^3

Biogas: $\text{CH}_4 -$

$\text{H}_2 \text{ CO}_2 -$

5300 kcal/m^3

Acetylene: (C_2H_2)

hydrolysis of calcium carbide

3000°C \rightarrow temperature of flame

calorific value of producer gas is still low because of

low percentage of CO

Benzilic process \rightarrow Nickel catalyst

coke

Fischer-Tropsch process \rightarrow $\text{Catalyst} + \text{H}_2$

Catalyst: Cobalt magnesia

polymerization process - low olefins (alkenes) and paraffins (alkanes).

Without catalyst

water from petroleum can be removed with electrolysis process called

Cottrell's process

sulphur from petroleum is removed by adding of CuO .
precipitate $\rightarrow \text{CUS}$

% of moisture, ash content, volatile matter, and fixed carbon can be determined by proximate analysis \rightarrow easiest way of judging coal.

% of carbon, hydrogen, sulphur, nitrogen can be determined by ultimate analysis

carbonisation can be carried out using Behr's oven or Otto Hoffmann's product oven

Refining of gasoline \rightarrow Doctor's process / sweetening process

non petroleum fuels alkylate (basic)

soot carbon plumbite

Na_2PbO_2 used

power alcohol \rightarrow ethyl alcohol mixed with petrol.

Benzal - product of coal carbonisation

producer gas:

prepared by passing air and steam

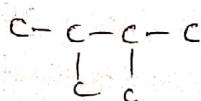
mixture over red hot coal / coke at 1100°C in a reactor

water gas:

prepared by passing [air + steam] through red hot coke at $900 - 1000^\circ\text{C}$.

Natural gas is mixture of [n-octane]

Highest octane ring



OC

Environmental Studies

Bhopal gas tragedy → on 31/12/1984
world Earth day - 22nd April
world environmental day - 5th June

Troposphere — upto 8km

stratosphere — upto 50km

Mesosphere — upto 80km

Ionosphere —

Lithosphere is solid component of earth,
↓
(soil, mountains)

pollutants

primary
(SO₂, oxides of)
N₂

secondary
Ex: PAN, SO₃, O₃

Bhopal gas tragedy → Methyl isocyanate
[CH₃NCO]

Oxides of N₂ react with uncombustible petrol and diesel and form petrochemical Smog

Smoke + Fog ⇒ Smog

Effect of petrol, benzene ⇒ Headache

O₂ carrying capacity of blood decreased due to CO

SO₂ — Death by respiratory disorder

NO_x — lung diseases

H₂S — Nausea, Irritation of eyes, Fatigue

CO — Reduce O₂ carrying capacity, Heart attack

HCN — Dry throat, headache

HF — Tooth respiratory, diseases.

HCl/Cl₂ — Respiratory diseases

NH₃ — Respiratory diseases

COCl₂ — Cough irritation & fatal

Aldehydes — Nasal & respiratory disorders

O₃ — Respiratory disorders

dust — Silicosis.

- formaldehyde causes irritation in eyes.
- London smog killed 5000 people in 1952

- [London smog] → [Sulphurous smog]
↓
[smoke + fog + SO₂]

- London smog causes bronchial irritation.

[photochemical smog] → Los Angeles smog

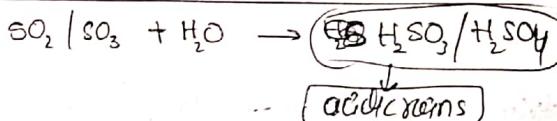
↓ causes loss of vision, eye irritation,

↓ PAN is responsible.

Green house gases: CO₂, CH₄, N₂O, Chlorofluorocarbons

Smoke is colloidal solution of very charged carbon particles

Smoke is controlled by corrugated electrostatic precipitator



O₃ → allotrope of O₂

drift → size of particle → O₃ — 0.25 μ

Lead — shouldn't exceed 40 ppm

EDTA — To remove lead
2,3 dimercapto propanol — British anti lewisite

Amoebic dysentery — caused by Hepatitis
Jaundice —

Matth hemoglobinemia (Blue baby) caused due to Nitrates.

Artificial sewage → Sewerage.

Atomic Bomb (II world war) → transuranium nitrate

PST — pollution standard index

pathogens → Disease causing microorganisms in drinking water.

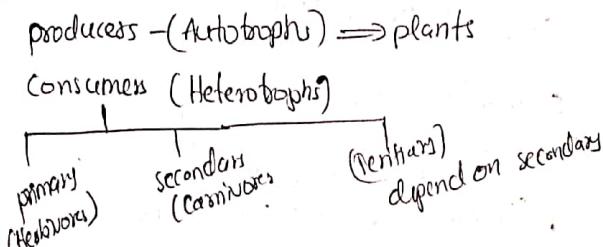
Turbidity is determined by Jackson apparatus

Osmoscope — Used to know intensity of small

threshold number calculated

- scale used for measuring color of polluted water is (Pt-cobalt)
- carbides in polluted water determined by Mohr's method using AgNO_3
- fluorides and N_3^- tritrate in polluted water are determined by (colorimetric method).
- Dissolved O_2 is determined by Coutinier method
- Residual fluorine in polluted water is determined by [starch iodide method]

Accumulation of plant nutrients like phosphates, and nitrates in soil is called eutrophication



presence of excess of fluorine - Fluorosis
 absence of fluorine (below 1 mg/l) - Dental decay

Eating Infected fish in Japan \rightarrow Minamata disease

destroying pathogen in drinking water \rightarrow chlorination.

Most stable pesticidal water pollutant - DDT

Defluoridation by Nalgonda process
 \hookrightarrow by using Bleaching powder + lime + Alum

Sodium - most dangerous radioactive pollutant.

Knock-tree - disease caused by fluorine

- London fog due to combustion of Coal industry.

Methane (CH_4) \rightarrow Marsh gas

Itai-Itai disease caused by Cadmium

Main source of phosphate pollutants in water \rightarrow Detergents.

major pollutant inde in industry - NH_3

BOD of raw municipal sewage - 150-300 mg/l

A Sample of air in hyderabad city contains:
 10 ppm of CO
 20 ppm of CO_2
 15 ppm of SO_2
 5 ppm of NO_2
 40 ppm of N_2

Sol: $\rightarrow \boxed{\text{N}_2 \text{ is not considered as pollutant}}$

\therefore Amount of Air pollution
 $= 10 + 20 + 15 + 5$
 $= 50 \text{ ppm}$

Weaker reducing agent = H_2 ($\text{H}_2, \text{C}_2\text{H}_5, \text{Al}, \text{CO}$)

Strong reducing agent = Na
 Weak reducing agent = Cl^-

Strong oxidising agent = F, Cl^-
 weak oxidising agent =

* Principles of Metallurgy *

| Metals | Non metals |
|-------------------------------|------------------------------------|
| Form basic oxides | Form acidic oxides |
| Form unstable hydrides | Form stable hydrides |
| Dissolve by chemical reaction | Dissolve without chemical reaction |
| Good conductor | Bad conductor |
| Good reducing agent | |

- All ores are minerals, but all minerals are not ores.
- gangue \rightarrow unwanted impurities
- flux \rightarrow added to mineral to remove gangue

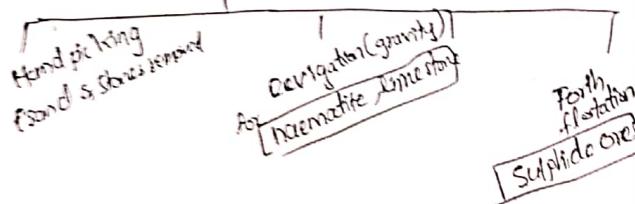
- acidic
taken gangue
basic [lime, metallic oxides]

- acidic fluxes [silica, borax]
are used

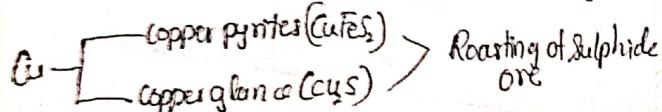
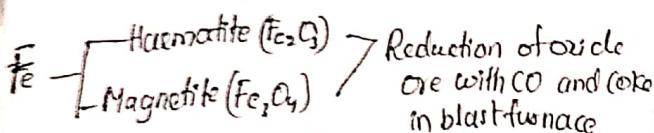
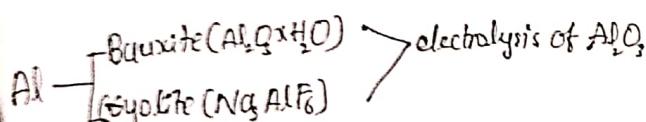
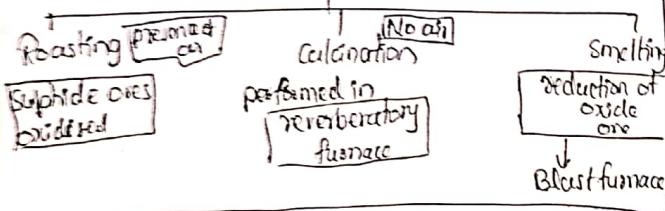
magnetic ore & non

[Magnetite Fe_3O_4]

concentration of ore (process elimination of gangue)



Extraction of crude metal



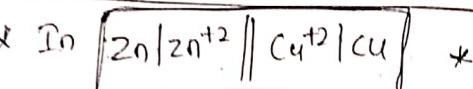
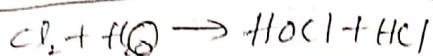
Zinc

- Zinc blende (ZnS)

- Calamine ($ZnCO_3$)

- Zincite (ZnO)

- roasting followed by reduction with smoke



Anode \rightarrow -ve terminal - more oxidized
Cathode \rightarrow +ve term - more reduced

Since Anode is more Oxidation potential,
it acts as reducing agent

$\therefore Zn$ reduces (Cu^{+2})

Cathode is more Reduction potential,

\rightarrow it acts as oxidising agent

Cu oxidises the Zn^{2+} ions

Special Bits

Lightest particle \rightarrow electron

\Downarrow
Position \rightarrow having same mass. of electron

ortho and para hydroxy

methyl benzenes on reaction to form Novalac

Rubber exhibits —
~~plasticity~~, elasticity,

order of orbitals:

\rightarrow based on $(n+l)$

$(n+l) \rightarrow$ lower \rightarrow lowest energy

$(n+l) \rightarrow$ higher \rightarrow higher energy

$n+l \rightarrow$ same \rightarrow consider ' n '

$n \rightarrow$ lower \rightarrow low energy

$m \rightarrow$ high \rightarrow high energy

oxidation number: residual charge on atom/molecule.

Eg: Na^+ \rightarrow O.N = 1

Note:

$\text{O.N} = 0 \Rightarrow$ For stable molecules no charge

F = -1

H = +1

Same group \rightarrow same valency

The pH of 1M KOH = —

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

$$-\log[\text{OH}^-] + \text{pH} = 14$$

$$-\log[1] + \text{pH} = 14$$

$$0 + \text{pH} = 14$$

$$\boxed{\text{pH} = 14}$$

Sulphide ores \rightarrow PbS
(Galena) $\xrightarrow{\text{Zn}}$ ZnS
(Zinc blende)

Special Bits:

Molarity of 9.8% (W/W) solution of H_2SO_4 is $(\rho = 1.2 \text{ g/mL})$.

$$\rho = \frac{\text{mass}}{\text{Volume}} = v = \frac{\text{mass}}{\rho} = \frac{100}{1.2} = 83.33 \text{ mL}$$

$$\frac{98 \times 1000}{1.2} = 1.2 \text{ M}$$

Atmospheric corrosion of metal result
— slow oxidation
compression moulding used for
Thermoplastic & Thermosetting

Polymerised in making optical lens

[PMMA]

Good water will have only High D.O

desalination can be done by desalination

Ship hulls undergo galvanic corrosion

End chain growth polymer = Teflon

Octane number of Alcohol = 90

Lead — cause sterility & loss of memory
in drinking water

Method of separation of tin stone ore

\rightarrow [Magnetic separation]

Ore that is concentrated by floatation

\rightarrow [Chalcopyrite]

Mock Test:

More no. of electrons in n shell $= 2n^2$

More no. of electrons in orbital $= 2(2l+1)$

Graphite \rightarrow covalent crystal

Amphiprotic solvents \rightarrow ROH

water neither attached to cation nor to anion is called lattice water

Anaerobic bacteria consists mon forming a corrosion product \rightarrow FeS.

Atomic weight of Silver \Rightarrow 107.87

Eutrophication means:

Increased productivity of lakes due to nutrient enrichment

Conditioner in froth flotation process -

Sodium carbonate

sodium ethyl xanthate (collecting agent in froth flotation)