GASEOUS STATE

+ <u>Kinetic Molecular Theory of gases :-</u>

⇒ <u>De-Bernauli (1738)</u>

⇒ This theory is named as kinetic molecular theory because any model form explaining the behaviour of gases assumes that, gases consists of molecules which are always in motion.

* Assumptions of Kinetic Molecular theory :-

① ⇒ Gases consists of large no. of spherical, tiny particals called <u>molecules</u>.

② ⇒ <u>Volume of the gas molecule is negligible in comparision to the volume occupied by the gas.</u>

⇒ (Always follow for Ideal gas.
Real gas के लिए विशेष परिस्थिति में सही होती है)

③ ⇒ Gas molecules always move on zig-zag streight line path, during motion they keep on colliding with each other and also will the wall of container.

④ ⇒ Collision of the gas molecule is <u>perfectly elastic</u> i.e. (there are no loss of energy) gas molecules may exchange energy during collision but energy is not converted into any other form like Heat, light, sound etc. (No loss of energy during collision).

⑤ ⇒ <u>Pressure of the gas is due to collision of the gas molecule with the wall of container.</u>

(i)→ There is no interaction between gas molecules or between molecules & wall of container and Motion of the molecules is independent of the presence of other molecules.

(VII)→ Classical law of Motion (Particularily second law of motion) apply to the molecular motion.

(VIII)→ Gravitational Pull have no effect on molecular motion due to Continuous collision.

(IX)→ Kinetic energy of the gas molecule depends upon the absolute temperature of the gas.
(परम ताप)

According to Kinetic Molecular theory :-

$$PV = \frac{1}{3} mNV^2 \qquad -------(1)$$

V = Volume (lit)

m = mass of one molecule

N = No. of molecule (Total)

V = Average velocity of gas.

P = Pressure

1 atm = 1.01325 bar

= 760 torr

= 10^5 N m²

= 10^5 Pascal

= 10^{10} Dyne/cm²

$$PV = \frac{1}{3} \underbrace{mN}V^2$$
Mass of the gas = M

$$PV = \frac{1}{3} MV^2 \qquad -------(11)$$

$$P = \frac{1}{3}\left(\frac{M}{V}\right)V^2$$

$$P = \frac{1}{3} D V^2 \qquad -------(111)$$

* Kinetic energy & Temperature :

$\Rightarrow$ Kinetic energy of one molecule, $E_K = \frac{1}{2} m v^2$

where m = mass of one molecule

v = velocity

Kinetic energy of N molecules, $E_K = m N v^2$ ——— (II)

from Kinetic molecular theory, $PV = \frac{1}{3} m N v^2$

$$PV = \frac{2}{3} \times \frac{1}{2} m N v^2 ——— (III)$$

Compare the equan (II) & (III) -

$$\boxed{PV = \frac{2}{3} \cdot E_K} ——————— (iv)$$

from gas equan $PV = RT$

$$RT = \frac{2}{3} \cdot E_K$$

$$E_K = \underbrace{\left(\frac{3}{2} R\right)}_{\text{constant}} T$$

$$\boxed{E_K \propto T} ——————— (v)$$

Hence, Kinetic energy of gases is directally proportiona to the absolute temp. of the gas.

$\Rightarrow$ Maxwell stated that, Kinetic energy of translatio of Ideal gases does not depends upon the Nature & Pressure of the gas, but it only depends upon the absolute temp. of the gas.

Again $E_K \propto v$ ————— (vi)

Again, $E_k \propto V$ ——————— (VI)

Compairing equa^n (V) & (VI)

$$V^2 \propto T$$

$$\boxed{V \propto \sqrt{T}}$$

Hence, velocity of the gas is the directally proportional to the square root of absolute temp. of the gas. hence, called thermal velocity of molecule.
(Thermal motion)

* **Gas Constant, R :-**

$$R = 0.08206 \text{ Lit. atm. } K^{-1} mol^{-1}$$
$$= 8.314 \text{ Joule } K^{-1} mol^{-1}$$
$$= \cancel{9.76} 1.967 \text{ Cal. } K^{-1} mol^{-1}$$

* **Nature of R :**

$$PV = RT$$

$$R = \frac{PV}{T} = \frac{(Force/Area)(Length)^3}{Temp.} = \frac{Force}{Length^2} \times \frac{Length^3}{Temp.}$$

$$R = \frac{Force \times Length}{Temp.} = \boxed{\frac{Work}{Temp.}}$$

* **Maxwell's distribution of Molecular Velocity :-**

$\Rightarrow$ Due to continuous collision of molecules, velocity of the molecule keeps on changing. The probability the molecules possess velocity between c to $(c + dc)$ is given by.
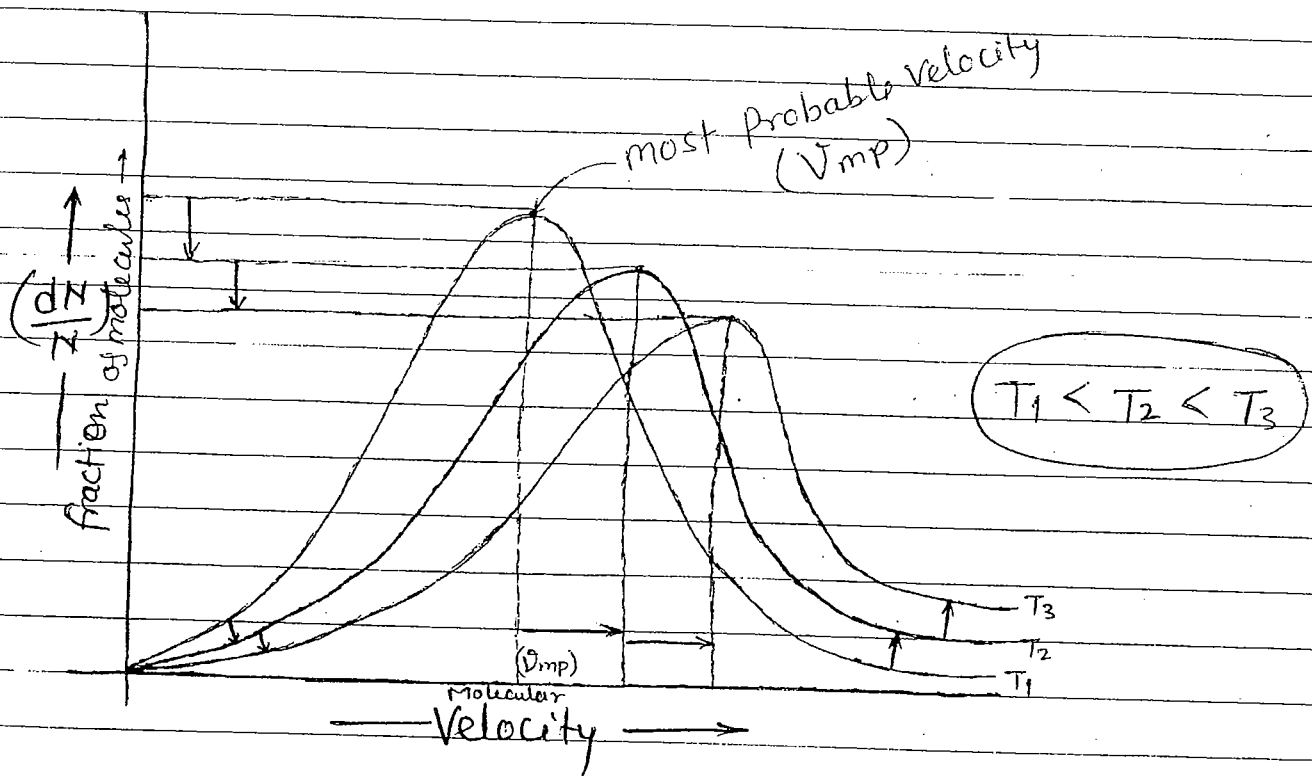
$$P_{(c)}(dc) = 4\pi \left(\frac{m}{2\pi KT}\right)^{3/2} c^2 \exp\left(-\frac{mc^2}{2KT}\right) dc$$

———————— (1)

⇒ This relation was derived by <u>Maxwell (1860)</u>, Hence, Called Maxwell distribution of molecular velocity.

⇒ fraction of the molecules $\frac{dN}{N}$, Passessing velocity between c to c+dc is given as -

$$\frac{dN}{N} = P_{(c)} dc = 4\pi \left(\frac{m}{2\pi RT}\right)^{3/2} c^2 \exp\left(-\frac{mc^2}{2RT}\right) dc$$

———————— (ii)

⇒ The Plot between molecular velocity and fractional molecules possessing that velocity at different temp are as follows.

$\Rightarrow$ fraction of the molecules with very low & very high velocity is very small.

$\Rightarrow$ With increasing velocity fraction of the molecule possessing that velocity increases, reaches to maximum & then decreases to minimum.

$\Rightarrow$ Velocity possessed by most of the molecules is called most probable velocity.

$\Rightarrow$ On increasing temp. most probable velocity increases but the fraction of molecules possessing most probable velocity decreases.

$\Rightarrow$ On increasing temp. fraction of the molecules with lower velocity decreases and those with higher velocity increases.

* Root mean square Velocity, (V_{rms}) :-

n $\circ$	$\longrightarrow$	v_n $\longrightarrow$	v_n^2
6 $\circ$	$\longrightarrow$	v_6 $\dashrightarrow$	v_6^2
5 $\circ$	$\longrightarrow$	v_5 $\longrightarrow$	v_5^2
4 $\circ$	$\longrightarrow$	v_4 $\longrightarrow$	v_4^2
3 $\circ$	$\longrightarrow$	v_3 $\longrightarrow$	v_3^2
2 $\circ$	$\longrightarrow$	v_2 $\longrightarrow$	v_2^2
1 $\circ$	$\longrightarrow$	v_1 $\longrightarrow$	v_1^2

$\Rightarrow$ Root mean square velocity is the square root of mean square velocities.

$$V_{rms} = \sqrt{\overline{v^2}} = \sqrt{\frac{v_1^2 + v_2^2 + v_3^2 + \cdots v_n^2}{N}} \quad --- \text{①}$$

$$PV = \tfrac{1}{3} m N v^2$$

$$PV = \frac{1}{3} m N V^2$$

$$V_{rms} = \sqrt{V^2} = \sqrt{\frac{3PV}{mN}} = \sqrt{\frac{3PV}{M}} = \sqrt{\frac{3P}{D}} = \sqrt{\frac{3RT}{mN}}$$

$$= \sqrt{\frac{3KT}{m}} \quad (\text{if } N = N_A) \quad \underline{\hspace{3cm}} \textcircled{11}$$

$$\boxed{V_{rms} = 1.58 \sqrt{\frac{T}{M}} \times 10^4 \; cm/sec.}$$

T = Temperature

M = molar mass.

* Average Velocity : (Vav or $\bar{V}$) :

⇒ It is the average of various velocities possess by different molecules of the gas.

$$V_{av.} \text{ or } \bar{V} \text{ or } <c> = \frac{V_1 + V_2 + V_3 + \text{--------} + V_n}{N}$$

$$\boxed{V_{av} = \sqrt{\frac{8RT}{\pi m}} = \sqrt{\frac{8KT}{\pi m}}} \qquad K = \frac{R}{N_A}$$

↑ mass of one mole molecule

↑ mass of One molecule

$$\boxed{m \times N_A = M}$$

* Most Probable Velocity , (Vmp.) :-

⇒ The velocity possessed by most of the molecules is called most probable velocity.

$$\boxed{V_{mp} = \sqrt{\frac{2RT}{m}} = \sqrt{\frac{2KT}{m}} = \sqrt{\frac{2PV}{m}} = \sqrt{\frac{2P}{D}}}$$

m = molar mass.

$\boxed{\text{9mp.}}$

* **Comparision of Molecular Velocity :**

Graph: y-axis labeled $\left(\dfrac{dN}{N}\right)$ "fraction of molecule →", x-axis labeled "Molecular Velocity →". Peak point 1 "most Probable velocity", point 2 "Average velocity", point 3 "Root mean square velocity".
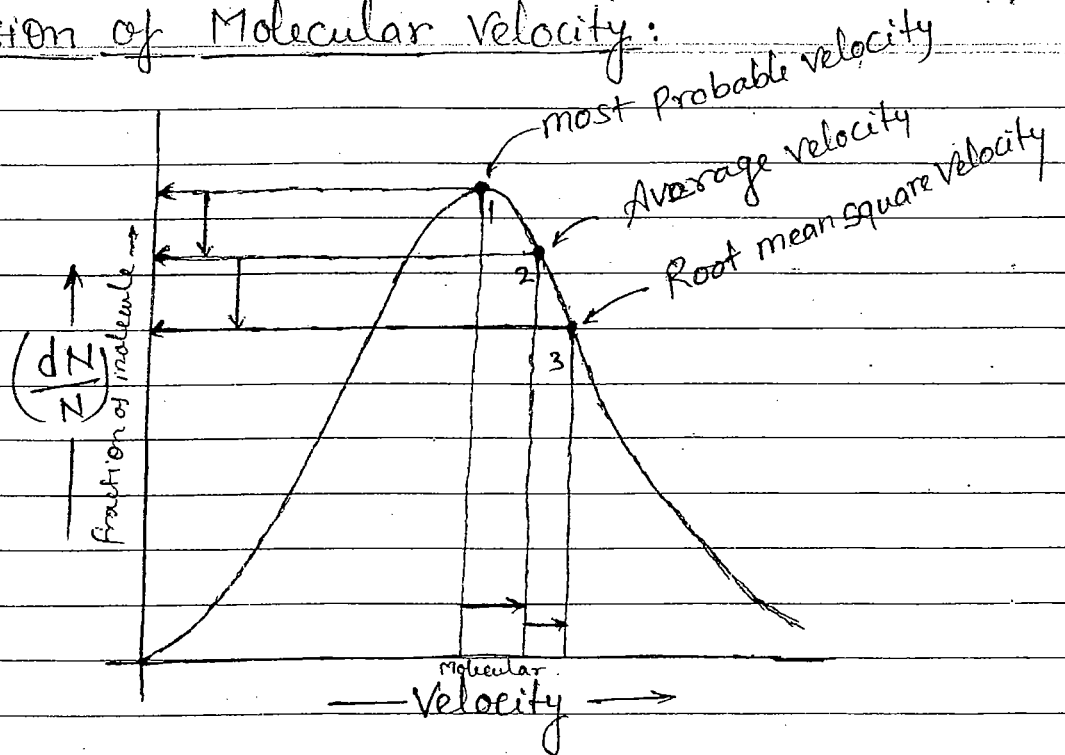
$$V_{rms} = \sqrt{\frac{3RT}{m}} = \sqrt{3}\left(\frac{RT}{m}\right)^{1/2}$$

$$V_{av} = \sqrt{\frac{8RT}{\pi m}} = \sqrt{\frac{2.54\,RT}{m}} = \sqrt{2.54}\left(\frac{RT}{m}\right)^{1/2}$$

$$V_{mp.} = \sqrt{\frac{2RT}{m}} = \sqrt{2}\left(\frac{RT}{m}\right)^{1/2}$$

$$\frac{V_{rms}}{V_{mp}} = \frac{\sqrt{\frac{3RT}{m}}}{\sqrt{\frac{2RT}{m}}} = \sqrt{\frac{3}{2}} = 1.224$$

$$\frac{V_{av.}}{V_{mp}} = \frac{\sqrt{\frac{8RT}{\pi m}}}{\sqrt{\frac{2RT}{m}}} = \sqrt{\frac{8}{2\pi}} = 1.128$$

$\boxed{\text{9mp.}}$
$\dfrac{2004/2011}{PGT}$

$$\boxed{V_{mp} : V_{av.} : V_{rms} = 1 : 1.128 : 1.224}$$

THERMOCHEMISTRY

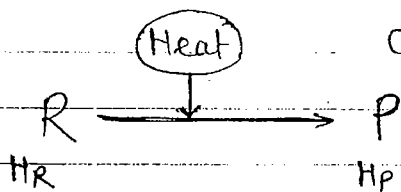* **Exothermic Reaction :** A reaction is said to be exothermic when heat evolve.

$$R \xrightarrow{\text{Heat} \uparrow} P$$
$$H_R \qquad\qquad\qquad H_P$$
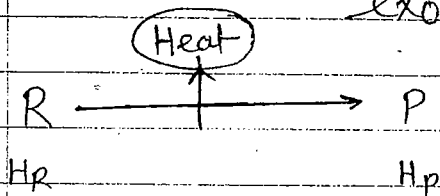
$$H_R > H_P$$

$$\boxed{\Delta H = H_P - H_R = (-)ve}$$

⇒ Exothermic reactions are generally expressed as -

$$A + B \longrightarrow Product + Q$$
$$OR \quad A + B \Longrightarrow Product \; ; \; \Delta H = -Q$$
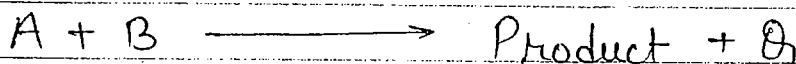
Nuclear reaction always (+)ve
Enthalpy change always (-)ve

* **Endothermic Reaction :** A reaction is said to be endothermic when heat is absorbed.

$$R \xrightarrow{\text{Heat} \downarrow} P$$
$$H_R \qquad\qquad H_P$$

$$H_R < H_P$$

$$\boxed{\Delta H = H_P - H_R = (+)ve}$$

⇒ Endothermic reaction are generally expressed as -

$$A + B + Q \longrightarrow Product$$
$$A + B \longrightarrow Product - Q$$

$$OR \quad A + B \longrightarrow Product ; \; \Delta H = +Q$$
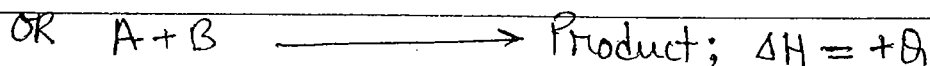
* **Heat of Reaction :** It is the amount of heat evolved or absorbed when quantities of substances indicated by balanced chemical equation have completely converted into product.

e.g. ⇒

1. $CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O \qquad \Delta H = -212 \cdot 99$

   gas   gas   (g)   (l)   KCal.

ii. $2H_2 + O_2 \longrightarrow 2H_2O : \quad \Delta H = -136 \cdot 93$ K.cal

   (g)   (g)   (l)
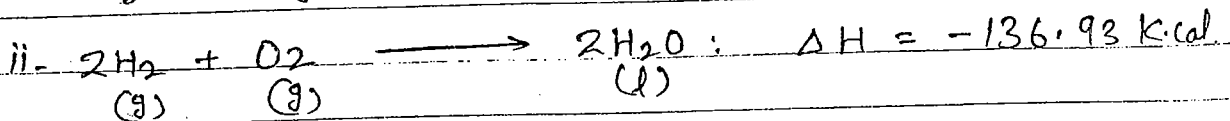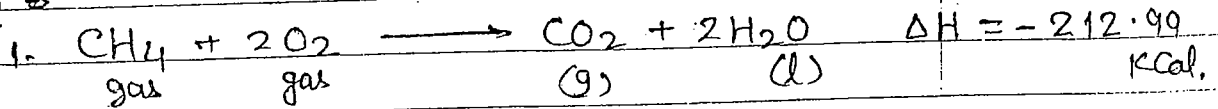
⇒ Heat of Reaction depends upon -

   1. Temperature
   2. Pressure
   3. Physical State of Reactant & Products.

⇒ Heat of Reaction at 1 atm. pressure, 25°c temp. and all the reactants & Products are in their natural state, is called Standard Heat of Reaction.

* **Heat of Reaction at Constant Volume :**

⇒ It is the Change in Internal energy in a chemi-cal reaction.

$$Reactant \longrightarrow Product$$
$$E_R \qquad\qquad\qquad E_p$$
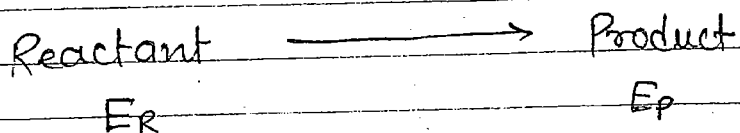
⇒ Change in Internal energy, $\Delta E = E_p - E_R$ ———— (i)

$$\Delta E = q + PdV ———— (ii)$$

from equation (i) & (ii) -

$$\Delta E = q + PdV$$

$$\Delta E = q + PdV$$

At constant volume $q = q_v$, $PdV = 0$

$$\boxed{\Delta E = q_v} \quad \text{---} \quad \text{(III)} \quad \text{Heat of Reaction at constant volume}$$

* **Heat of Reaction at constant Pressure :**

⟹ It is the change in Enthalpy in a chemical reaction.
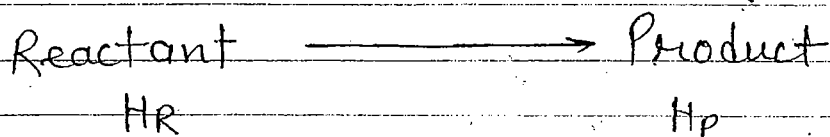
$$\text{Reactant} \longrightarrow \text{Product}$$
$$H_R \qquad\qquad\qquad H_p$$

$$\Delta H = H_p - H_R \quad \text{---} \quad \text{①}$$

But. $\Delta H = \Delta E + P\Delta V \quad \text{---} \quad \text{②}$

$\Delta E = q - P\Delta V$

$q = \Delta E + P\Delta V \quad \text{---} \quad \text{(III)}$

} Compaire

$$\boxed{\Delta H = q_p} \quad \text{---} \quad \text{(IV)}$$

Heat of reaction at constant Pressure.

* **Relation between ΔE & ΔH :**

$$\Delta H = \Delta E + PdV \quad \text{---} \quad \text{①}$$

$$PV = nRT$$

$$PdV = \Delta n RT \quad \text{---} \quad \text{②}$$

Comparing equⁿ ① & ②.

$$\boxed{\Delta H = \Delta E + \Delta n_g RT} \quad \text{---} \quad \text{(III)}$$

Where $\Delta n_g = \begin{bmatrix} \text{no. of moles of gasious product} - \text{no. of moles of} \\ \text{gasious reactant} \end{bmatrix}$

$\Rightarrow$ When reaction occurs in a closed vessel, PdV=0

$$\boxed{\Delta H = \Delta E}$$

$\Rightarrow$ When Reactants & Products are in solid or liquid state, there is no appreciable change in volume.

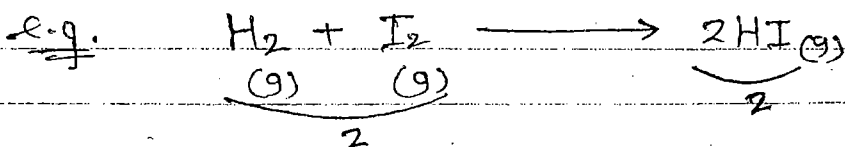$$PdV = 0$$

$$\boxed{\Delta H = \Delta E}$$

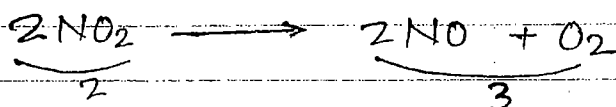$\Rightarrow$ When no. of moles of Reactants & Products are same.-

$$n_R = n_P$$

$$\Delta n_g = 0$$

$$\Delta H = \Delta E + \underbrace{\Delta n RT}_{=0}$$

$$\boxed{\Delta H = \Delta E}$$

e.g. $\underset{\underbrace{(g)\quad(g)}_{2}}{H_2 + I_2} \longrightarrow \underset{\underbrace{}_{2}}{2HI_{(g)}}$

$\Rightarrow$ When $\Delta n_g = (+)ve$.-

$$\underset{\underbrace{}_{2}}{2NO_2} \longrightarrow \underset{\underbrace{}_{3}}{2NO + O_2}$$

$$\Delta n_g = 3-2 = +1$$

$$\boxed{\Delta H = \Delta E + RT}$$

$$\boxed{\cancel{\Delta H - \Delta E = RT}} \quad \boxed{\Delta H - RT = \Delta E}$$

$$\boxed{\Delta H > \Delta E}$$

$\Rightarrow$ When $\Delta n_g = (-)ve$

$$2NO + O_2 \rightleftharpoons 2NO_2$$

$\underbrace{}_{3} \qquad \underbrace{}_{2} \qquad \Delta n_g = 2 - 3 = -1$
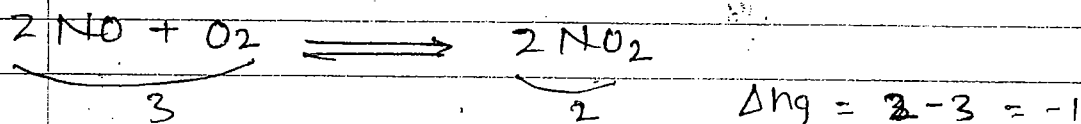
$$\boxed{\Delta H = \Delta E - RT}$$

$$\boxed{\Delta H + RT = \Delta E}$$

$$\boxed{\Delta H < \Delta E}$$

* **Enthalpy of formation : $(\Delta_f H / \Delta H_f)$:-**

$\Rightarrow$ It is enthalpy change, accompanying the formation of one mole of the compounds from it is elements.

* **Standard enthalpy of formation (ΔH_f°) :-**

$\overbrace{}^{H_R^\circ}$

$$\underset{\text{graphite}}{C} + \underset{\text{(gas)}}{O_2} \longrightarrow \underset{\underbrace{}_{H_P}}{CO_{2\ (g)}}$$
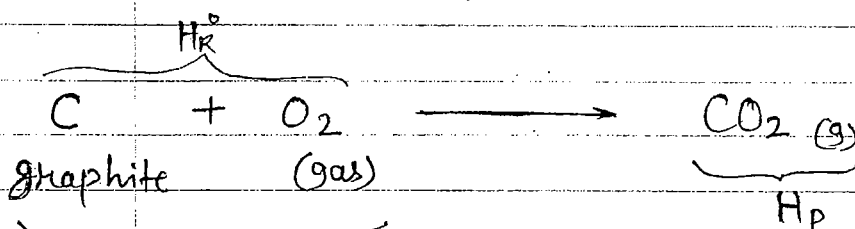
free element in their
Natural form their
enthalpy is taken as
Zero at 25°c and 1 atm.

$\Delta_f \overset{\circ}{H} = \overset{\circ}{H_P} - \underset{=0}{\overset{\circ}{H_R}}$

$$\boxed{\Delta H_f^\circ = H_P^\circ}$$

$\Rightarrow$ The enthalpy of free element at 25°c and one atm. pressure are taken Arbitrarily as <u>zero</u>.

→ The enthalpy of compounds obtained under these conditions then becomes identical with their standard enthalpy of formation.

$$H_2 + \tfrac{1}{2} O_2 \rightleftharpoons H_2O$$

$$\underbrace{(g) \qquad (g)}_{H_R^\circ = 0} \qquad \underbrace{(liqu.)}_{H_P^\circ}$$
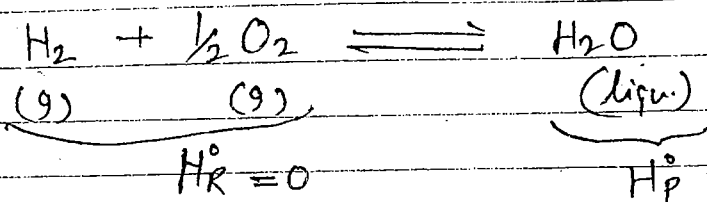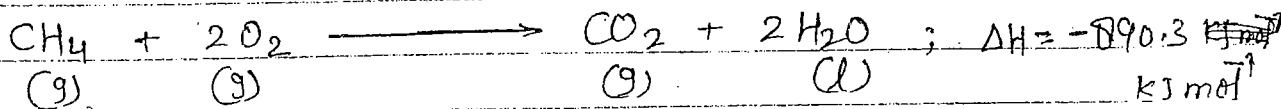
$$\Delta H_f^\circ = H_P^\circ - \underbrace{H_R^\circ}_{=0}$$
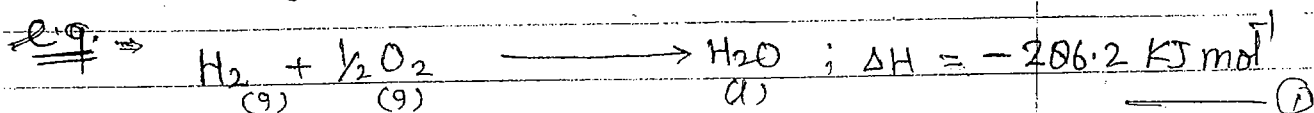
$$\boxed{\Delta H_f^\circ = H_P^\circ}$$

14/08

* Enthalpy of Combustion :⇒

⇒ It is the enthalpy change accompanying the complete combustion of 1 mole of any substance at that temp.

e.g:-

$$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O \quad ; \quad \Delta H = -890.3 \ \cancel{kJmol} \ kJ\,mol^{-1}$$
$$(g) \qquad (g) \qquad\qquad (g) \qquad (l)$$

$$H_2 + \tfrac{1}{2}O_2 \longrightarrow H_2O_{(l)} \quad ; \quad \Delta H = -286.2 \ kJ\,mol^{-1}$$
$$(g) \qquad (g)$$
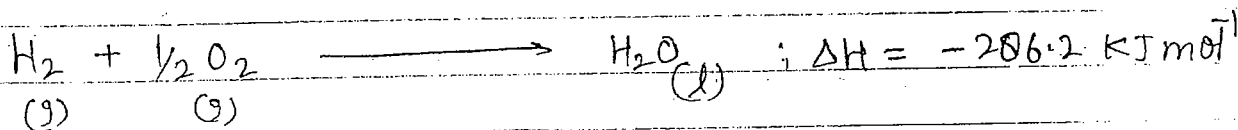
⇒ Enthalpy of combustion depends upon the physical state of the substance involved.

e.g ⇒

$$H_{2(g)} + \tfrac{1}{2}O_{2(g)} \longrightarrow H_2O_{(l)} \quad ; \quad \Delta H = -286.2 \ kJ\,mol^{-1} \qquad —— ①$$

$$H_{2(g)} + \tfrac{1}{2}O_{2(g)} \longrightarrow H_2O_{(Vap.)} \quad ; \quad \Delta H = -245.5 \ kJ\,mol^{-1} \qquad —— ②$$

Substracting equa^n ② from ① —

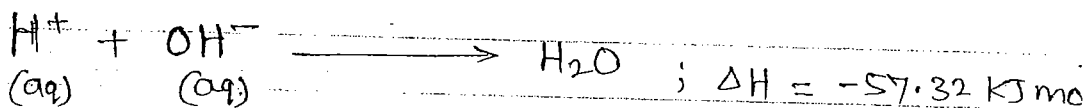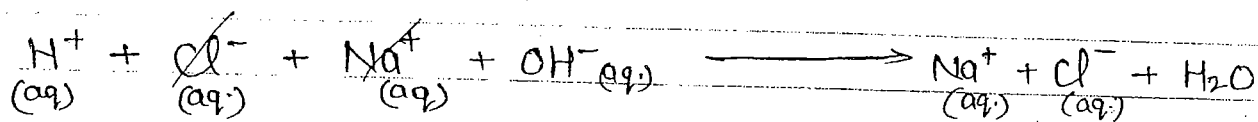$$H_2O_{(l)} \longrightarrow H_2O_{(vap)} \; ; \; \Delta H = -40.7 \; KJ\,mol^{-1}$$
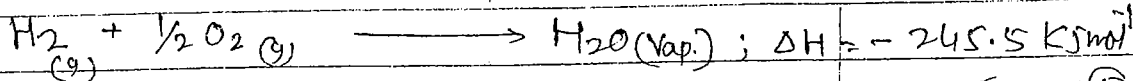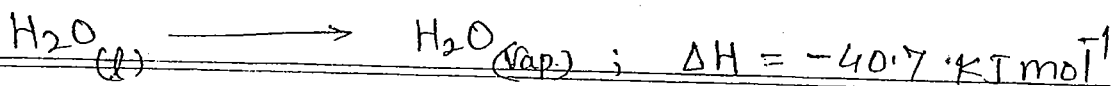
This is the heat of vapou- sation.

* Enthalpy of Neutralisation :⟹

It is the enthalpy change accompanying the neutralisation of 1 gram equivalent of the acid by base In dilute solution.

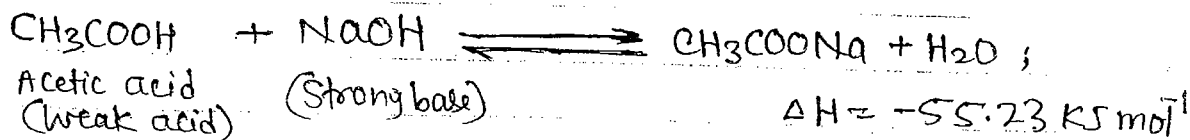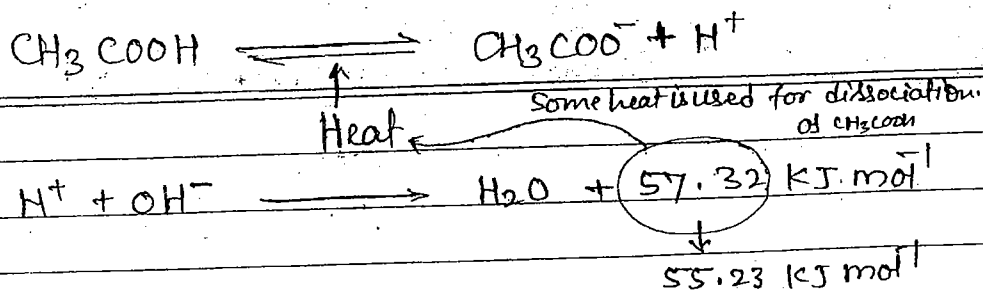$$HCl_{(aq.)} + NaCl_{(aq.)} \longrightarrow NaCl_{(aq)} + H_2O \; ;$$
$$\Delta H = -57.32 \; KJ\,mo$$

But in aquoous Solution-

$$H^+_{(aq)} + Cl^-_{(aq.)} + Na^+_{(aq)} + OH^-_{(aq.)} \longrightarrow Na^+_{(aq.)} + Cl^-_{(aq.)} + H_2O$$

$$H^+_{(aq)} + OH^-_{(aq)} \longrightarrow H_2O \; ; \; \Delta H = -57.32 \; KJ\,mo$$
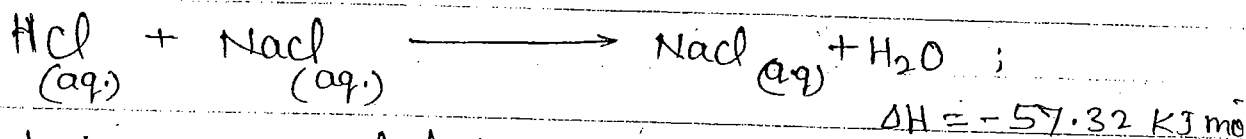
⟹ Thus in every case of Neutralisation, it involve the Combination of H^+ & OH^- ions to form H_2O, therefore, Heat of Neutralisation for stron acid and strong base is always same.

⟹ In case of weak acid or weak base, heat of neutralisation is less than $57.32 \; KJ\,mol^{-1}$, because Certain heat is being used up in the dissociation of weak acid or weak base.

e.g.

$$\underset{\substack{\text{Acetic acid} \\ \text{(weak acid)}}}{CH_3COOH} + \underset{\text{(Strong base)}}{NaOH} \rightleftharpoons CH_3COONa + H_2O \; ;$$
$$\Delta H = -55.23 \; KJ\,mol^{-1}$$

$$CH_3COOH \rightleftharpoons CH_3COO^- + H^+$$

Heat $\longleftarrow$ Some heat is used for dissociation of CH_3COOH

$$H^+ + OH^- \longrightarrow H_2O + \boxed{57.32} \text{ KJ mol}^{-1}$$

$$\downarrow$$

$$55.23 \text{ KJ mol}^{-1}$$

$$\Delta H_{diss.} = -57.32 - (-55.23)$$

$$= -(57.32 + 55.23)$$

$$\boxed{\Delta H_{diss.} = -2.09 \text{ KJ mol}^{-1}}$$

* Law of Thermochemistry ⇒

① Lavoisier & Laplace Law ⇒

Lavoisier & Laplace (1780), stated that, "the amount of Heat supplied to decompose a compound into its element is equal to the heat of formation of that compound from its elements."

(−) Heat of formation = (+) Heat of decomposition

(+) Heat of formation = (−) Heat of decomposition.

$$C_{(graphite)} + O_{2(g)} \longrightarrow CO_{2(g)} \; ; \; \Delta \overset{\circ}{H} = -94.3 \text{ Kcal mol}^{-1}$$

$$CO_{2(g)} \longrightarrow C_{(graphite)} + O_{2(g)} \; ; \; \Delta \overset{\circ}{H} = +94.3 \text{ Kcal mol}^{-1}$$
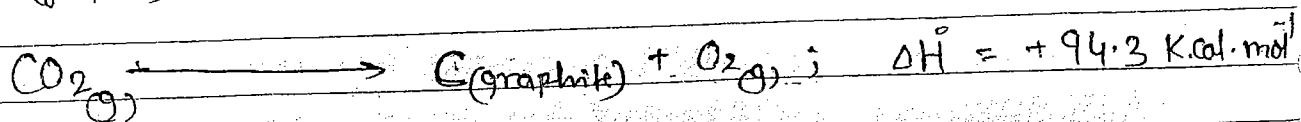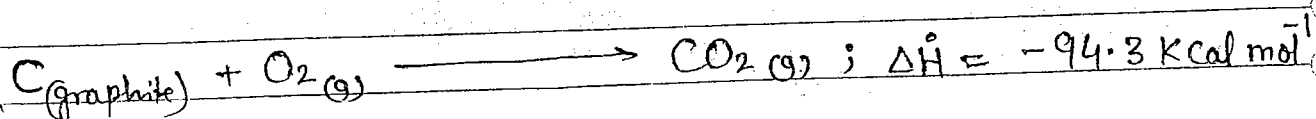
* Daltons Atomic Theory :

Atom - Indivisible   Dalton → Atom.

Daltons atomic theory for the "Structure of matter is based on the law of Conservation of mass (Lavoisier - father of modern chemistry) & law of Definite proportion (Proust).

⇒ As a consequence of atomic theory of matter, Dalton propose the "law of multiple proportion."

⇒ According to Dalton -

① Matter consists of very small, indivisible, indestructible, and structureless particles called Atom.

⑪ All the atoms of an elements are identicle in their properties.

Isotopes → Atoms of the same elements.

e.g. Hydrogen → Protium, $_1H^1$
Deuterium, $_1D^2$ } → Stable isotope
Tritium, $_1T^3$] → Radioisotope - β-emitter
$$_1H^3 \longrightarrow \ _2He^3 + \beta$$
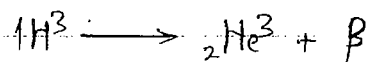
H_2O → Solid H_2O float over the water. Hence.
$_1H^1$ - Ordinary Hydrogen.

D_2O → Solid D_2O sink in water, Hence, D_2O - Heavy water
$_1D^2 \longrightarrow$ Heavy Hydrogen.

⑪⑪ Atoms of different elements have different properties

(IV) Atoms of Same or different elements combine in definite proportion to give Compound atom (called molecule by Avogadro)
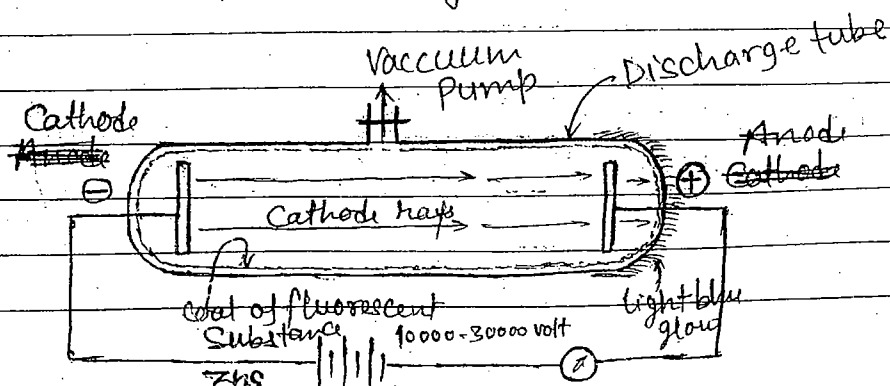
(V) Atoms retain their properties in the compound atoms.

$$H_2 \quad + \quad O_2$$

→ gas   → gas
→ Inflamable   → Support combustion

(H₂)   (O₂)

(H₂O)

→ Liquid
→ Non-imflamable
→ Does not support Combustion
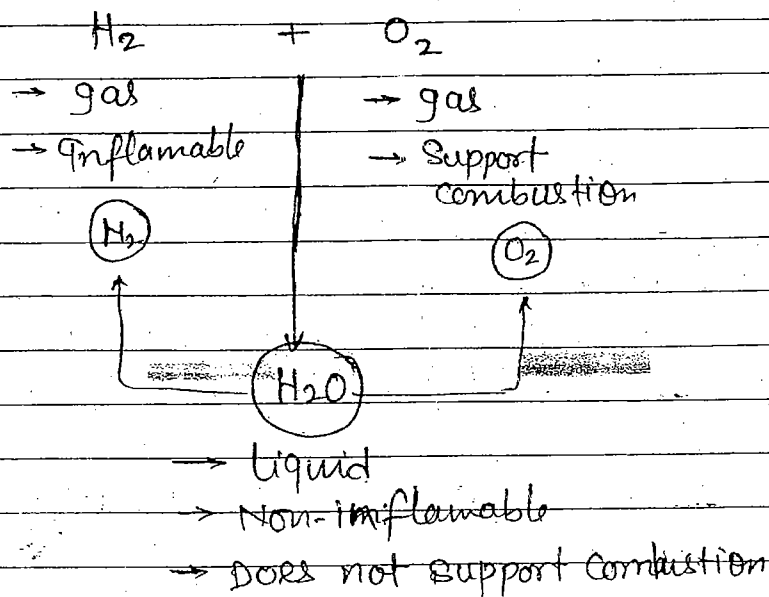
* <u>Cathode rays : Discovery of Electron :→</u>

⇒ Julius Plucker & William crooks
   conduction of electricity through atmospheric gases under reduced pressure.

⇒ J.J. Thomsons - Discharge tube experiment.

Vaccuum Pump — Discharge tube
Cathode   Anode
Anode   Cathode
⊖   ⊕
            Cathode rays
coat of fluorescent   light blue
Substance   10000-30000 volt   glow
ZHS

$P = 760 \text{ mm Hg} \rightarrow$ No conduction of Current
No lighting in the tube

$P = 10^{-2} - 10^{-3} \text{ mm Hg} \rightarrow$ Conduction of electricity
$\rightarrow$ Lighting in the tube

$P = 10^{-3} \text{ to } 10^{-4} \text{ mm Hg} \rightarrow$ Conduction of electricity
$\rightarrow$ No lighting in the tube, but light
blue glow on the wall of
$\rightarrow$ discharge tube behind anode.

$\Rightarrow$ J.J. Thomson, while repeating the experiment of Julius plucker & William pt. Crooks, observed that Certain invisible rays travel from Cathode to Anode & Causes light blue glow on the wall of discharge tube behind anode, these rays were Called Cathode rays, because, they travel from Cathode to Anode.

* <u>Origin of Cathod rays</u> :
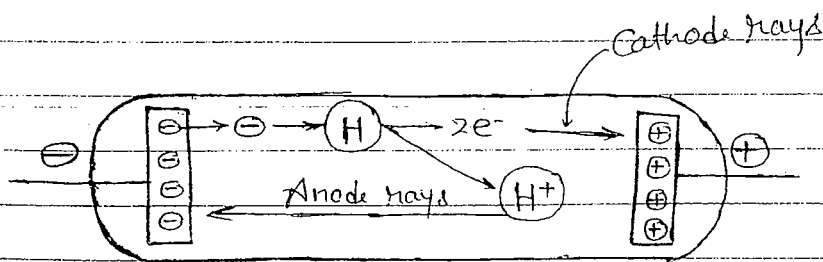
$\Rightarrow$ <u>Cathode rays arise from the surface of cathode</u>
$\Rightarrow$ <u>Anode rays arise due to ionisation of gases filled in the discharge tube.</u>

* Properties of Cathode Rays :-

⇒ Studied by J.J. Thomson.

⇒ Travell in straight line, with the velocity about $(1/10)^{th}$ of the velocity of light.

⇒ Cathode rays passes momentum & Kinetic energy.

⇒ They diflect in electric and magnetic field, in electric field diflection towards (+)ve plate indicates the presenc of (-)ve charge on Cathode rays.

⇒ Ionise the gases to which they pass, reducing affect on chemical reaction.

⇒ Produce X-rays when allowed to fall on heavy metals.

⇒ Blackening effect on photofilm.

⇒ Penetrate thin sheat of metals.

* Nature of Cathode rays :⇒

(i) Cathode rays consists of fast moving negatevely charged, mass particle called Negetron by J.J. Thomson.

⇒ On the basis of electromagnetic properties, Stoney suggest the name electron & Lorentz gave the name electron to this properties.

(ii) Nature of Cathode rays does not depends upon any factor.

(iii) Specific charge (e/m) −

⇒ Determined by J.J. Thomson.

Cathodi rays

$F = \dfrac{mv^2}{r}$

N

S

$F = evB$

Charge Velocity Intensity of magnetic field

glow

$e = charge$

$v = velocity$

$B = intensity\ of\ magnetic\ field$
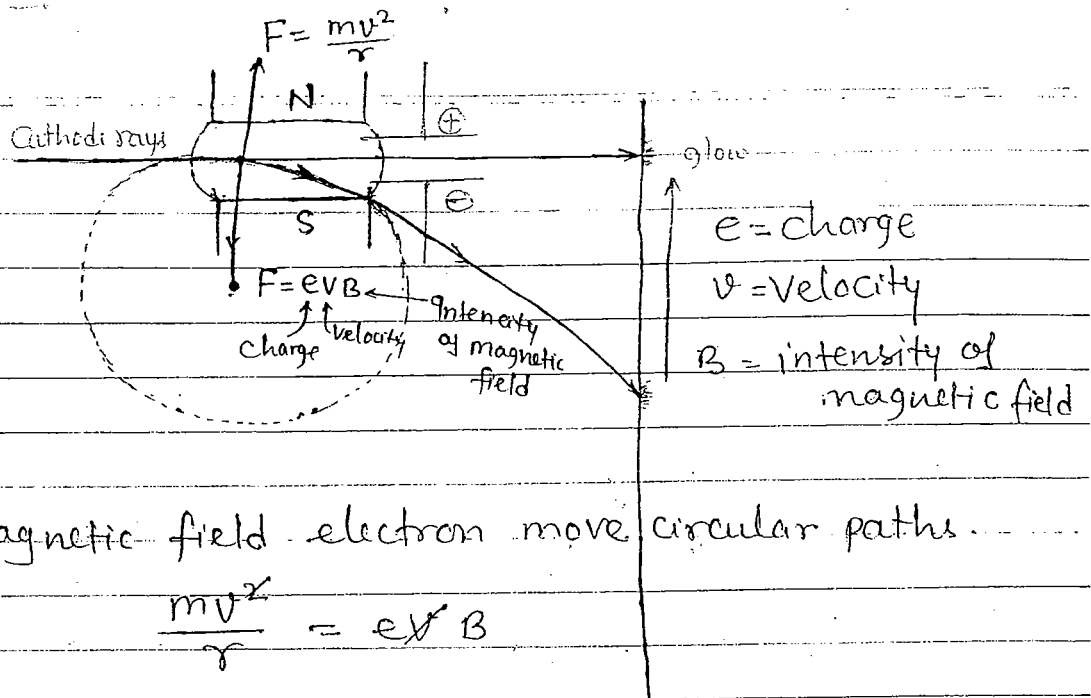
⇒ In magnetic field electron move circular paths.

$$\dfrac{mv^2}{r} = evB$$

$$\dfrac{e}{m} = \dfrac{v}{rB} \quad\quad\quad ─── ①$$

⇒ Now apply electric et field in opposite direction to magnetic field, when Electric force Cancle the magnetic force on electron, then the glow come back to its original point.

$$eE = evB$$

$$ev = \dfrac{E}{B} \quad\quad\quad ─── ⑪$$

from equⁿ ① & ⑪

$$\boxed{\dfrac{e}{m} = \dfrac{v}{rB} = \dfrac{E}{rB^2} = 1.759 \times 10^{8}}\ Coulomb/gm.$$

$── ⑪⑪$

(IV) Charge on electron :-

$\Rightarrow$ Determined by R.A. Mullikan with the help of his famous "Oil drop experiment".
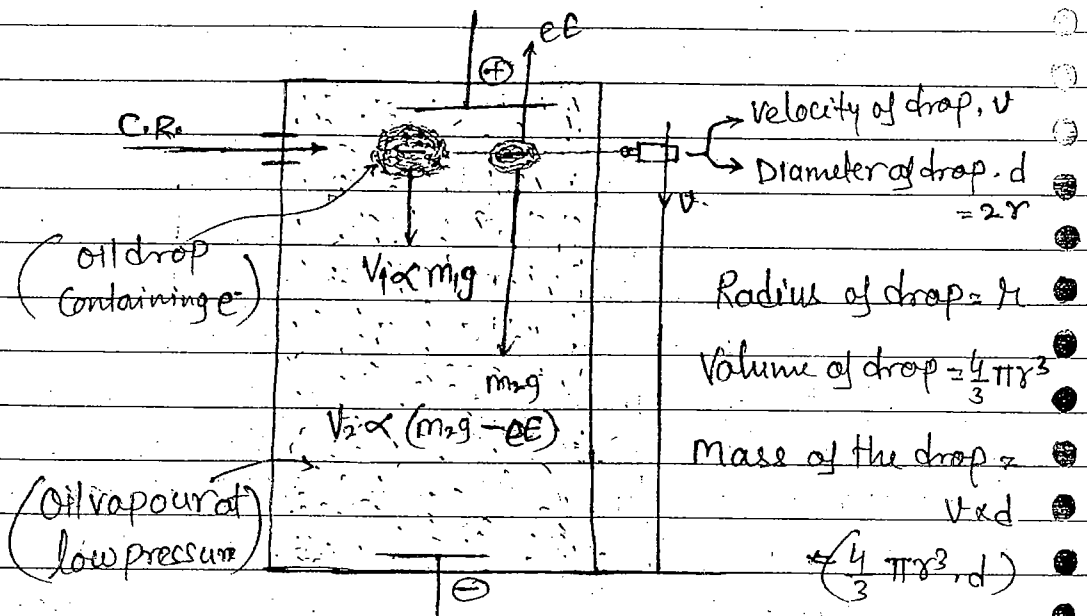
$\Rightarrow$ $V_1 \propto m_1 g$

$V_2 \propto (m_2 g - eE)$

$\Rightarrow \dfrac{V_2}{V_1} = \dfrac{m_2 g - eE}{m_1 g}$

$\Rightarrow \dfrac{V_2}{V_1} m_1 g = m_2 g - eE$

$\Rightarrow eE = m_2 g - \dfrac{V_2}{V_1} m_1 g$

$e = \dfrac{\left(m_2 - \dfrac{V_2}{V_1} m_1\right) g}{E} = 1.602 \times 10^{-19} \text{ coulomb}$

Labels in figure:
- C.R.
- oil drop (containing e⁻)
- oil vapour at low pressure
- $V_1 \propto m_1 g$
- $m_2 g$
- $V_2 \propto (m_2 g - eE)$
- eE
- velocity of drop, v
- Diameter of drop. $d = 2r$
- Radius of drop = r
- Volume of drop = $\frac{4}{3}\pi r^3$
- Mass of the drop $= v \times d$ $\left(\frac{4}{3}\pi r^3, d\right)$

* Mass of electron :

Specific charge $(e/m) = \dfrac{E}{r B^2} = 1.759 \times 10^8$ coulomb/gm.

Charge on electron $(e) = 1.602 \times 10^{-19}$ coulomb

$$\dfrac{\text{Charge}}{\text{Specific charge}} = \dfrac{e}{e/m} = m = \dfrac{1.602 \times 10^{-19} C}{1.759 \times 10^8 C/g}$$

$$= 9.108 \times 10^{-28} \text{ gm.}$$
$$= 9.108 \times 10^{-31} \text{ Kg.}$$

⟹ This mass of electron is called Rest mass of electron, it is calculated by assuming that the velocity of electron is less than the velocity of light.

⟹ Relative mass of electron is related with the rest mass by the relation,

$$\text{Relative mass of electron}, (m_r) = \dfrac{\text{Rest mass of electron } (m_0)}{\sqrt{\left(1 - \dfrac{v^2}{c^2}\right)}}$$

$$\boxed{m_r = \dfrac{m_0}{\sqrt{\left(1 - \dfrac{v^2}{c^2}\right)}}}$$ — If $v \to c$ then
Relative mass of $e^- = \infty$

⟹ When velocity of ~~light~~ particle approches the velocity of light, mass of the particle disappears and charge into energy by the equation -
$$E = mc^2$$

⟹ Mass of one mole of $e^- = 9.108 \times 10^{-31}$ Kg $\times 6.022 \times 10^{23}$
$$= 5.5 \times 10^{-7} \text{ Kg.}$$

* Size of electron :-

$\Rightarrow$ Energy of electron $= \dfrac{e^2}{r}$ ①

$\Rightarrow$ If mass of the electron is considered to be electromagnetic in origin, then - $E = mc^2$ ⑪

$\dfrac{e^2}{r} = mc^2$

$\Rightarrow r = \dfrac{e^2}{mc^2} = 2.8 \times 10^{-15}$ meter

$= 2.8 \times 10^{-13}$ cm.

$\Rightarrow$ Radius of atom is of the order of 10^{-10} mtr.

* Positive rays / Canal Rays / Anode Rays / Discovery of Proton :-

e & C.R $\Rightarrow$ J.J. Thomson

P & A.R. $\Rightarrow$ (Goldstein) & (Rutherford.)

            ↓   ↓

       Anode Rays   Proton.

       fast moving cation

$\Rightarrow$ Credit for the discovery of Proton goes to both Goldstein & Rutherford.

Cathode ⊖   ⊕ Anode

Purforated.
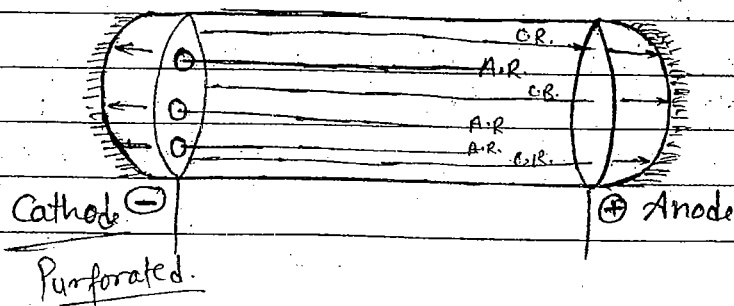
*. Structure of Protein

① Primary structure of Protein ⟹

⟹ It refers to the sequence in which the various amino acids present in the protein are link to the one an other.

⟹ The first ever primary structure of Protein i.e., insuline was determined by British chemist Fraderic Sanger and for this work he was awarded Noble price in 1958.
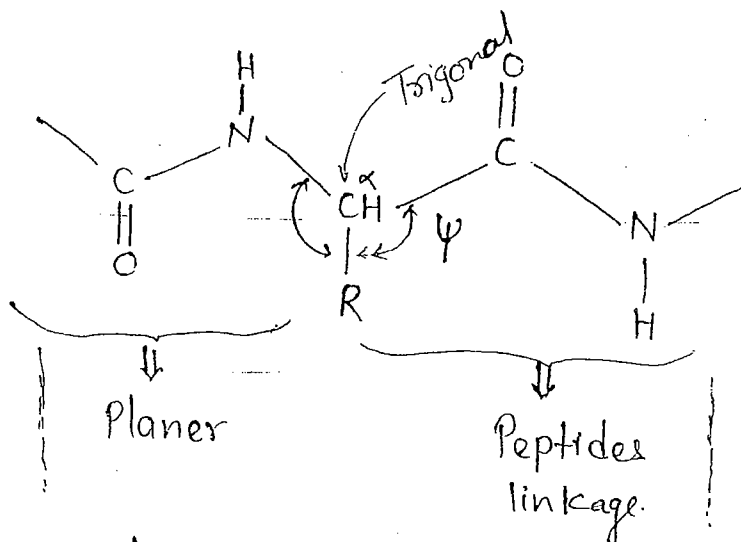
The angle ϕ & ψ are called Ramachandran Angle after the name of Indian bio physicist G.N.A. Ramachandran.

(ii) Secondary Structure of Protein ⇒

⇒ The Confermation which polypeptide chain assume as a result of <u>Hydrogen bonding</u> is called the <u>secondary structure</u>.

⇒ Depending upon the size of <u>-R</u> at α-Carbon the following two different structures are Possible—

(a) α-Helix Structure ⇒

⇒ Pastulated by <u>Linus Pauling</u> (1951).

$$-N-\overset{R}{\underset{H}{\underset{|}{\overset{|}{C}}}}H-\overset{}{\underset{O}{\overset{|}{C}}}\Big|\overset{H}{\underset{|}{N}}-\overset{R}{\underset{2}{\overset{|}{C}}}H-\overset{}{\underset{O}{\overset{|}{C}}}\Big|\overset{H}{\underset{}{N}}-\overset{R}{\underset{3}{\overset{|}{C}}}H-\overset{}{\underset{O}{\overset{|}{C}}}\Big|\underset{H}{N}-\overset{R}{\underset{4}{\overset{|}{C}}}H-\overset{}{\underset{O}{\overset{|}{C}}}-$$
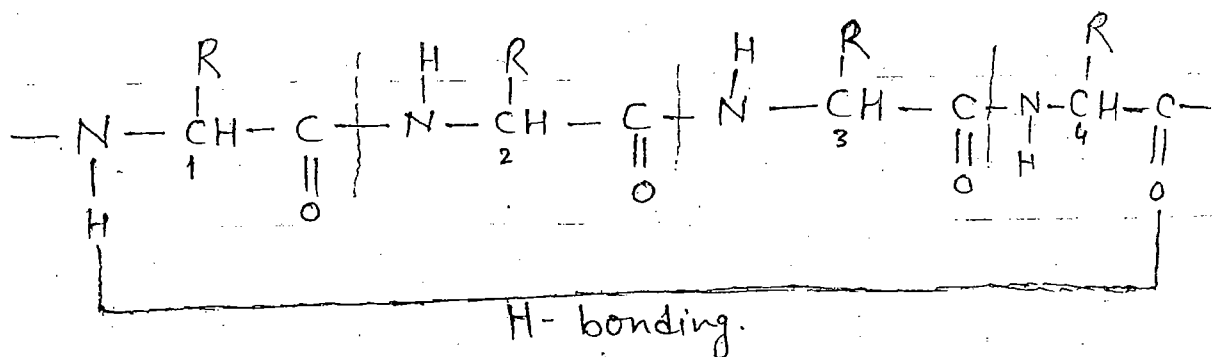
H- bonding.

⇒ If size of -R group is quite Large, the hydrogen bond (<u>Intramolecular</u>) are formed between the <u>>C=o of one amino acid</u> & <u>NH of the fourth amino acid residue in the chain</u>.

⇒ This causes the polypeptide chain to coiling into a spiral structure called right handed α-helix structure.

⇒ The α-helix is also known as 3.6_{13} helix since, each turn of the helix has approximataly 3.6 amino acid and a 13-membered ring is formed by hydrogen bond.
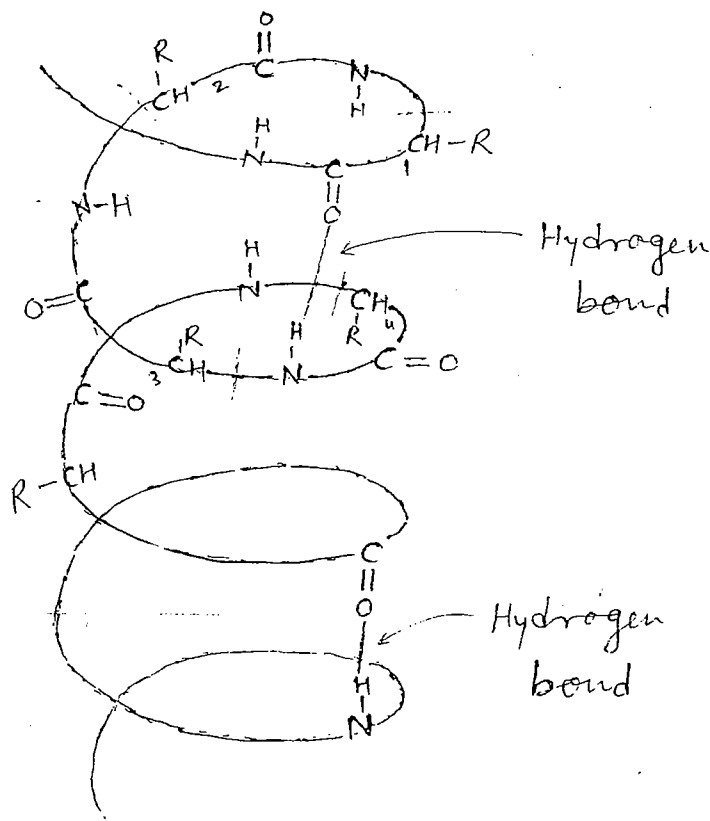
⇒ The helical structure of Protein is always right handed i.e., a polypeptide chain turn in the clockwise direction.

(b) <u>β- flat Structure</u> or <u>β- pleated Sheet Structure</u>
or <u>Simple β- Structure</u> ⇒

⇒ The Polypeptide chain stretched out to maximum extent and then held side by side by <u>inter molecular hydrogen bonding.</u>

Intermolecular Hydrogen bond

वालों में Coiling के कारण Disulphide bond.

वालों के जलाने पर जली का कारण Sulphur होता है

(Sulpher containing)

<u>Parallel Structure</u>
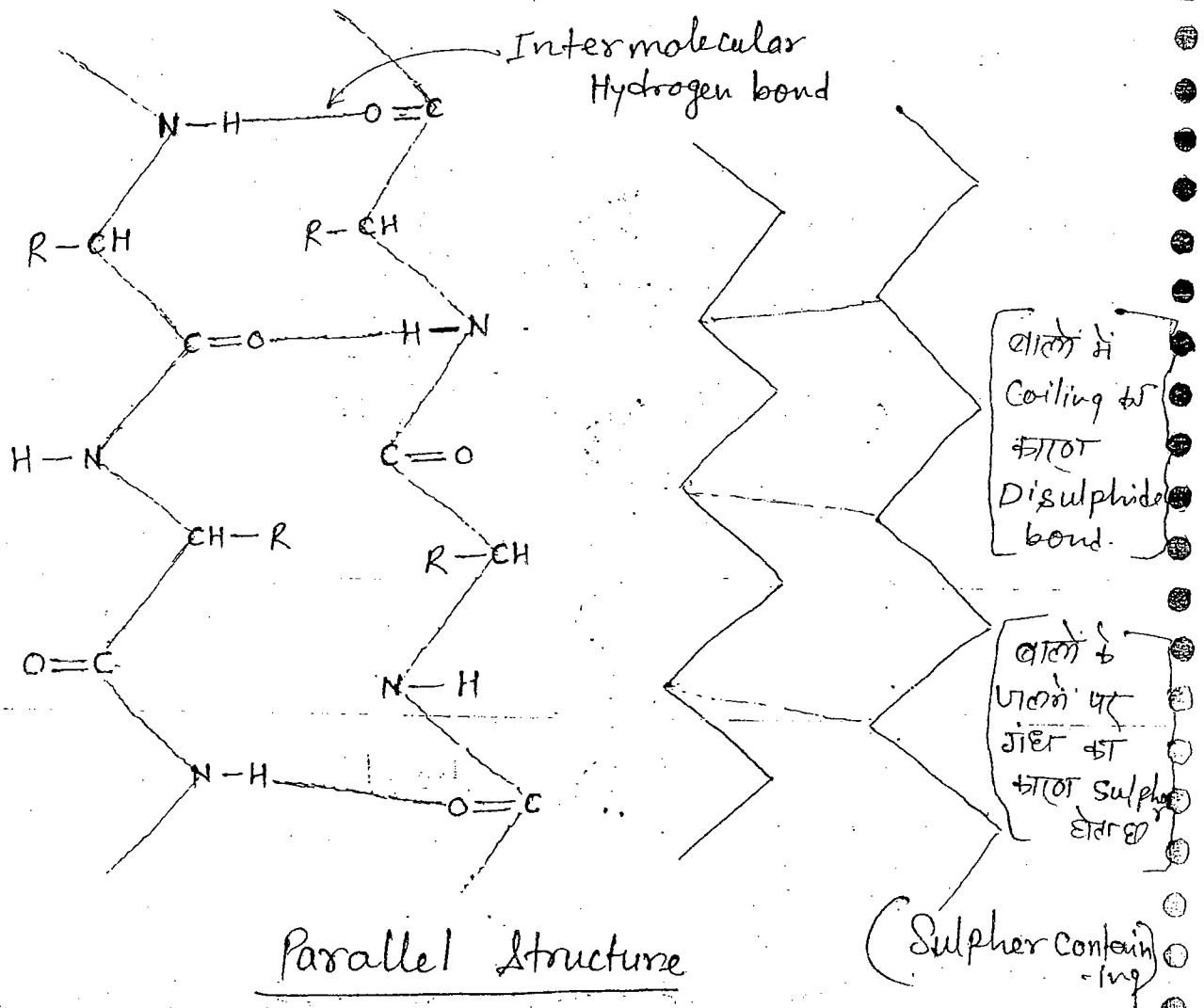
e.g. <u>Keratin - Parallel- β- Sheet Structure</u>
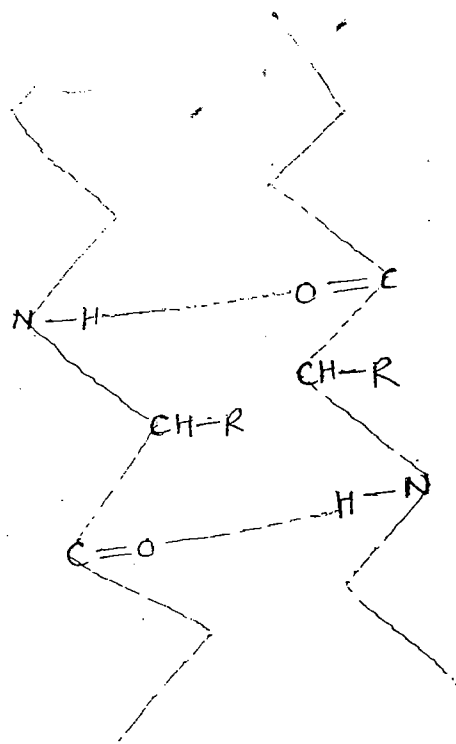
$\Rightarrow$ Fibrion - antiparallel
  - β - Sheet Structure.

Anti parallel Structure

$\Rightarrow$ A protein may or may not have the Secondary Structure through out its length. i.e. Secondary Structure is a local Structure

$\Rightarrow$ Some part of a protein may have α-helix Structure, other may have β - pleated Sheet Structure. Some part even may have no Secondary Structure at' all, Such Structure are called Random coil / Random Structure.

(iii) Tertiary Structure of Protein ⇒

⇒ It refers to complete three-dimentional structure i.e. the manner in which entire protein molecule fold up in the three-dimentional space to produce a specific shape.

⇒ Shape of protein is specified to a given amino acid sequence and is called Native shape of the protein, thus, Primary structure of protein dictates its tertiary structure.

⇒

(iv) Quaternary Structure ⇒

⇒ It refers to the determination of the no. of subunits and their arrangement in an agreable protein molecule.

e.g. ⇒ Haemoglobin is an aggregate of four Polypeptide chain or subunits.

⇒ Two identical α-chain (each containing 141-amino acids residue) and Two identical β-chain (each containing 146 amino acids).

* Denaturation of Protein *

⇒ Protein are very sensitive to heat and p^H changes on heating protein coagulates. The coagulated protein are called denaturated protein.

⇒ Chemical denaturation does not changes the primary structure but bring about the change in secondary and tertiary structure of protein.

⇒ In case of enzyme process is reversible, are the reverse process is called renaturation.

* Nuclic Acid *

Nuclic acid constitute nucleoprotein i.e., protein containing nuclic acid as prosthetic group.

e.g: Coagulation of albumin present in egg.

↓

Boiling of egg

↓

Entropy increases

⇒ Composition of Nuclic acid on hydrolysis nuclic acid give three types of components.

   i - phosphoric acid
   ii - Sugar
   iii - Nitrogenous Base

* Sugar *

Two sugar have been isolated i.e., ~~D(-)~~ D(-)·Deoxy ribose & 2- Deoxy-D·(-)-Ribose both are found in furanose form.
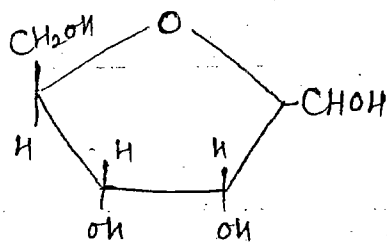
D(-)·Ribose
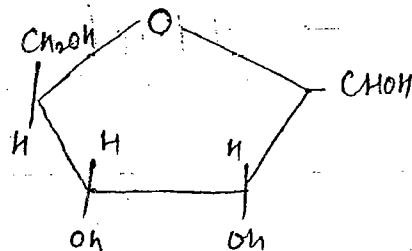
2- Deoxy D (-) ribose

Base ⇒

① Purines - Most commonly found in nuclic acid are-
           ⇒ Adenine (A)
           ⇒ Guanine (G)

* Nitric Acid, HNO_3 :

Manufacture :

(A) Ostwald process :

⟹ This process involve Catalytic oxidation of ammonia by atmospheric oxygen.

$$4 NH_3 + 5O_2 \xrightarrow{Pt} 4 NO + 6 H_2O$$

$$2 NO + O_2 \longrightarrow 2 NO_2$$

$$4 NO_2 + O_2 + 2 H_2O \longrightarrow 4 HNO_3$$
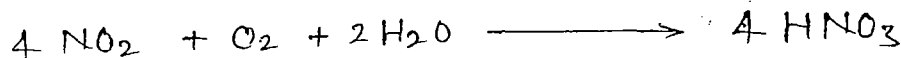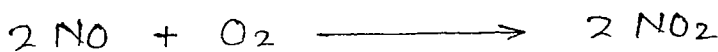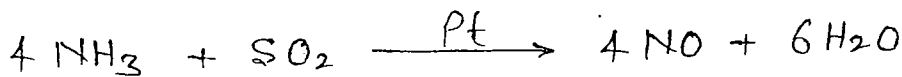
⟹ The various part and the reaction occuring are -

① Catalyst chamber (Converter) :

Platinum guage as catalyst
Temperature = 1155 K
Oxidation of ammonia.

$$4 NH_3 + 5O_2 \xrightarrow[1155K]{Pt} 4 NO + 6 H_2O ; \quad \Delta H = -1275 \frac{KJ}{mol}$$
$$4 : 8$$
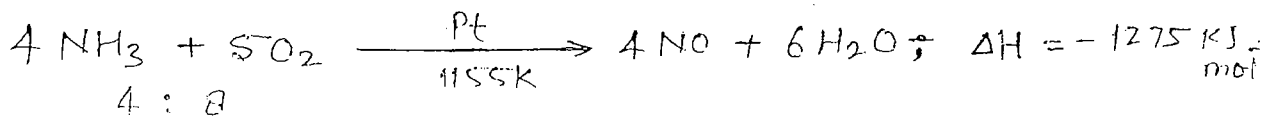
② Cooling chamber :

Gases comming out are colled.

③ oxidation chamber :

Nitric oxide are get oxidised into Nitrogen dioxide.

$$2 NO + O_2 \longrightarrow 2 NO_2$$
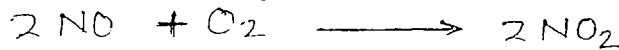
④ Absorption of water : Formation of Nitric acid.

$$3 NO_2 + H_2O \longrightarrow 2 HNO_3 + NO$$
$$2 NO + O_2 \longrightarrow 2 NO_2$$
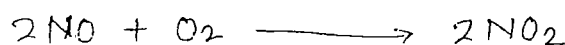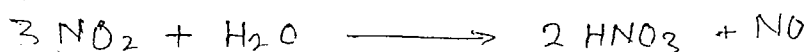
⟹ Dil. HNO_3 is concentrated by distillation containing 60% HNO_3 (Azeotropic mix.)

$\Rightarrow$ Further contain 98% HNO_3.

$\Rightarrow$ 100% Pure HNO_3 Can be obtained by cooling fuming HNO_3 in a freezing mixture Crystals of pure HNO_3 get separated.

Lab Method :*

$\Rightarrow$ In laboratory HNO_3 prepared by heating Sodium Nitrate with Conc. H_2SO_4.

$$NaNO_3 + Conc.\ H_2SO_4 \longrightarrow HNO_3 + NaHSO_4$$
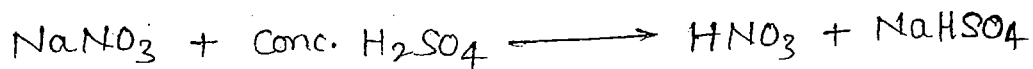
* Properties :

Pure HNO_3 : Colourless

Impure HNO_3 : Yellow due to presence of NO_2 as impurities.

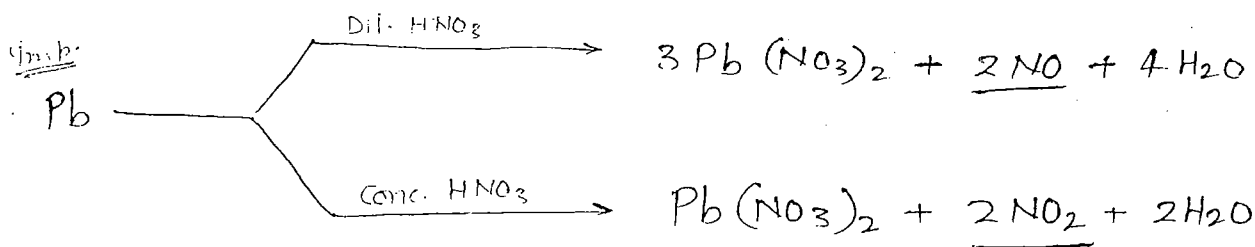Strong acid $\Rightarrow$ Monobasic HNO_3 $\left[O \leftarrow \overset{\overset{O}{\|}}{N} - \overset{..}{\overset{..}{O}} - H \right]$

$\Rightarrow$ Decompose slowely in presence of <u>sunlight</u>.

$$4 HNO_3 \longrightarrow \underset{Yellow}{4 NO_2} + 2 H_2O + O_2$$
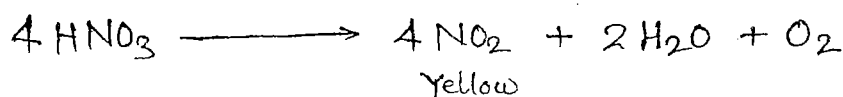
$\Rightarrow$ Powerfull Oxidising Agent because it decomposes easily to give <u>Nascent oxygen.</u>

$$2 HNO_3 \longrightarrow 2 NO_2 + H_2O + [O]$$

$$2 HNO_3 \longrightarrow 2 NO + H_2O + 3 [O]$$
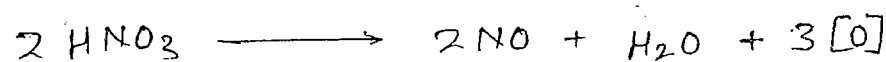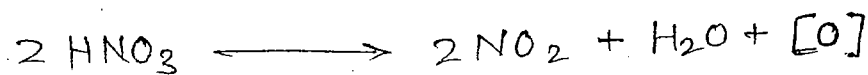
$\Rightarrow$ React with almost all metals <u>except Au and Pt</u>

Zn

Very dil. HNO₃ 6% →
$$4\,Zn(NO_3)_2 + NH_4NO_3 + 3\,H_2O$$

Dil. HNO₃ 20% →
$$4\,Zn(NO_3)_2 + N_2O + 5\,H_2O$$
$\uparrow$
Nitrous oxide

Conc. HNO₃ 70% →
$$Zn(NO_3)_2 + NO_2 + 5\,H_2O$$
$\uparrow$
Brown colour

Sn

Dil. HNO₃ →
$$4\,Sn(NO_3)_2 + NH_4NO_3 + 3\,H_2O$$

Hot & Conc. HNO₃ →
$$H_2SnO_3 + 4\,NO_2 + H_2O$$
Metastannic
acid

Fe

Very dil. HNO₃ →
$$4\,Fe(NO_3)_2 + NH_4NO_3 + 3\,H_2O$$

Dil. HNO₃ →
$$4\,Fe(NO_3)_2 + N_2O + 5\,H_2O$$

Conc. HNO₃ →
$$Fe(NO_3)_2 + 3\,NO_2 + 3\,H_2O$$

Highly conc. 80% →
Makes Fe Passive

Pb

Dil. HNO₃ →
$$3\,Pb(NO_3)_2 + \underline{2\,NO} + 4\,H_2O$$

Conc. HNO₃ →
$$Pb(NO_3)_2 + \underline{2\,NO_2} + 2\,H_2O$$

Cu

Cold & Dil. HNO₃ →
$$3\,Cu(NO_3)_2 + \underline{2\,NO} + 4\,H_2O$$

Hot & Conc. HNO₃ →
$$Cu(NO_3)_2 + \underline{2\,NO_2} + H_2O$$

Ag

Dil. HNO₃ →
$$3\,AgNO_3 + NO + 2\,H_2O$$

Conc. HNO₃ →
$$AgNO_3 + NO_2 + H_2O$$

$$Hg \begin{cases} \xrightarrow{\text{Dil. } HNO_3} 3\,Hg(NO_3)_2 + 2NO + 4H_2O \\ \\ \xrightarrow{\text{Conc. } HNO_3} Hg(NO_3)_2 + 2NO_2 + 2H_2O \end{cases}$$

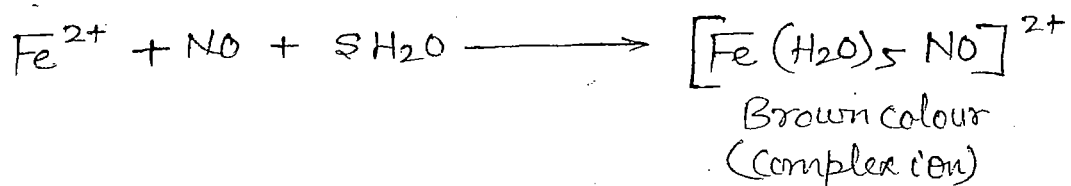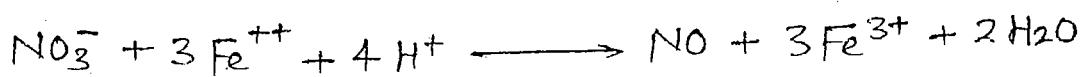// ⇒ Nobel metal like <u>Gold</u>, <u>Platinum</u>, <u>Iridium</u> and <u>Rhodium</u> etc. are not acted upon by HNO_3, they dissolve only in <u>Aquaragia</u> $(3\,HCl + 1\,HNO_3)$.
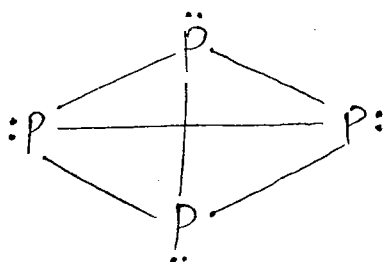
$$2\,Au + 3\,HNO_3 + 11\,HCl \longrightarrow 2\,H\,AuCl_4 + 3\,NOCl + 6H_2O$$

$\qquad\qquad\qquad\qquad\qquad\qquad$ <u>Chloro auric acid</u> $\qquad$ <u>Nitrosyl Chloride</u>

$$Pt + 2\,HNO_3 + 8\,HCl \longrightarrow H_2\,Pt\,Cl_6 + 2\,NOCl + 4H_2O$$

$\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad$ <u>Chloro platinic acid</u>

9mk.
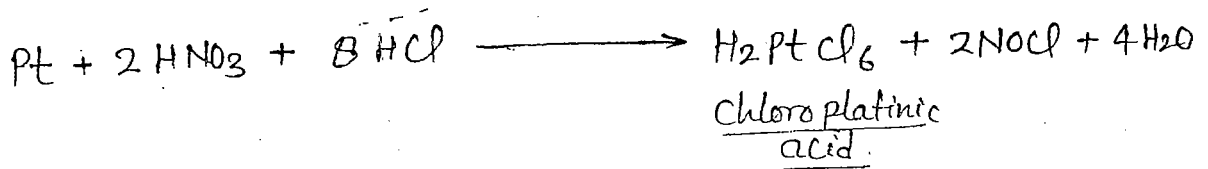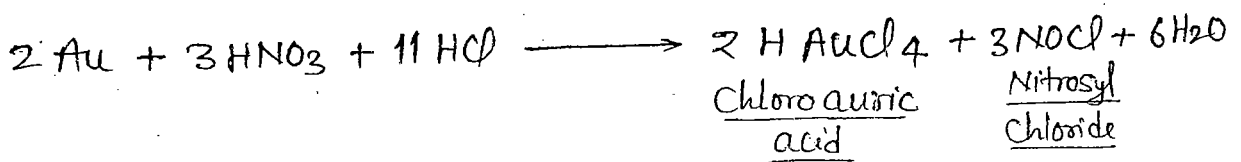
<u>Ring test of Nitrate Ion :</u>

Nitrate ion give brown ring test with Fe^{++} in Presence of Conc. H_2SO_4.

$$NO_3^- + 3\,Fe^{++} + 4\,H^+ \longrightarrow NO + 3\,Fe^{3+} + 2H_2O$$

$$Fe^{2+} + NO + 5H_2O \longrightarrow [Fe(H_2O)_5\,NO]^{2+}$$

$\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad$ Brown colour

$\qquad\qquad\qquad\qquad\qquad\qquad\qquad$ (Complex ion)

* Phosphoreus, P :

⟹ Waxy solid with molecular formula P_4.

⟹ Exist in several Allotropic form.

① white or Yellow Phosphoreus : (P_4) :

⟹ colourless when freshly prepared aquire a light yellow colour on standing.

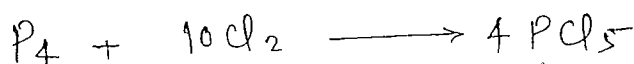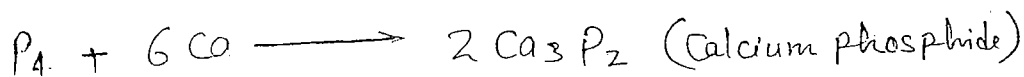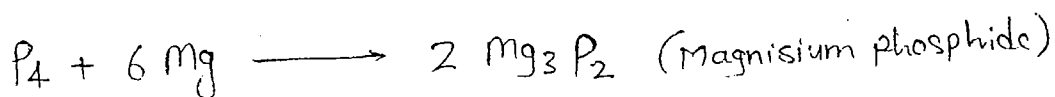⟹ It has a characteristic garlic like smell.

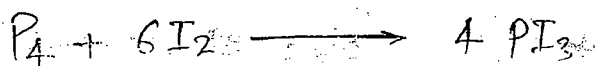⟹ Poisonous in nature, person's working with it suffer a desease Jaw bone called Phossy Jaw

⟹ It insoluble in water, soluble in CS_2 & oil.

⟹ In air undergo flow combustion and glow in dark this phenamena is known as Chemiluminiscence.
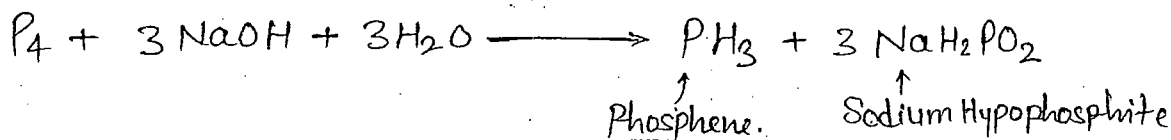
⟹ Catches fire when heated in air given dense white fumes of P_2O_5. hence it has always stored under water.
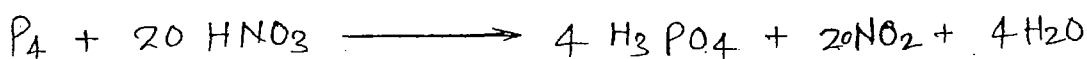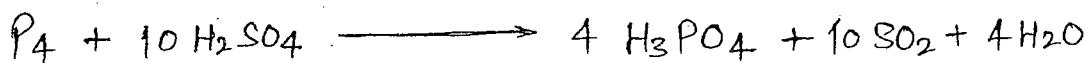
⟹ Combination with metals & non-metals.

$$P_4 + 6\,Mg \longrightarrow 2\,Mg_3P_2 \text{ (Magnisium phosphide)}$$

$$P_4 + 6\,CO \longrightarrow 2\,Ca_3P_2 \text{ (Calcium phosphide)}$$

$$P_4 + 6\,Cl_2 \longrightarrow 4\,PCl_3$$

$$P_4 + 10\,Cl_2 \longrightarrow 4\,PCl_5$$

$$P_4 + 6I_2 \longrightarrow 4PI_3$$

$$P_4 + 10S \longrightarrow 2P_2S_5$$
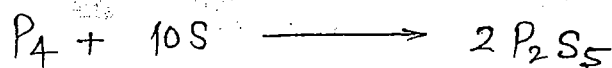
⇒ With __Caustic Soda__ it forms __phosphene.__

$$P_4 + 3NaOH + 3H_2O \longrightarrow \underset{\underset{\text{Phosphene.}}{\uparrow}}{PH_3} + \underset{\underset{\text{Sodium Hypophosphite}}{\uparrow}}{3NaH_2PO_2}$$

⇒ Reduce HNO_3 & H_2SO_4 in NO_2 and SO_2.

$$P_4 + 10H_2SO_4 \longrightarrow 4H_3PO_4 + 10SO_2 + 4H_2O$$

$$P_4 + 20HNO_3 \longrightarrow 4H_3PO_4 + 20NO_2 + 4H_2O$$

* __Structure :__

⇒ Tetrahedra geometry, each phosphorus atom lie at the corner of a regular tetrahedron.

⇒ Hybridization → SP^3
⇒ 6 P-P σ-bond
⇒ 4 Lone pair of e^-
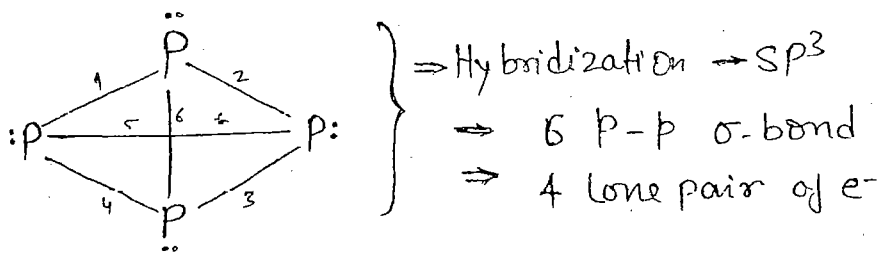
07/03

② __Red Phosphorus :(P_4):__

⇒ Prepared by heating white phosphorus for several hours

$$\text{white phosphorus} \xrightarrow[\text{(Inert atm)}]{525K} \text{Red Phosphorus.}$$
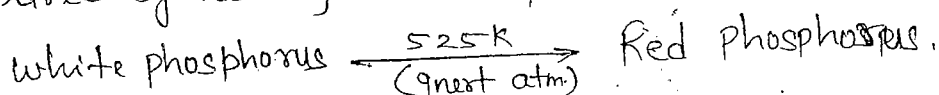
* Properties of Red phosphorus :

⇒ Red, solid, odourless, and non-poisonous.
⇒ Insoluble in water and CS_2.
⇒ Does not glow in dark.

⇒ More stable and chemically less reactive.

⇒ Does not react with caustic soda.

⇒ On heating in inert atmosphere and condensing it changes into white phosphorus.

⇒ It has a Polymeric structure consist of chain of P4 tetrahedron linked together.

(Polymeric structure of Red phosphorus)

③ Black phosphorus :
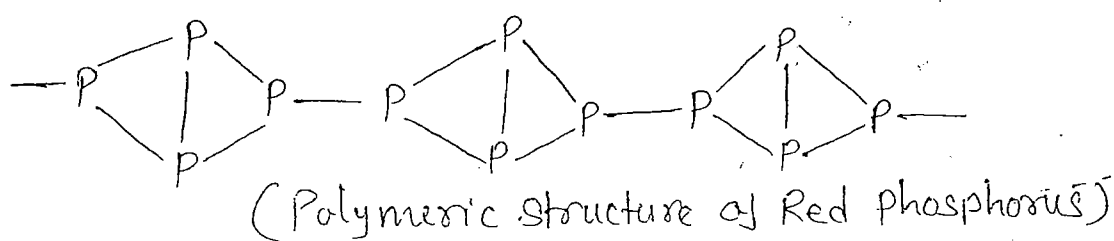
White phosphorus $\xrightarrow{473 K}$ Black Phosphorus.
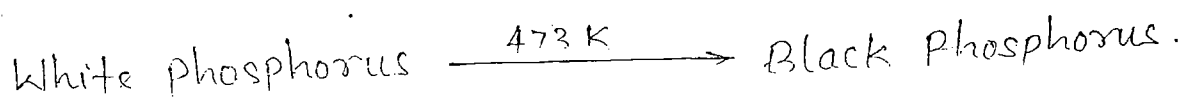
⇒ Exist in three crystalline and one amorphous form.

⇒ α - Black :- Non-conductor of electricity.

β-Black :- Good conductor of electricity
Black metallic lusture
- Most stable and least reactive form.
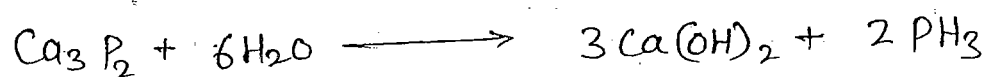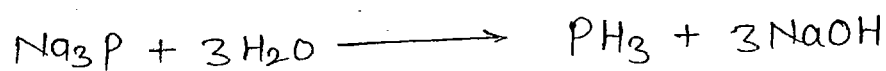
* Use of Phosphorus :

⇒ Yellow phosphorus: Smoke screen

⇒ Red phosphorus: Safty matches

⇒ White phosphorus and zinc phosphide are used as
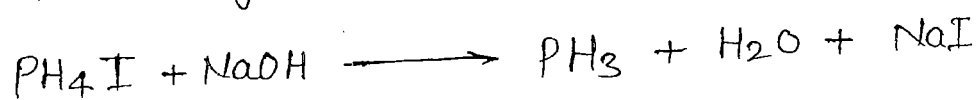Poison for Rat.
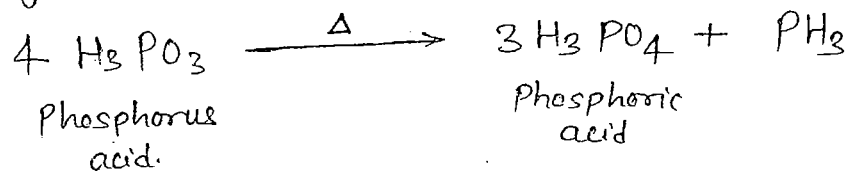
* Phosphene, (PH₃) :

Method of Preparation :

⇒ By action of Water on <u>sodium</u> or <u>Calcium phosphide</u>.

$$Na_3P + 3H_2O \longrightarrow PH_3 + 3NaOH$$

$$Ca_3P_2 + 6H_2O \longrightarrow 3Ca(OH)_2 + 2PH_3$$

$$2AlP + 3H_2SO_4 \longrightarrow 2PH_3 + Al_2(SO_4)_3$$

(Aluminium phosphide)

⇒ Phosphonium Iodide when heated with <u>Caustic soda</u> solution give <u>Pure phosphene</u>.

$$PH_4I + NaOH \longrightarrow PH_3 + H_2O + NaI$$

⇒ By Heating phosphorus acid.

$$4H_3PO_3 \xrightarrow{\Delta} 3H_3PO_4 + PH_3$$

Phosphorus acid.   Phosphoric acid

⇒ Phosphene gas thus form contain impurity of spontaneously inflamable phosphorus dihydride, (P_2H_4) as the Bubbles of P_2H_4 rise above the surface of water they catch fire spontaneously and form a series of vertex ring of smoke.

← vertex ring
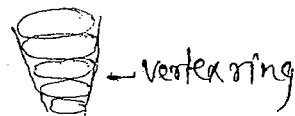
* Polymers *

Greek. Poly = many
meros = parts

⇒ Polymers are high molecular mass compounds obtained by joining together is large number and single molecules through covalent bond in a regular form.

n monomer. ___Polymerisation___→ Polymer. (or micromers)

⇒ No. of monomer units present in a polymer chain is called degree of polymerisation.

⇒ "The simple molecules from which the repeating structural units are derived are called <u>monomers</u> and the process by which these simple molecules i.e. monomers are converted into polymers is called <u>Polymerization</u>."
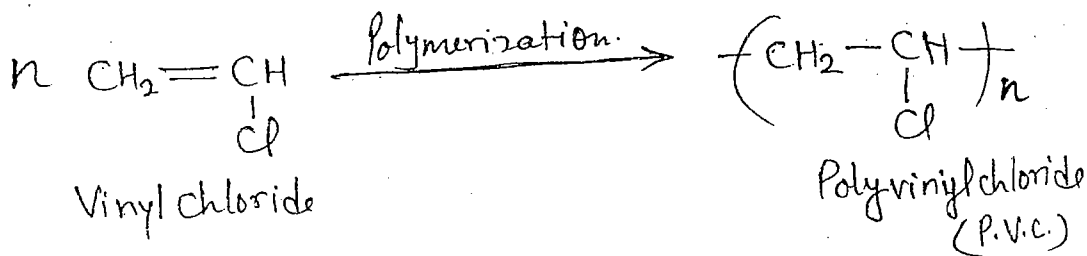
Polymers and macromolecules ⇒
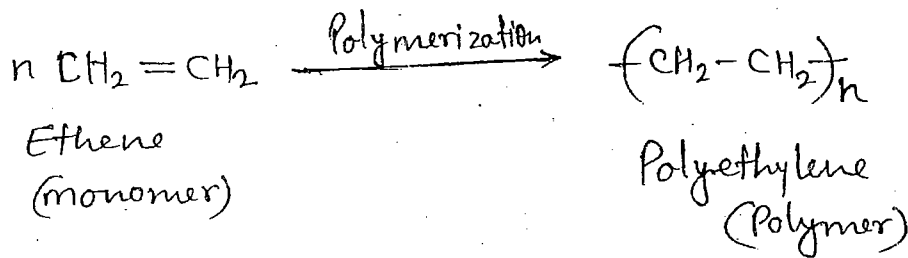
A polymers always contain large no. of repeating monomer units. On the other hand a macromolecule grant molecule which may or may not contain monomer units. is <u>Chlorophyll</u> & <u>Heamoglobin</u> macromolecule but and polymer.

⇒ Thus all the Polymers are macromolecule but all the macromolecules are not Polymer.

* Homopolymer ⇒

A polymer obtained from identical monomer units.

e.g. Polythene, P.V.C. Polypropylene, Polyisoprene, PAN. Nylon-6, Polybutadiene, teflon, Cellulose, Starch etc.

$$n\ CH_2 = CH_2 \xrightarrow{Polymerization} (CH_2-CH_2)_n$$

Ethene
(monomer)

Polyethylene
(Polymer)

$$n\ CH_2 = \underset{\underset{Cl}{|}}{CH} \xrightarrow{Polymerization} (CH_2-\underset{\underset{Cl}{|}}{CH})_n$$

Vinyl chloride
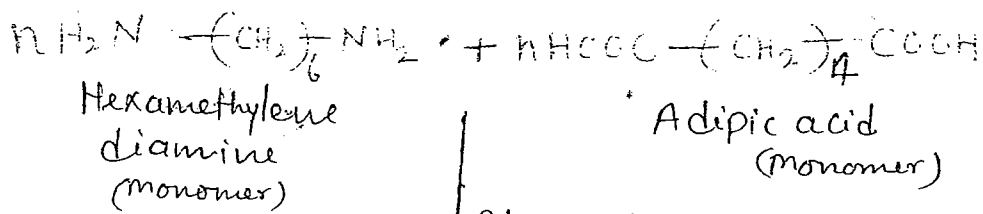
Polyvinylchloride
(P.V.C.)

* Co-polymer ⇒

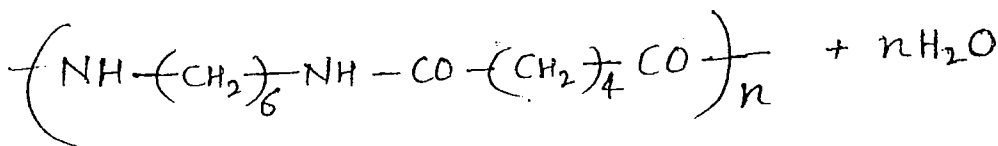A polymer obtained from two or more types of monomer units.

e.g. Nylon-6.6 (Copolymer of Hexamethylene Diamine and Adipic acid.)

Buna-S. rubber (Copolymer of Butadiene and Styrene)

Polyesters, alkyl resins, bakelite, melamine-formaldehyde Polymer etc.

$$n H_2N - (CH_2)_6 - NH_2 + n HCOC - (CH_2)_4 - COOH$$

Hexamethylene diamine (monomer)   Adipic acid (monomer)

| Polymerization

$$(NH-(CH_2)_6-NH-CO-(CH_2)_4-CO)_n + n H_2O$$

Nylon-6 6
(Polymer)

※ **Classification of Polymer** ⇒

1. **Based On Origin** ⇒

① **Natural Polymer** ⇒

Polymer which are found in nature (obtained Natural sources) i.e. in animals and plants are called natural polymer.

e.g. Protein - which make much our body.

Nucleic acid - which control heredity at molecular level.

Cellulose - which provides food, clothing & shelter

Rubber - which is used for making various articles.

wool .

② **Semisynthetic Polymers** ⇒

mostly derived from naturally occurring polymers by chemical modification.

e.g. → Cellulose acetate (Cellulose + acetic anhydride)

→ Vulcanized rubber

→ Cellulose trinitrate (Gun cotton)

(iii) <u>Synthetic Polymers</u> ⇒

A large number of man made Polymers.

<u>e.g.</u> Nylon, Polyester (Fibres)

Polyethylene, Polypropylene (Plastic)

Neoprene, Polystyrene (Rubbers)

2- <u>Based On Structure</u> ⇒

(i) <u>Linear polymer</u> ⇒

⇒ Monomer form unbranched long straight chain of Polymer molecules.

⇒ Due to closed Packing they have high m.p., high density, high tensile straingth.

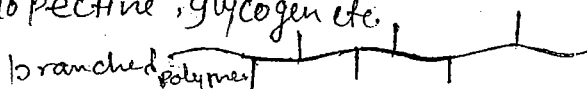<u>e.g.</u> High density Polythene, Polyester, Nylon etc.

Linear Polymer.

(ii) <u>Branched Polymer</u> ⇒

⇒ Monomer units combine to form linear chain & also branches of different length.

⇒ Due to branching they do not Pack weth. They have low density, low m.p., low tensile straingth.

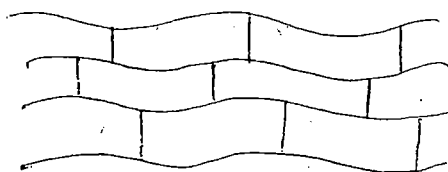<u>e.g.</u> Low density Polythene, Amilopectine, glycogen etc.

branched Polymer

(iii) <u>Three dimentional Network Polymer</u> ⟹

⟹ Linear molecule join to form three dimentional network structure.

⟹ Due to cross linkage they are hard, rigid & brittle.

<u>e.g</u>: Bakelite, Urea formeldehyde, copolyme malamine formaldehyde etc.

3-D network Polymer.

3. <u>Based on mode of Polymerization</u> ⟹

① <u>Addition Polymer</u> OR <u>Chain growth Polymer</u> ⟹

⟹ They are obtain by addition or combination of small molecule contain <u>double bond</u> without elimination of simple molecule such as <u>water</u>

⟹ Molecular wt. of Polymer = $\underline{n \times \text{molecular wt of monomer}}$
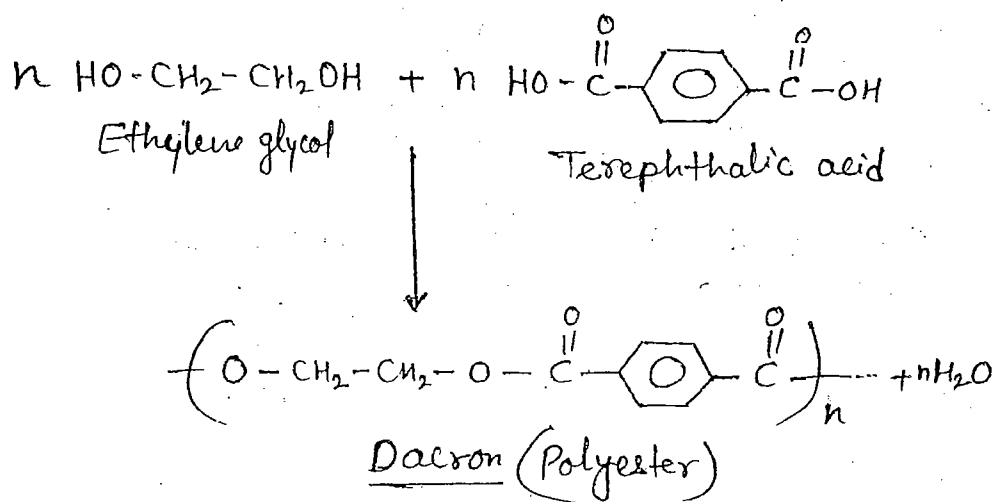
  where n = No. of monomer unit

⟹

$$n \ CH_2=CH_2 \xrightarrow[\text{Polymerization}]{\text{Addition}} (CH_2-CH_2)_n$$

Ethene   Polythene
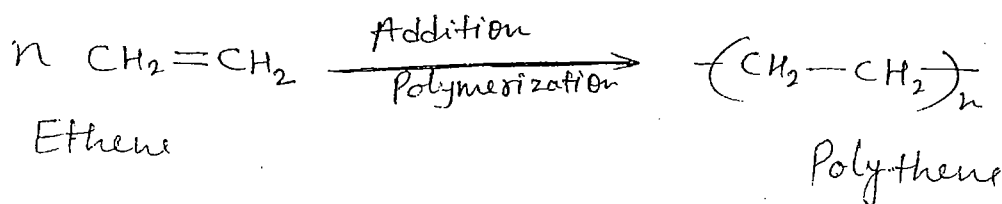
(ii) Condensation Polymer ⇒

⇒ Obtain by condensation of molecules having more than one functional group, resulting in the elimination of simple molecule such as H_2O, NH_3 CH_3OH etc.

⇒ Molar mass of Polymer ⇒ molecular wt. of Polymer $< n \times$ molecular wt. of monomers.

$$n\ HO-CH_2-CH_2OH\ +\ n\ HO-\overset{\overset{O}{\parallel}}{C}-\langle O \rangle-\overset{\overset{O}{\parallel}}{C}-OH$$

Ethylene glycol   Terephthalic acid

$$\left(O-CH_2-CH_2-O-\overset{\overset{O}{\parallel}}{C}-\langle O \rangle-\overset{\overset{O}{\parallel}}{C} \right)_n ---+nH_2O$$

Dacron (Polyester)

4. Based on molecular forces ⇒

(i) Elastomer ⇒

⇒ Inter molecular forces operating b/w the polymer chain are weakest.

⇒ These are amorphous polymer with high degree of elasticity.

eq: Vulcanised rubber, Buna-S (Copolymer of 75% Butadiene & 25% styrine)

⇒ Highly Vulcanised rubber containing 20-25% Sulpher is called abonite.

(ii) **Fibbres** →

→ Intermolecular force of attraction strongest (Dipole-Dipole interaction on hydrogen bond.)

→ They have high tensile strength and least elasticity high density & sharp melting point.

e.g. Nylon-66, Terylene, Dacron etc..

(iii) **Thermoplastics** →

→ Intermolecular force of attraction are in b/w these of elastomers & fibres.

→ Hard at room temp. and becomes soft on heating hence can be moulded.

→ Show reversible changes when heated & cooled.

e.g. Polythene, Polypropylene, Polystyrene, P.V.C, teflon, Polyacrylonitrile, Polymethacrylate etc.

Plasticiser →

They make plastic soft & workable.

e.g. n-butyl phthalite — used to made P.V.C. soft

Dialkyl phthalate —

(iv) Thermosetting polymer ⇒

⇒ These are semifluid substances with low molecular weight.

⇒ When heated in a mould undergo change in chemical composition to give a hard infusible an insoluble mass.

⇒ This hardening is due to extensive cross linkage between the different polymer chain.

e.g.- Phenol formeldehyde, Urea formeldehyde, melamine formel--dehyde etc.

Difference between Thermoplastic & Thermosetting Polymer

Thermoplastic Polymer	Thermosetting Polymer
1- These are formed by addition Polymerization.	1- These are formed by Condensation Polymerization
2. They have usually linear Structure.	2- They have 3-D, cross linked structure
3- Softer on heating and harden on cooling.	3- Don't soften on heating but becomes hard.
4. Remoulded, Recast and Reshaped.	4- Can not remoulded and reshaped.