

A Ideal Gas

Characteristics of gases:-

- ② The Gaseous state is characterised by following physical properties.
- 1. Gases are Highly compressible.
- 2. Gases exerts pressure equally in all directions.
- 3. Gases have much lower density than solid & liquid.
- 4. The volume & the shape of gases are not fixed.
These acquire volume & shape of the container.
- 5. Gases mix evenly & completely in all proportions without any mechanical method.
- 6. Simplicity of gases is due to the fact that force of interaction between their molecules are negligible

$$PV = nRT$$

→ ideal gas equation.

P = Pressure of Gas

V = Volume of Gas

n = no. of moles of Gas

R = ~~Universal~~ Universal Gas Constant

T = Absolute Temperature (Kelvin)

① Pressure:-

SI:- Pascal or N/m^2

Other:- atm, mmHg, Torr, bar

$$1 \text{ atm} = 1.01325 \times 10^5 \text{ Pa}$$

$$1 \text{ atm} = 1.01325 \text{ Bar}$$

$$1 \text{ Bar} = 10^5 \text{ Pa}$$

$$1 \text{ Torr} = 1 \text{ mmHg/mmHg}$$

$$1 \text{ atm} = 760 \text{ mmHg/Torr}$$

② Volume :-

SI unit:- m^3

$\rightarrow \text{cm}^3, \text{CC, ml, lit}$

$$1 \text{ m}^3 = 1000 \text{ l}$$

$$1 \text{ m}^3 = 10^6 \text{ cm}^3 \text{ or } 10^6 \text{ CC}$$

$$1 \text{ lit} = 1000 \text{ ml}$$

$$1 \text{ m}^3 = 10^6 \text{ ml}$$

$$1 \text{ ml} = 1 \text{ CC or } 1 \text{ cm}^3$$

③ Temperature :-

$$K = C + 273.15$$

$$C = \frac{5}{9} ({}^{\circ}\text{F} - 32)$$

④ Gas Constant R (R)

SI unit :- $\frac{N \cdot m^3}{\text{mol} \cdot \text{K}}$

$$\therefore \frac{Nm}{\text{mol} \cdot \text{K}}$$

$$R = 8.314 \frac{P \cdot m^3}{\text{mol} \cdot \text{K}} \text{ or } \frac{N \cdot m}{\text{mol} \cdot \text{K}} \text{ or } \frac{J}{\text{mol} \cdot \text{K}}$$

or

$$R = \frac{25}{3} \frac{J}{\text{mol} \cdot \text{K}}$$

① $P \rightarrow \text{atm}, V \rightarrow \text{lit}$

$$R = 0.0821 \frac{\text{dm}^3 \text{atm}}{\text{mol} \cdot \text{K}}$$

② Calories &

$$R = 1.98 \frac{\text{J}}{\text{mol} \cdot \text{K}} = \frac{2 \text{ cal}}{\text{mol} \cdot \text{K}}$$

Note:- $0.0821 \times 273 = 22.4$

$$0.0821 \times 546 = 44.8$$

$$0.0821 \times 300 = 24.63$$

~~Difficult~~

Note:-

→ The gas which follows $PV = nRT$ is considered as an ideal gas.

Experimental gas laws

- ① Boyle's Law - For a fixed mass of gas at constant temperature, volume of gas is inversely proportional to its pressure.

$PV = nRT$ (GELS)

$n, T, R \rightarrow \text{Constant}$

$PV = \text{constant}$

$P = \frac{\text{constant}}{V}$

$$P \propto \frac{1}{V}$$

$P_1 V_1 = P_2 V_2$

Charles law - For the fixed mass of gas at constant pressure, volume of gas is directly proportional to its absolute temperature.

$PV = nRT$

$n, R, P \rightarrow \text{Constant}$

$PV = T \times \text{constant}$

$\frac{V}{T} = \text{constant}$

$$V \propto T$$

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

④ Gay-Lussac's law - (pressure-temp. law)

→ For the fixed mass of Gas at constant volume The pressure of gas is directly proportional to its absolute temperature.

$$PV = nRT$$

$V, n, R = \text{constant}$

$P = \text{proportional}$

$$\boxed{P \propto T}$$

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

⑤ Bosektis law - According to this law at Constant Pressure Temperature equal volume of all the gases contains equal no. of gaseous molecules.

$$PV = nRT$$

$P, T, R \Rightarrow \text{constant}$

$V = n \times \text{constant}$

$$\boxed{V \propto n}$$

$$\frac{V_1}{n_1} = \frac{V_2}{n_2} = \text{const}$$

Combining

① $V \propto \frac{1}{P} \quad \{ n, T \text{ constant} \}$

② $V \propto T \quad \{ n, P = \text{constant} \}$

③ $V \propto \frac{1}{P} \quad \{ P, T \text{ constant} \}$

$$V \propto \frac{nT}{P}$$

$$VP \propto nT$$

$$\boxed{PV = nRT}$$

Q1. A certain mass of gas occupy 100 ml at 2 atm what is the volume of the gas if it is isothermally extended to 950 bar.

\rightarrow constant by

$$950 \text{ bars} = \frac{950}{760} \text{ atm} = \frac{95}{76} \text{ atm} \rightarrow n, T \text{ constant}$$

$$= 1.25 \text{ atm}$$

$$100(?) = V(1.25)$$

$$V = \frac{200}{1.25}$$

$$V = \frac{20000}{125} \text{ OTTOBLS}$$

$$V = \frac{4000}{25}$$

$$V = \frac{800}{5}$$

$$\boxed{V = 160 \text{ ml GL}}$$

Q2. The pressure of certain mass of gas is increased by 25% at constant temp. Calculate % decrease in volume.

$n, T \Rightarrow \text{constant}$

$$P'V = \frac{5P}{4}V'$$

$$V' = \frac{4}{5}V$$

$$\% \text{ decrease} \Rightarrow \frac{1}{5}V \times \frac{1}{V} \times 100$$

$$= \frac{100}{5}\%$$

$$\boxed{= 20\%}$$

Q3. A vessel of 4 l capacity contains some gas at 20 bar. It is connected to another evacuated vessel of irregular shape with the help of evacuated tube of capacity of 0.5 l maintaining constant temperature. If the final pressure of gas is 4 bars, what was the capacity of irregular vessel.

$$\text{At } P \quad P_1 V_1 = P_2 V_2$$

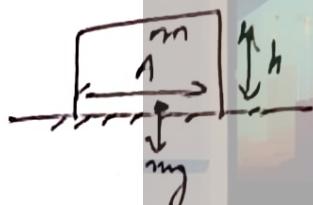
$$(20)(4) = (P_2)(4)(V_2)$$

$$V_2 = 20 \text{ l}$$

$$V_2 = 4 + 0.5 + x$$

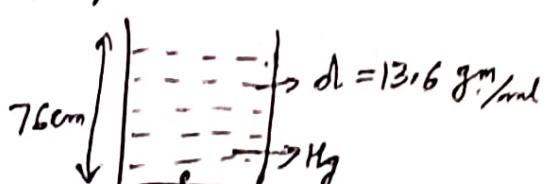
$$x = 15.5 \text{ l}$$

At pressure
for solid.



$$P = \rho gh$$

for liquid



$$P = \rho gh$$

$$P = 13.6 \frac{\text{g}}{\text{ml}} \times 76 \text{ cm} \times 9.81 \times \frac{100 \text{ cm}}{\text{sec}^2} \times 10^3$$

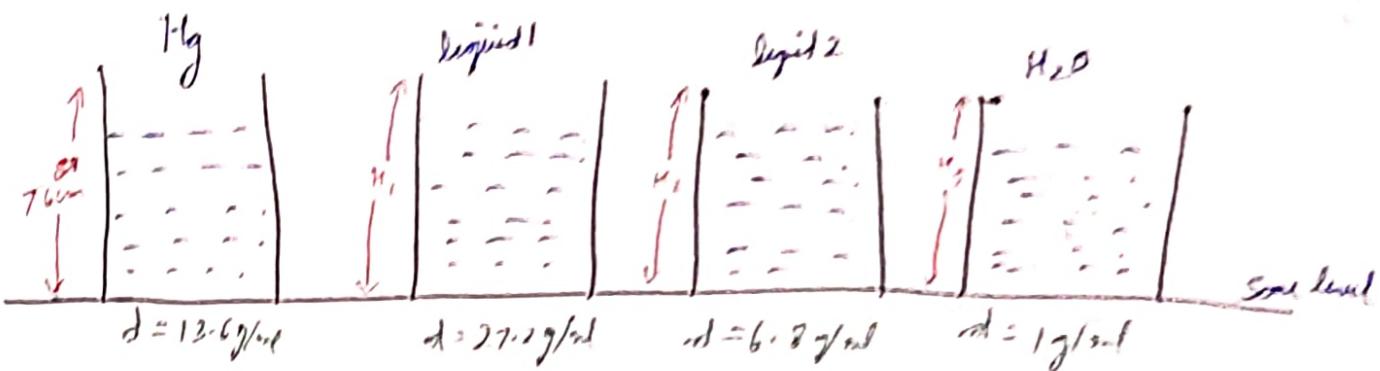
$$P = \dots \text{ dyne/cm}^2$$

$$P = 1.01325 \times 10^5 \text{ N/m}^2$$

$$P = 1 \text{ atm}$$

$$1 \text{ atm} = 76 \text{ cm Hg} = 760 \text{ mm Hg}$$

Q2.

 $\propto h$

$$P = \rho h \times g$$

constant

ARCHIMEDE'S PRINCIPLE

$$h_1 d_1 = h_2 d_2$$

$$76 \times 13.6 \times g = h_1 \times 27.2 \times g$$

$$h_1 = 38 \text{ cm}$$

$$76 \times 13.6 \times g = h_2 \times 6.8 \times g$$

$$h_2 = 152 \text{ cm}$$

$$\frac{76 \times 13.6}{1} = h_3$$

$$h_3 = 1033.6 \text{ cm}$$

$$1 \text{ atm} = 10.33 \text{ m H}_2\text{O}$$

Note:- In pressure measuring devices, mercury is used because it has is most dense dry liquid. Therefore, height will be less & easy to handle.

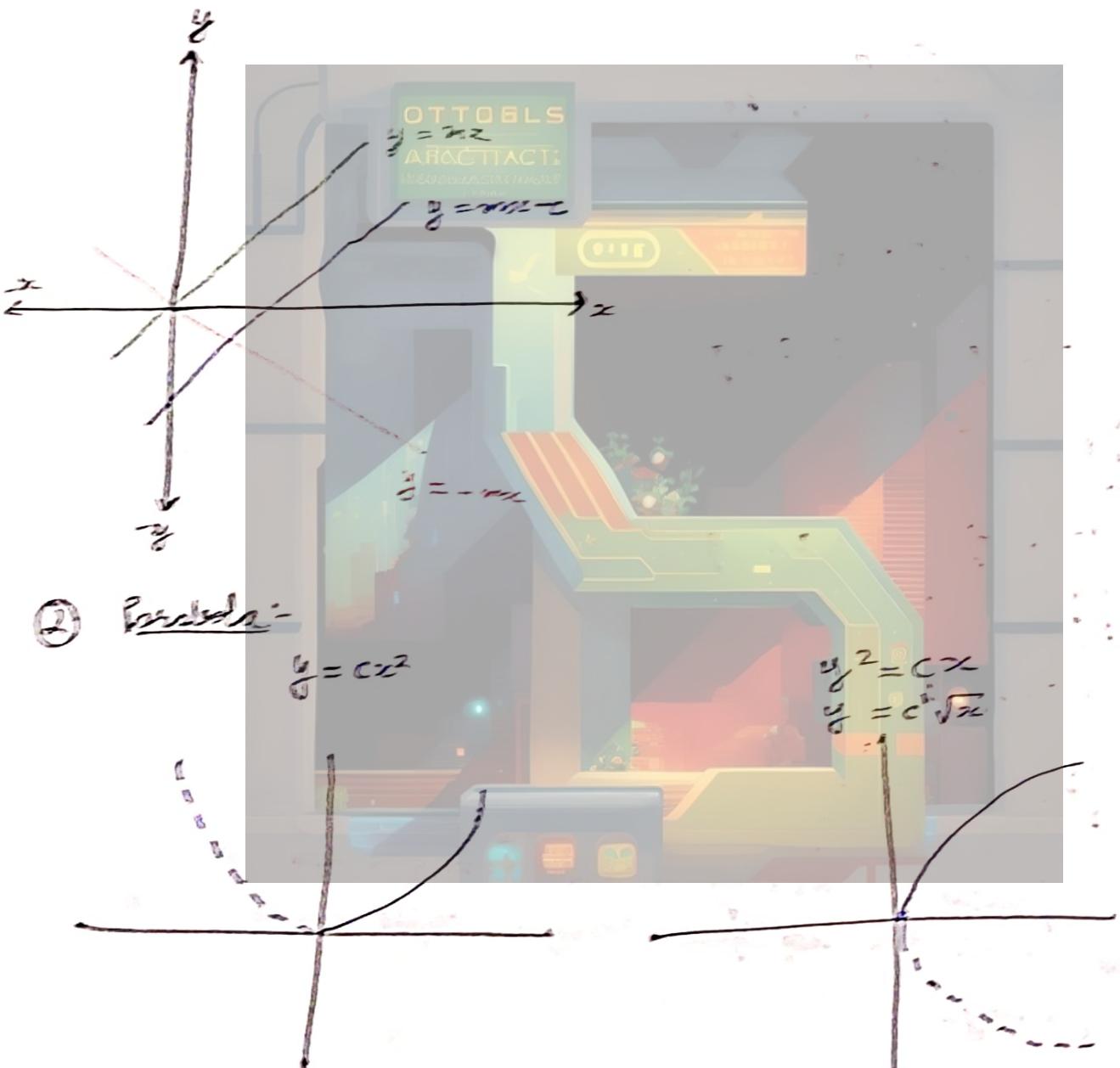
Important graphs

① Straight line:-

$$y = mx + c \rightarrow \text{Intercept/2}$$

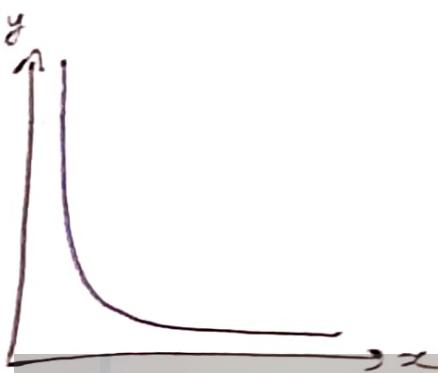
slope

$$\tan \theta = m = \frac{y}{x}$$



③ Hyperbola

$$xy = c \Rightarrow y = \frac{c}{x} \quad [\text{symmetric}]$$



$$\begin{aligned} x^2 y &= c \\ y x^{2/3} &= c \\ x^2 y^3 &= c \end{aligned}$$

not symmetric

Rectangular Hyperbola

A RECTANGLE

④ Exponential curves

$$y = e^x \quad \text{or} \quad \ln(y) = x$$



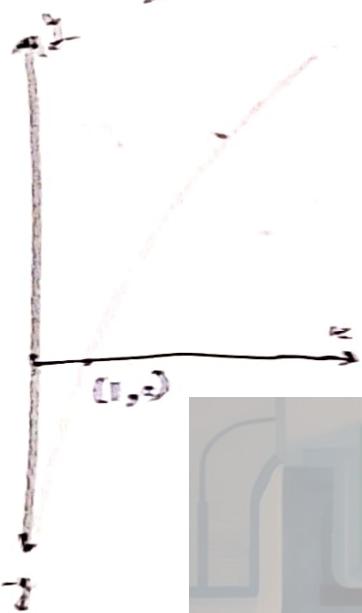
$$y = e^{-x} \quad \text{or} \quad \ln(y) = -x$$



• exponentially decreasing.

5 Logarithmic Law

$$y = \log z \quad \text{or} \quad z = e^y$$



Graphs of logarithmic & exponential functions

① Spiral law - ρ, θ, r, t constant

$$\rho V = C \text{ const}$$

$$V = \frac{C}{\rho}$$

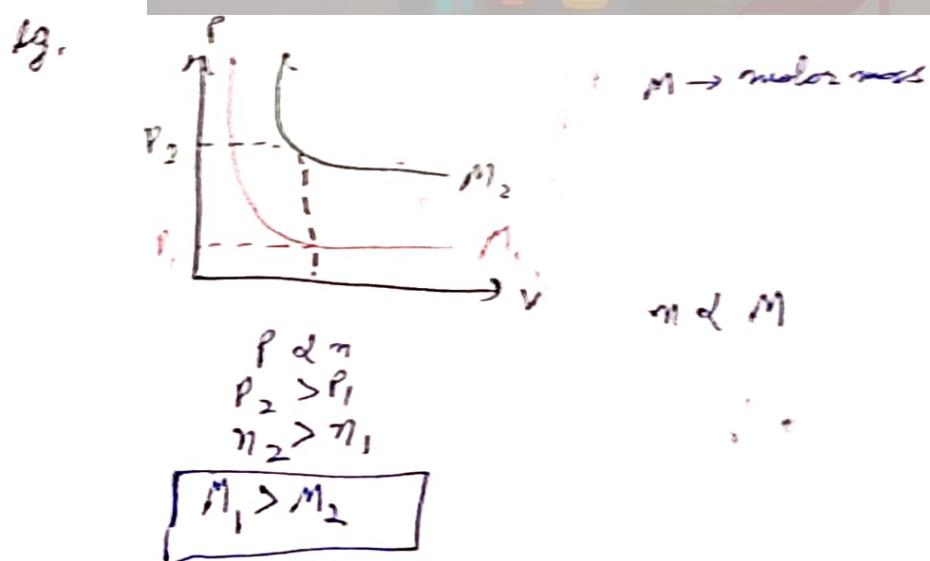
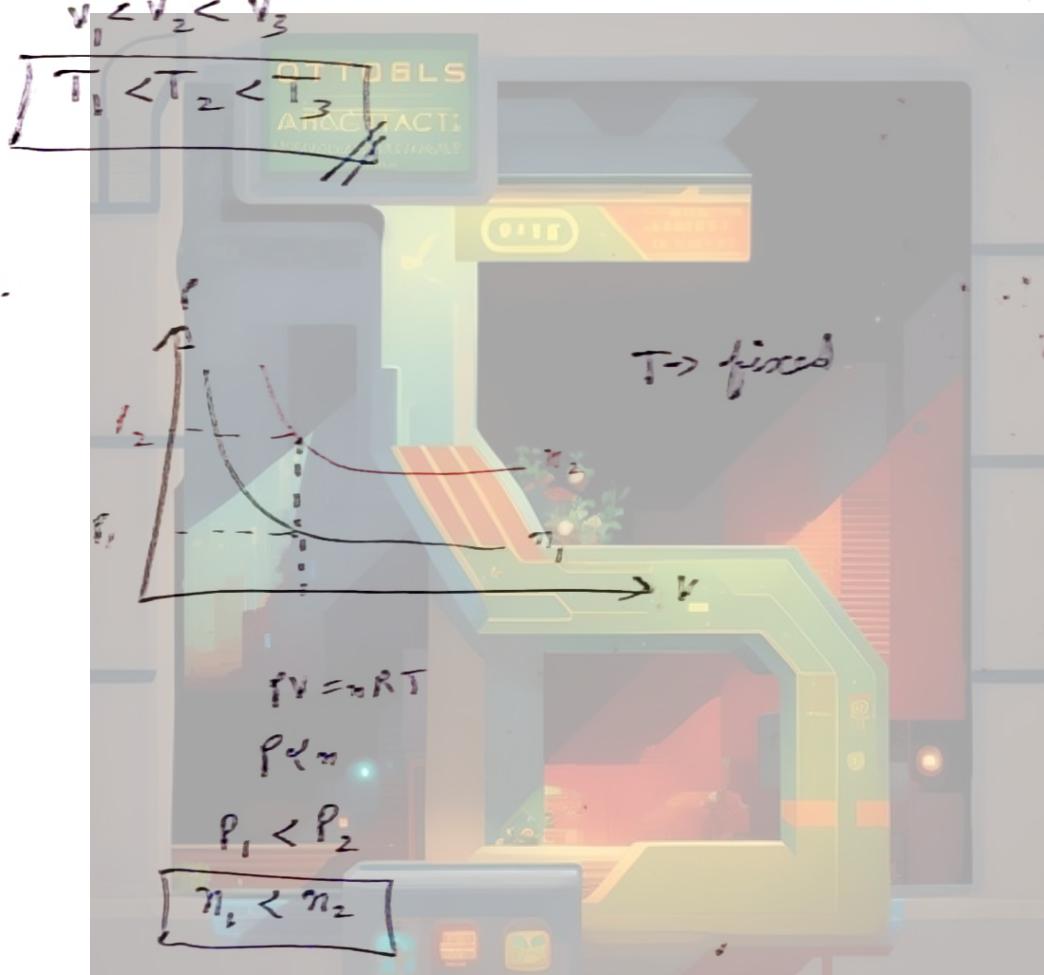
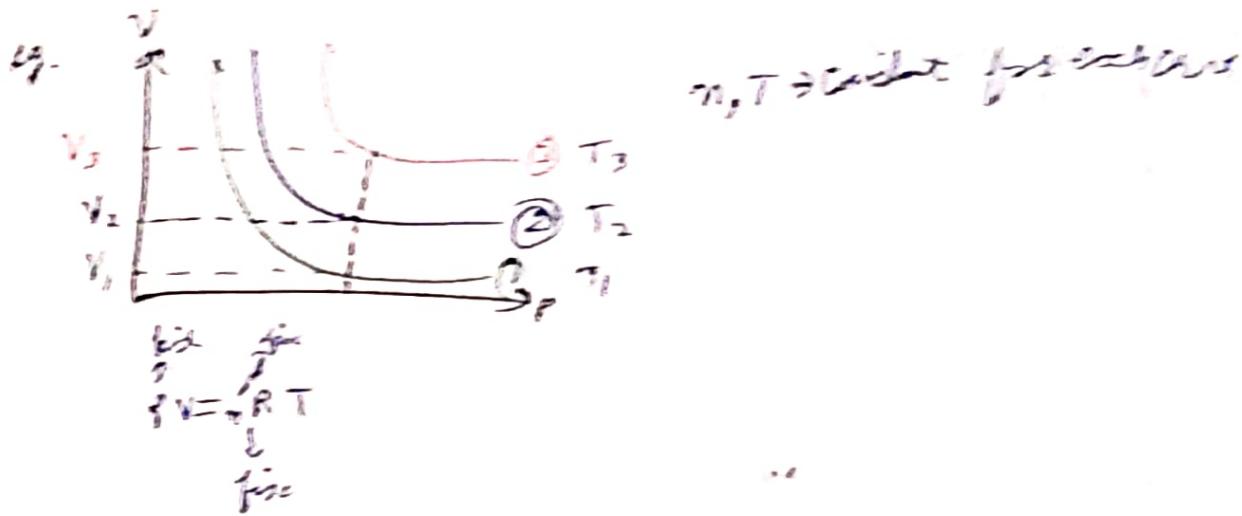


$$V = \frac{C}{\rho} \rightarrow x \text{ axis}$$

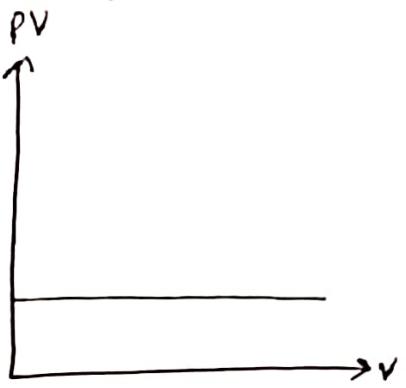
$$xy = C \text{ (hyperbola)}$$

isotropic law

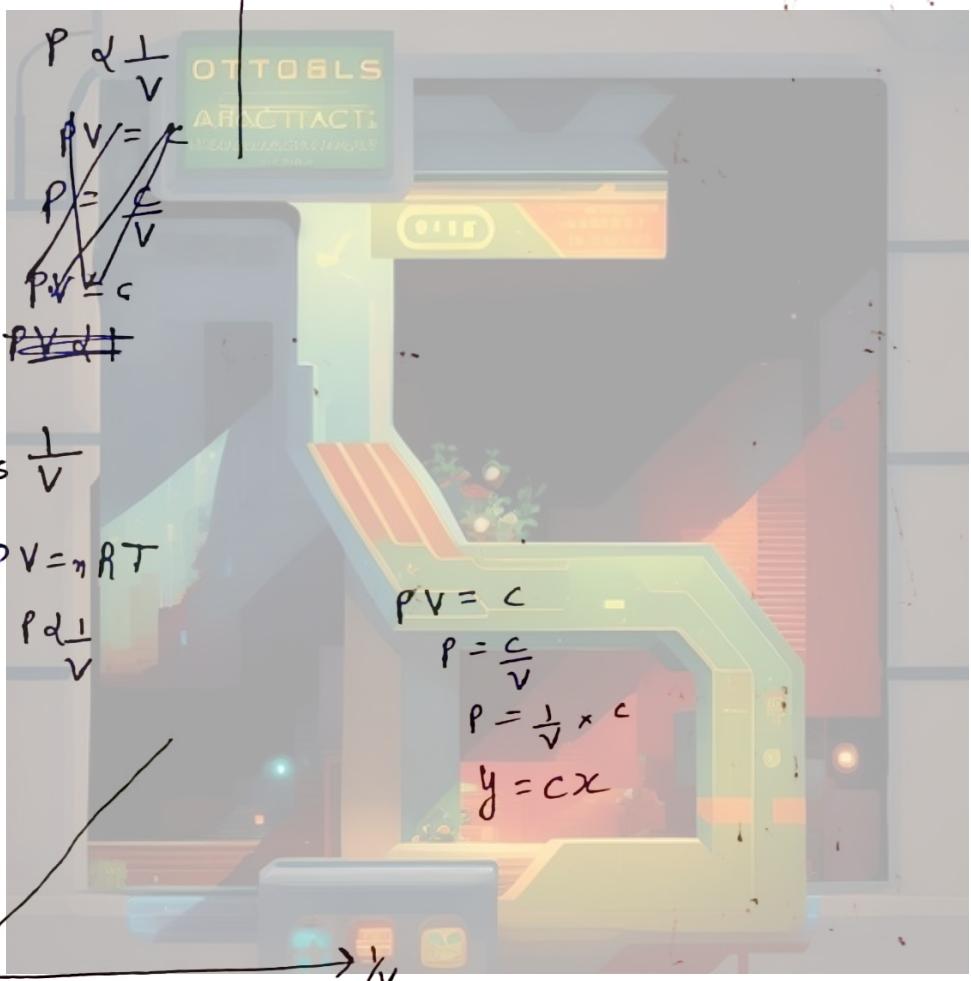
constant trap



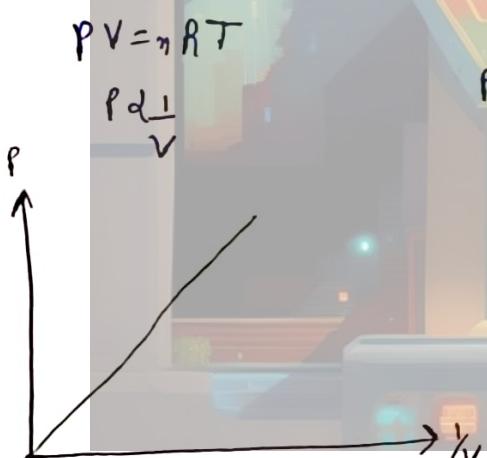
Q4. ① Graph of PV vs V .



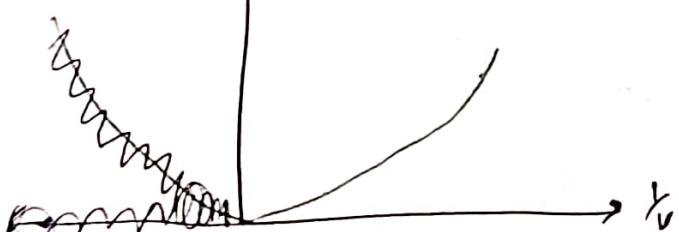
$$PV = nRT \quad | \quad \text{and} \quad PV = C \quad (\text{constant})$$



② P vs $\frac{1}{V}$

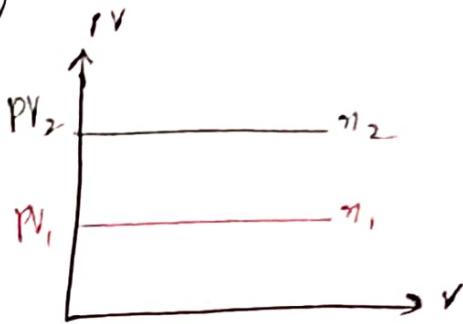


③ $\frac{P}{V}$ vs $\frac{1}{V}$



$$\begin{aligned} PV &= C \\ P &= \frac{1}{V} C \\ \frac{P}{V} &= \left(\frac{1}{V}\right)^2 C \\ y &= x^2 C \end{aligned}$$

Q5. find relation b/w η_2 & η_1 .



$$PV = nRT$$

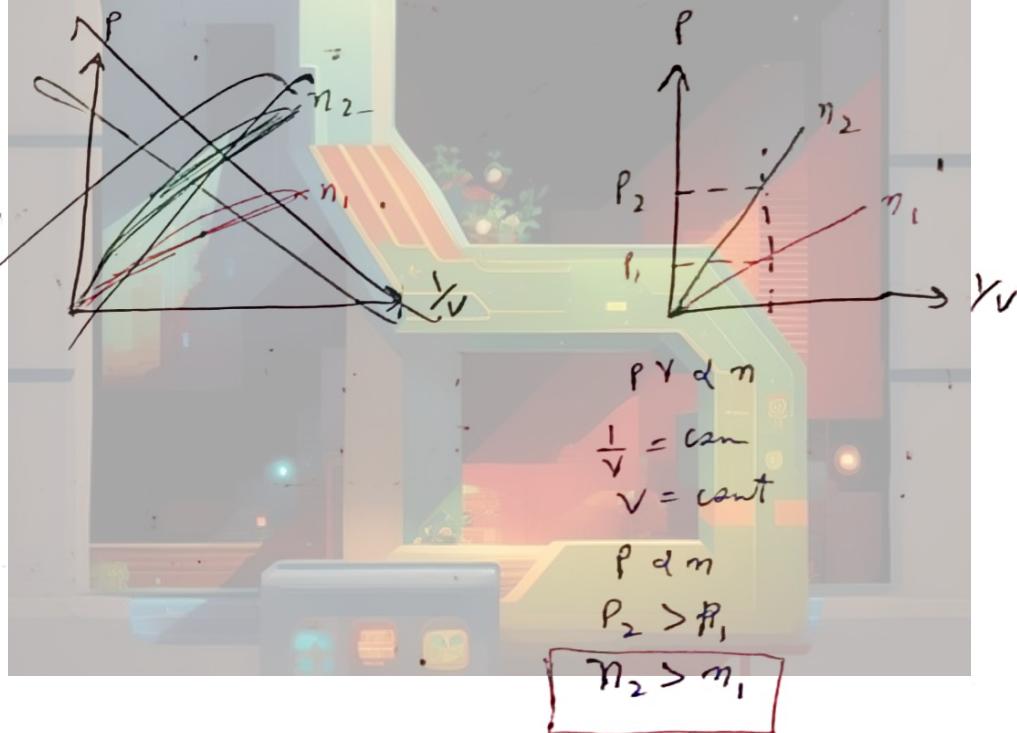
$$PV \propto n$$

$$PV_1 < PV_2$$

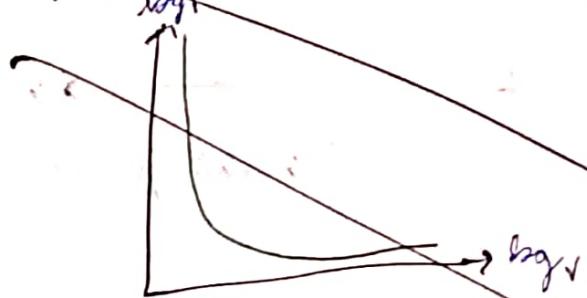
OTTO CYCLES

$$\boxed{\eta_1 < \eta_2}$$

Q6. Relation:-



Q7. graph of $\log P$ vs $\log V$.



$$\log P \propto \log V = C$$

$$\log P = \frac{C}{\log V}$$

$$y = \frac{C}{x}$$

$$\begin{aligned} PV &= C \\ \log P + \log V &= \log C + (\log V) \\ \log P &= \log C + (\log V) \end{aligned}$$

Q7. Graph $\log P$ vs $\log V$

$$PV = c$$

$$\log P + \log V = \log c$$

$$\log P = \alpha + (-\log V)$$

$$y = \alpha - x$$

$$\alpha > y > x$$

$$y = \alpha(-1)x + \alpha$$



② Charles Law

$$n, P \rightarrow \text{const}$$

$$PV = nRT$$

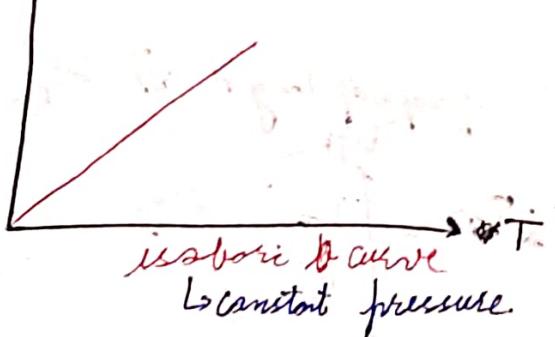
$$V \propto T$$

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

$$V = CT \rightarrow$$

$$\cancel{y = cx} \quad \cancel{y = \frac{C}{x}}$$

$$V \propto P$$



Q B. Draw graphs

① $V \propto T (K)$

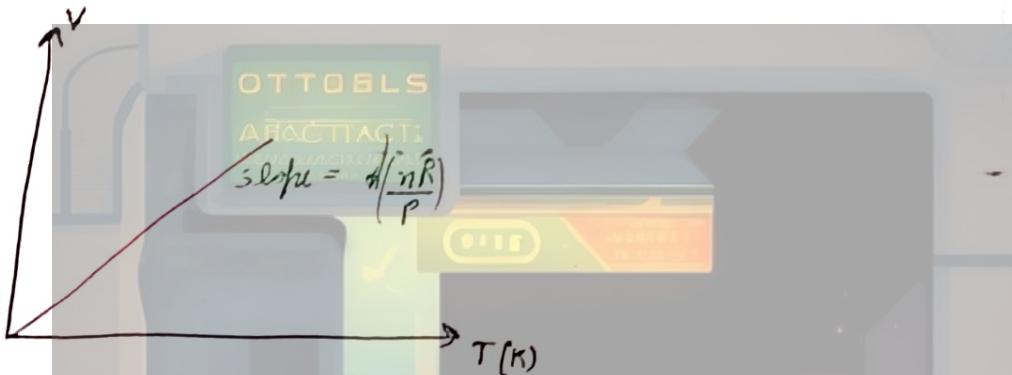
② $V \propto T (^{\circ}C)$

③ $V \propto T$

① $\cancel{PV = nRT}$

$$V = \left(\frac{nR}{P}\right) T$$

$$y = mx$$



②

$$PV = nRT$$

$$V = m \cdot x$$

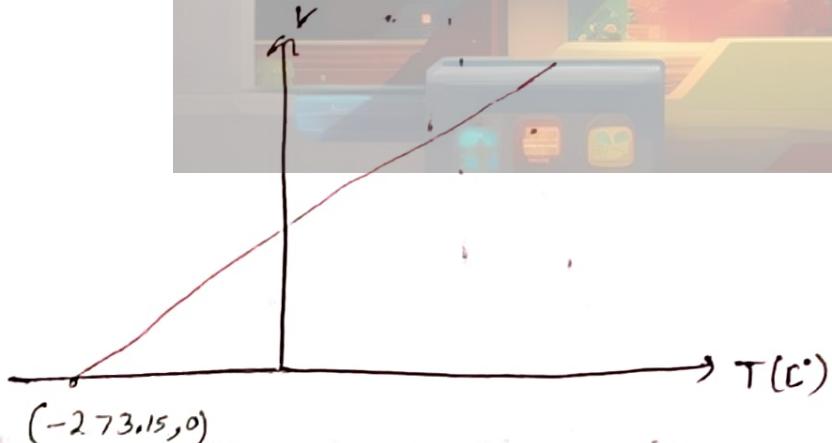
$$V = \left(\frac{nR}{P}\right) [T (^{\circ}C) + 273.15]$$

$$V = \frac{nR}{P} T$$

$$y = mx + c$$

~~C~~

$$C = \frac{nR}{P} \times 273.15$$

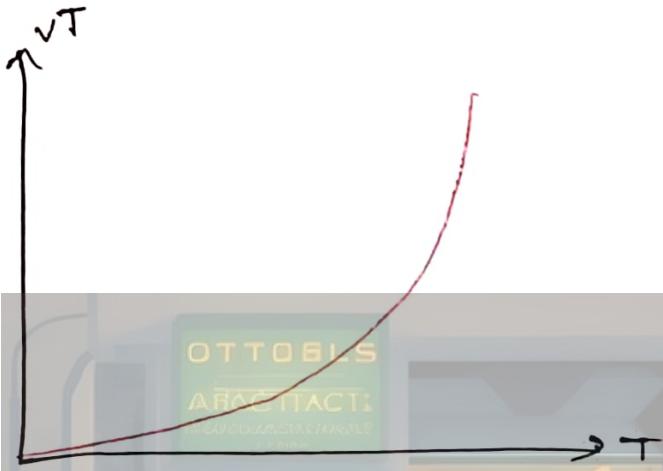


$$③ V = \frac{nR}{P} T$$

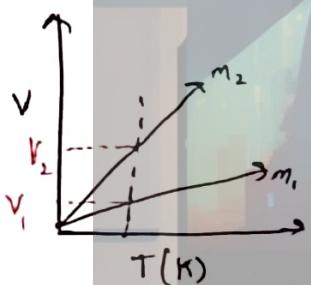
$$V = cT$$

$$VT = cT^2$$

$$y = cx^2$$



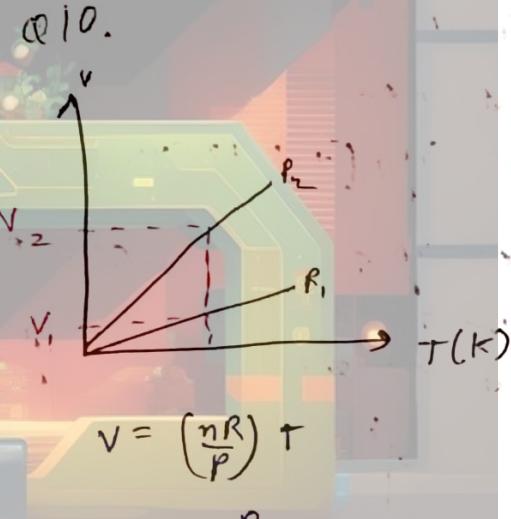
Q9.



$$V = \left(\frac{nR}{P}\right) T$$

$$V_2 > V_1$$

$$\boxed{\eta_2 > \eta_1}$$



$$V = \left(\frac{nR}{P}\right) T$$

$$V \propto P$$

$$V_2 > V_1$$

$$\boxed{P_2 < P_1}$$

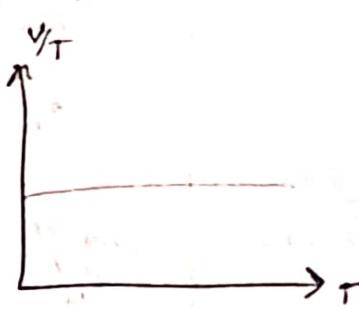
Note:- Absolute 0 ($0K = 0 - 273.15^\circ C$) is theoretically minimum possible temperature but practically absolute zero can never be achieved.

Q11. $\frac{V}{T}$ vs T

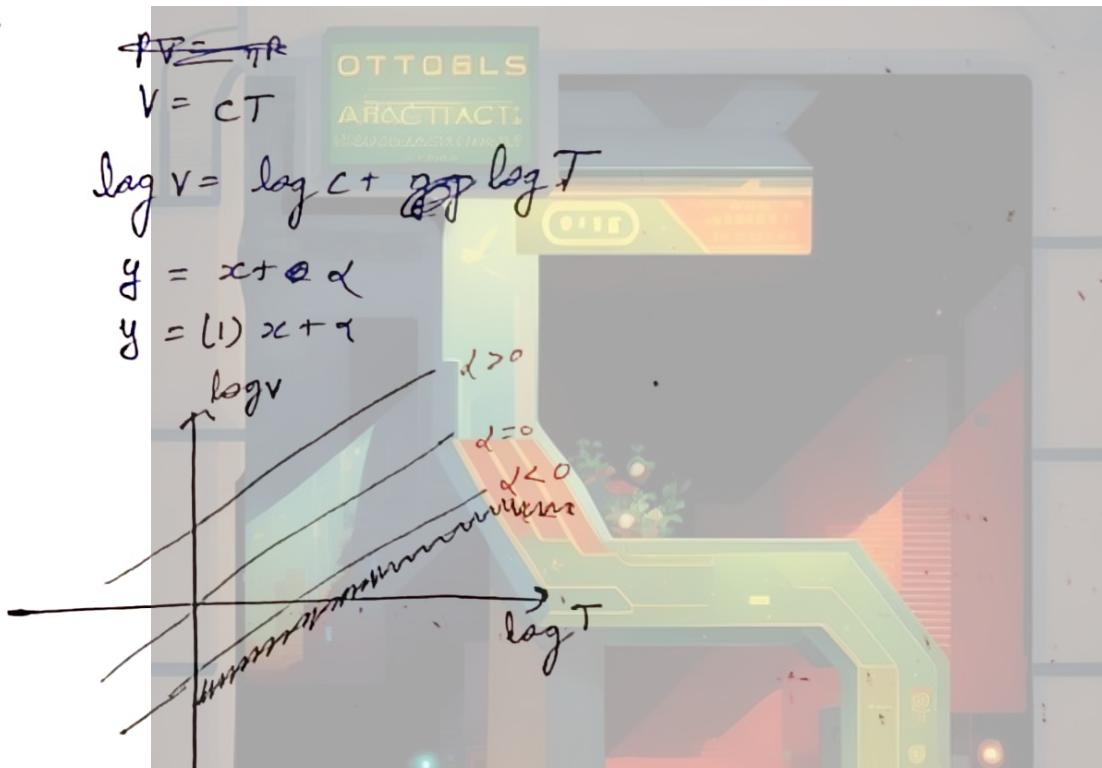
$$PV = nRT$$

$$\frac{V}{T} = \frac{nR}{P}$$

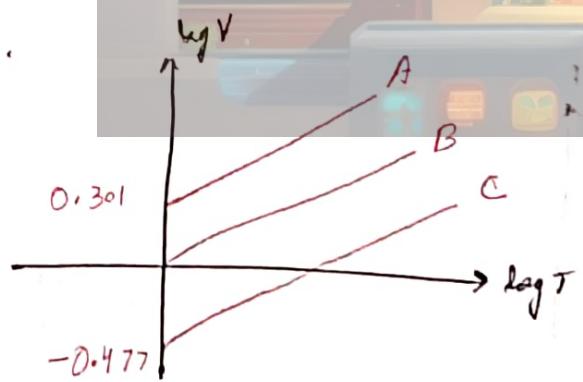
$$\frac{V}{T} = \text{constant}$$



Q12. Graph of log V vs log T



Q13.



$\frac{nR}{P}$ is diff for each gas

$$P = 0.0821 \text{ atm}$$

log V vs log T. graph for
3 diff gases
first mols of each gas.

$$\log 2 = 0.3010$$

$$\log 3 = 0.4771$$

$$\log 5 = 0.699$$

$$\log 10 = 1$$

$$\log \frac{2}{10} = \frac{n \times 0.0821}{0.0821}$$

$$\vartheta = 0.301 = \frac{n \times 0.0821}{0.0821}$$

~~0.031~~

$$\vartheta = 0.301 = \log_{10} \frac{nR}{T}$$

$$\log_{10} \frac{nR}{P} = 0$$

$$n_B = 1$$

$$\log_{10} \frac{nR}{P} = \log_{10} \gamma_3$$

$$n_e = \gamma_3$$

$$2 = \frac{n \times 0.0821}{0.0821}$$

$$n_A = 2$$

③ Gesetz von Lussac's Law

$n, V \rightarrow \text{constant}$

$$PV = nRT$$

$$P = \left(\frac{nR}{V} \right) T + C$$

$$P \propto T(K)$$

is characteristic
↳ constant Volume.

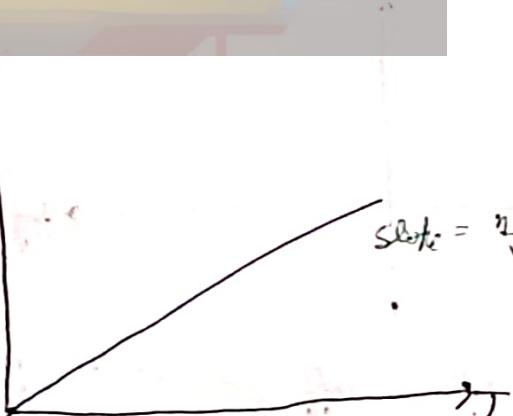
Q14. P vs $T(K)$

$$PV = nRT$$

$$P = \left(\frac{nR}{V} \right) T + C$$

$$y = mx$$

$$Slope = \frac{nR}{V}$$

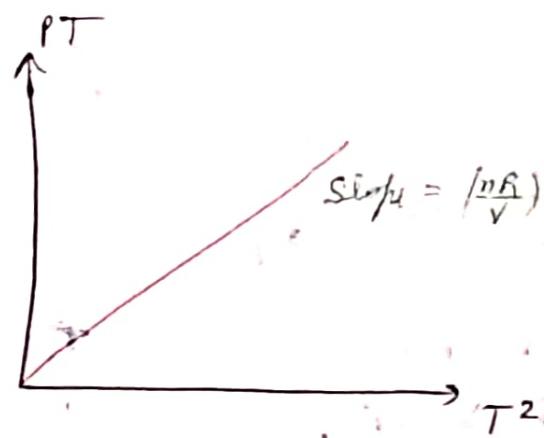


Q15. $PT \propto T^2$

$$P = \left(\frac{nR}{V}\right) T$$

$$PT = \left(\frac{nR}{V}\right) T^2$$

$$y = \frac{nR}{V} x$$



Q16. A gas cylinder containing gas can withstand a pressure of 18 atm. The pressure gauge of cylinder indicates, 12 atm at $27^\circ C$. Due to sudden fire in building the temp. Starts rising, at what temp will cylinder explode.

$$P = 12 \text{ atm}$$

$$T = 300 \text{ K}$$

$$P' = 18 \text{ atm}$$

$$T' = ?$$

$$PV = nRT$$

$$P = cT$$

$$(c = \frac{nR}{V})$$

$$\frac{P}{T} = \frac{P'}{T'}$$

$$\frac{12}{300} = \frac{18}{T'}$$

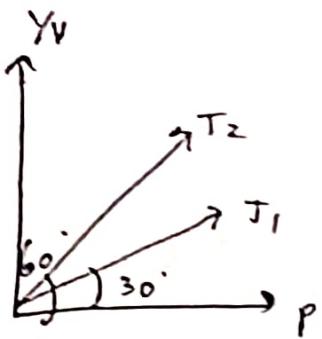
$$T' = \frac{300 \times 3}{2}$$

$$T' = \frac{900}{2}$$

$$T' = 450 \text{ K}$$

Ans

Q17.



$$\text{find } \frac{T_1}{T_2} = ?$$

$$PV = nRT$$

~~$$\cancel{V} = \frac{(nR)}{\cancel{T}}$$~~

$$P \times V = C$$

$$P = C \times \frac{1}{V}$$

$$C \cdot y = x$$

$$y = \frac{1}{C} (x)$$

↳ slope

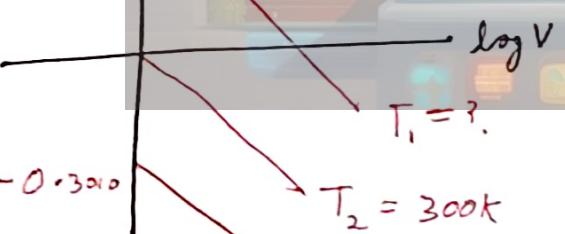
$$y = mx$$

~~$$\frac{1}{nRT} = m$$~~

~~$$T = \frac{m}{nR}$$~~

$$T = \frac{1}{nRm}$$

$$\log P$$



$$nRT_1 = 3$$

$$\boxed{T_1 = 900 \text{ K}}$$

$$T_2 = \frac{1}{2} \times 300$$

$$\boxed{T_2 = 150 \text{ K}}$$

$$\frac{T_1}{T_2} = \frac{m_1}{m_2} = \frac{V_3}{\sqrt{3}}$$

$$\frac{T_1}{T_2} = \frac{Y_1 R m_1}{Y_2 R m_2} = \frac{m_2}{m_1} = \frac{\sqrt{3}}{Y\sqrt{3}} = 3$$

$$\boxed{\frac{T_1}{T_2} = 3}$$

$$P = \left(\frac{nR}{V}\right) \times \frac{1}{V}$$

$$\log P = \frac{nRT}{V} - \log V$$

$$\log P = (-1) \log V + \frac{nR}{V} \log \left(\frac{nR}{V} + 1 \right)$$

$$\log \frac{nRT}{V} = \log \frac{P}{P_0} \quad 0$$

~~$$P_0 R = 390$$~~

$$nR = Y_{300}$$

$$\begin{aligned} \log 2 &= \log \frac{nR}{T_1} \\ \log 3 &= \log \frac{nR}{T_2} \\ T_1 &= \frac{nR}{2} \\ T_2 &= \frac{nR}{3} \end{aligned}$$

Q18. Avogadro's law

$P, T = \text{constant}$

$$PV = nRT$$

$V \propto n$

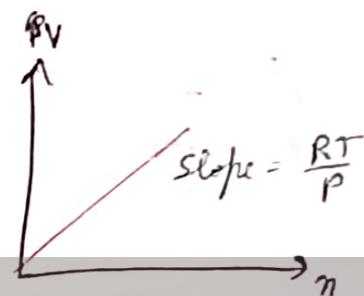
$$\frac{V_1}{n_1} = \frac{V_2}{n_2}$$

Q19. V vs n

$$PV = nRT$$

$$V = \frac{nRT}{P}$$

$$y = x \times \left(\frac{RT}{P} \right)$$



Q20.



$$\begin{aligned} & \cancel{V \propto n} \\ & \cancel{n \propto P} \\ & n_2 > n_1 \\ & \boxed{P_2 > P_1} \end{aligned}$$

Q21. $\frac{P}{d} \propto P$

~~$\frac{P}{d} \propto P$~~

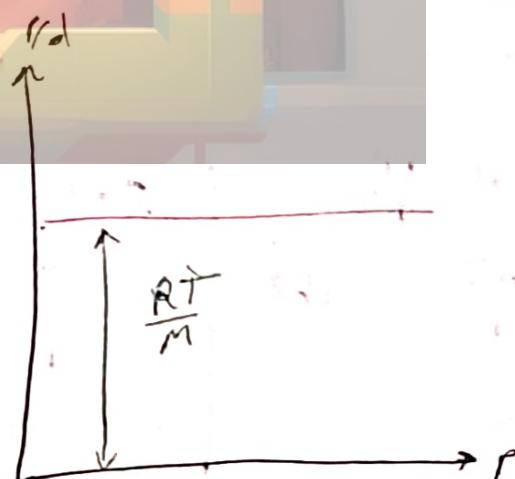
$$\frac{P}{P_M} \times \frac{RT}{M} = \frac{RT}{M} \quad \cancel{V \propto P}$$

$\cancel{\frac{P}{P_M}} = \cancel{\frac{RT}{M}}$ constant

$$\cancel{\frac{P}{P_M}} = \cancel{\frac{RT}{M}}$$

$$\cancel{\frac{P}{P_M}} = \cancel{\frac{RT}{M}} y$$

$$y = f(P_M)$$



Q22. 5g. SO_2 gas occupying 800 ml at 87°C , find temperature at which 10g. SO_2 gas will occupy 600 ml at same pressure.

$$PV = nRT$$

$$\frac{nT}{V} = \text{constant}$$

$$\frac{\frac{5}{64} \times \frac{360}{1730}}{800} = \frac{\frac{10}{64} \times \frac{T}{1730}}{600}$$

$$\frac{3 \times 260}{2 \times 1730} \times T$$

$$\boxed{T = 125 \text{ K}}$$

OTTOBLS
ARACTA
MECHANICAL

$$\boxed{T = -138^\circ\text{C}}$$

Q23. The density of ideal gas is 2.5 g/l at 227°C .

At what pressure at 227°C the density is 5 g/ml.

$$\cancel{PV = nRT}$$

$$\cancel{d = \frac{PM}{RT}}$$

$$d = \frac{PM}{RT}$$

$$\frac{dT}{P} = \text{constant}$$

$$\frac{2.5 \times 200}{2} = \frac{5 \times 500}{P}$$

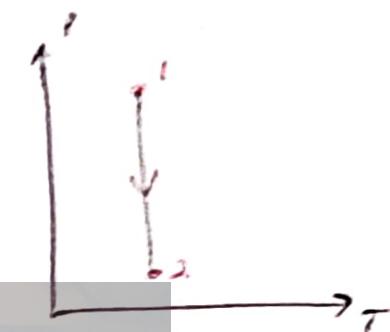
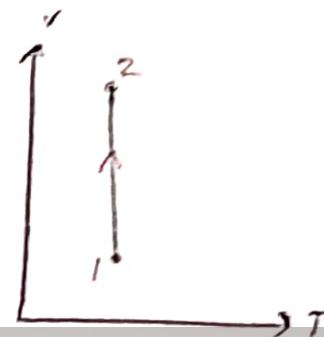
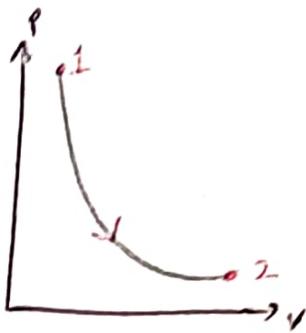
$$P = \frac{500 \times 2 \times 2}{3.0 \times 200}$$

$$\boxed{P = \frac{20}{3} \text{ Bar}}$$

Graph Conversions

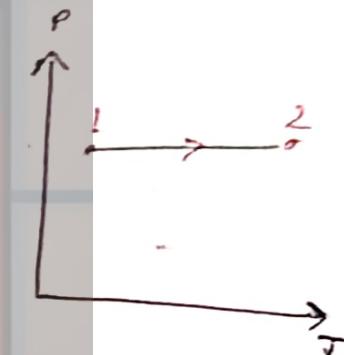
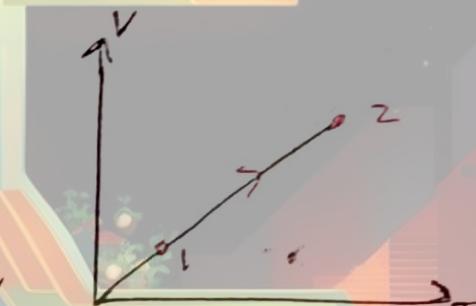
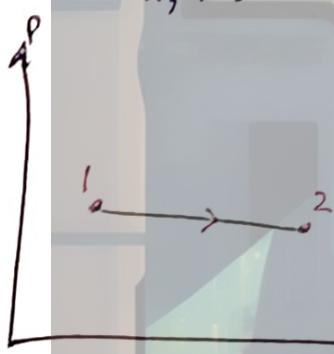
① Isotherms / Isothermal curve

$T, n = \text{constant}$

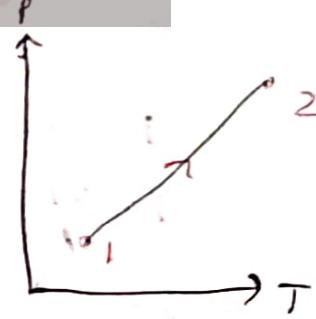
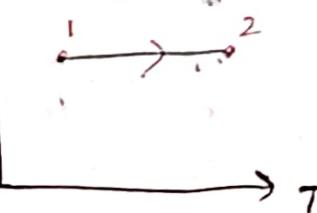


② Isobars / Isobaric graphs

$n, P \text{ constant}$



③ Isoches / Isochoric graphs



$n, V \rightarrow \text{constant}$

$$PV = nRT$$

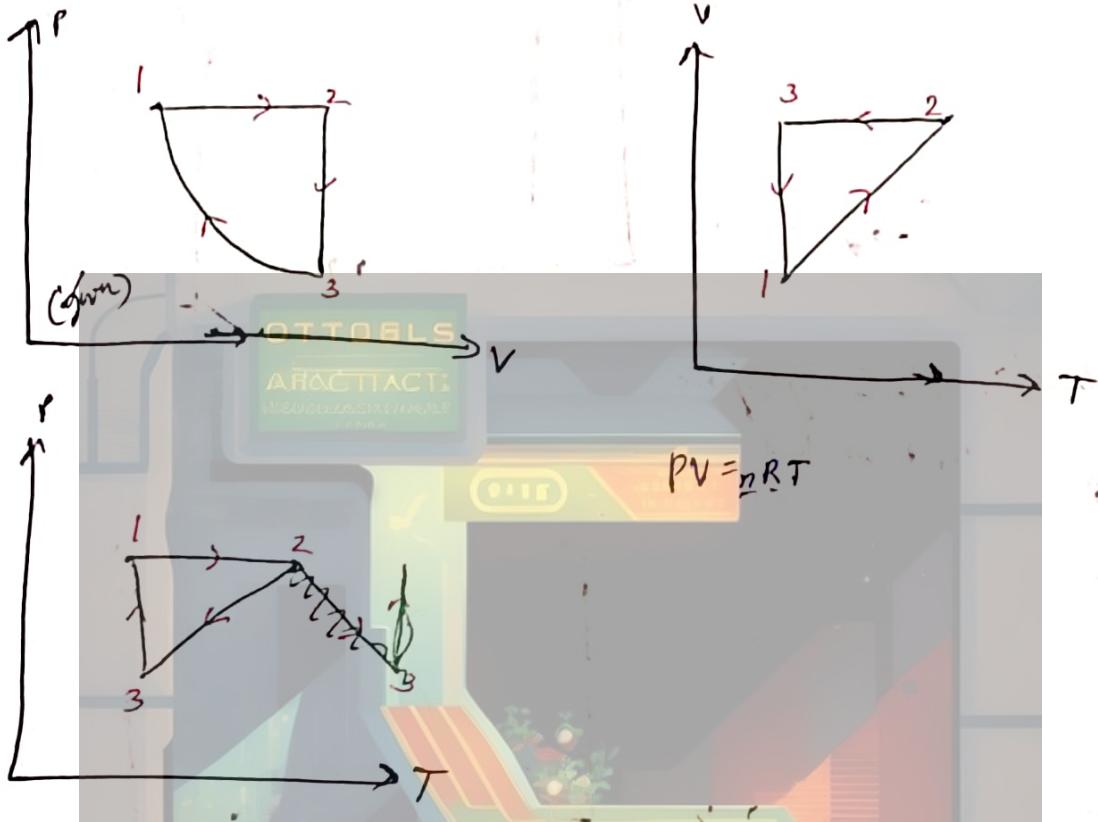
$$P \propto T$$

14.Wi 30-9-24

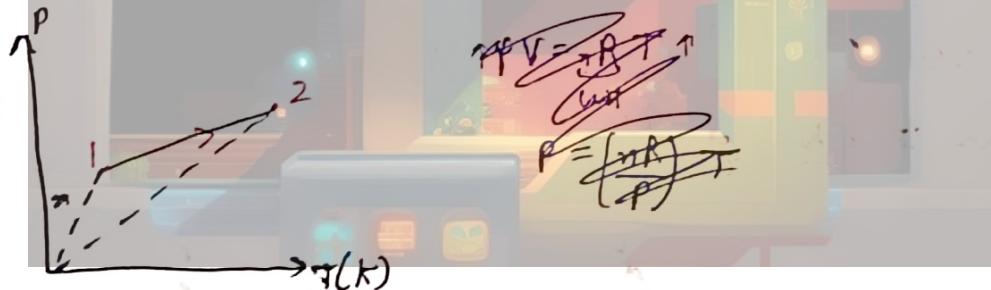
Q1 [1-25] [26-33]

S-1 [1-23] [24-33]

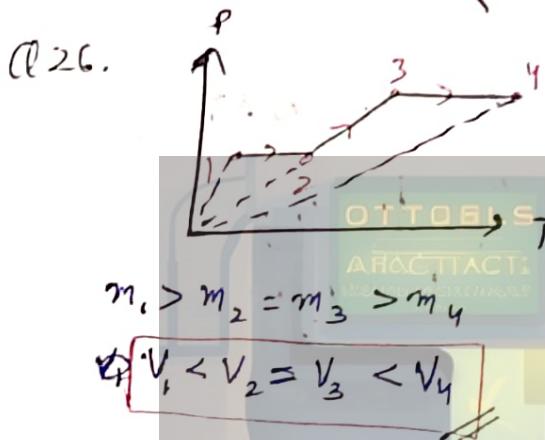
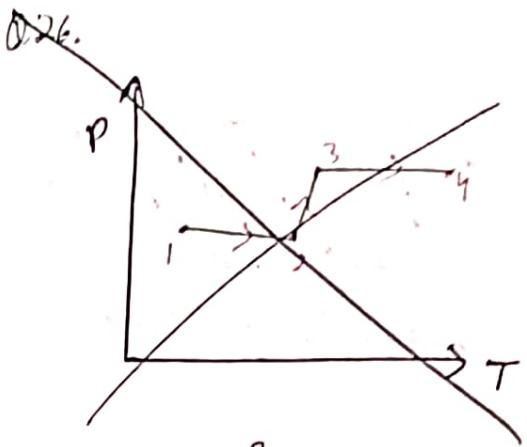
Q24. n -constant



Q25. 1 \rightarrow 2 expansion or contraction? n -constant.



$$\left. \begin{array}{l} PV = nRT \\ P = \left(\frac{nR}{V}\right)T \\ V = \frac{m}{R} \end{array} \right| \quad \begin{array}{l} m_1 > m_2 \\ \frac{nR}{V_1} > \frac{nR}{V_2} \\ V_2 > V_1 \end{array} \quad \text{expansion}$$

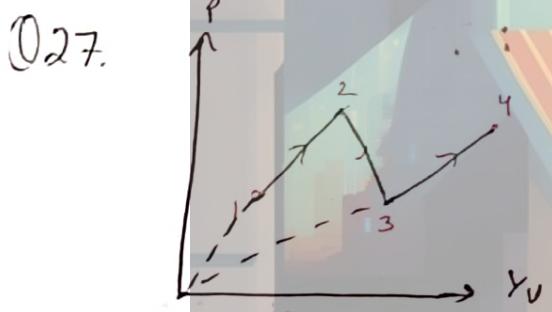


find order $V_1 V_2 V_3 \& V_4$.

$$PV = nRT$$

$$P = \frac{nR}{V} T$$

$$y = mx$$



find order of

$$T_1 T_2 T_3 \& T_4$$

$$PV = nRT$$

$$P = (nRT) \times \frac{1}{V}$$

$$y = mx$$

$$\cancel{m_1 = m_2 > m_3 > m_4}$$

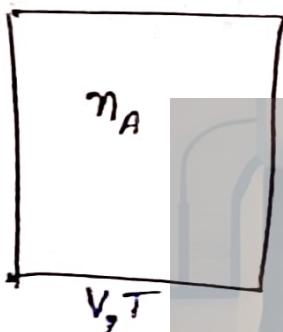
$$\cancel{T_1 = T_2 > T_3 = T_4}$$

$$m_1 = m_2 > m_3 = m_4$$

$$\boxed{T_1 = T_2 > T_3 = T_4}$$

Dalton's law of partial pressure:

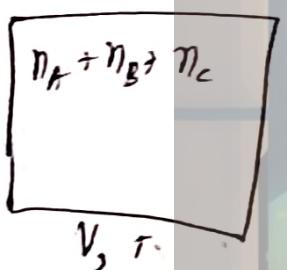
① Concept of partial pressure. - In a mixture of non-reacting gases, partial pressure of any component gas is defined as the pressure exerted by individual gas, if the ~~whole~~ of the ~~total~~ volume of the mixture had been occupied by this component gas only.



$$\text{Partial pressure of gas } A \Rightarrow P_A = \frac{n_A RT}{V} \quad \text{--- (1)}$$

$$\text{Partial pressure of gas } B \Rightarrow P_B = \frac{n_B RT}{V} \quad \text{--- (2)}$$

$$\text{Partial pressure of gas } C \Rightarrow P_C = \frac{n_C RT}{V} \quad \text{--- (3)}$$



$$P_T V = n_T RT$$

$$P_T V = (n_A + n_B + n_C) RT \quad \text{--- (4)}$$

$$P_T = P_A + P_B + P_C$$

Dalton's law:

→ In a mixture of non-reacting gases, the total pressure is equal to the sum of partial pressure or individual pressure at some temperature and some volume.

$$\frac{P_A}{P_T} = \frac{n_A}{n_A + n_B + n_C}$$

$$P_A = X_A P_T$$

$$P_B = X_B P_T$$

$$P_C = X_C P_T$$

$$\boxed{\text{Partial pressure of a component} = \text{mole fraction} \times P_T}$$

Note:- Partial pressure of any gas remains ~~not~~ unchanged by the addition of any other gas. Any non-reacting gas.

- Q28. Find the total pressure & partial pressure of each gas if 2 ~~1000~~ moles of A & 3 moles of B are kept in a container of a volume 8.21 l at 300 K.

$$P_A = n_A \times \frac{0.0821 \times 300}{8.21}$$

$$P_A = 3n_A$$

$$P_A = 6$$

$$P_B = 9$$

$$P_T = 15$$

- Q29. If 2 lit of gas A at 1.5 atm & 3 lit of gas B at 2 atm are mixed and kept at 5 l container. find total pressure & partial pressure of A & B [Assume the temp is constant].

$$\cancel{n_A RT = 3}$$

$$n_B RT = 6$$

$$n_T RT = 9$$

$$P_T = 9/5 \text{ atm}$$

$$P_A = \frac{3}{5} \text{ atm}$$

$$P_B = \frac{6}{5} \text{ atm}$$

Q38. 2 moles of N_2 gas & 6 mol H_2 gas are taken in a container of volume 8.21 l and 300 K. When they react to form NH_3 gas. find partial pressure of N_2 & H_2 if partial pressure of NH_3 after some time is 6 atm.

$$P_T (\text{final}) = \frac{n_T \times 0.0821 \times 300}{8.21}$$

$$P_T = 3 n_T$$

$$\frac{G}{3} = n_T$$

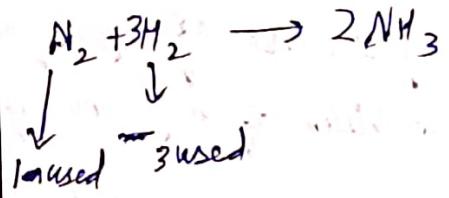
$$n_T = 2$$

$$n_{N_2} = 1 \text{ mol}$$

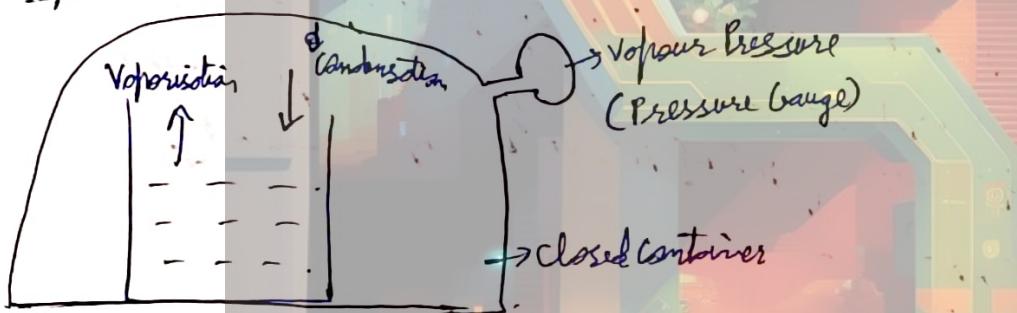
$$n_{H_2} = 3 \text{ mol}$$

$$P_{N_2} = 3 \text{ atm}$$

$$P_{H_2} = 9 \text{ atm}$$



Vapour Pressure



$$\text{at absolute temp} = T(K)$$

$$(\text{Rate of vaporisation}) = (\text{Rate of condensation})$$



→ In a closed container, the pressure exerted by the liquid vapour at equilibrium is called as vapour pressure of that liquid.

↓
rate of vaporisation - rate of condensation

→ Vapour liquid P is pressure exert by.

→ In case of H_2O Vapour Pressure (V.P.) is also known as aqueous tension. $760 \text{ torr at } 100^\circ\text{C}$

→ It depends only upon absolute temperature as long as temperature is same vapour pressure will not change.
 ↳ Vapour pressure does not depend on volume & amount of liquid taken.

→ It has been observed that gases are generally collected over water therefore they are moist.

Note:

$$P_{\text{Tot}} = P_{N_2} + P_{H_2O}$$

aq tension

$$= 740 + 20$$

$$= 760 \text{ torr}$$

$P_{\text{moist gas}} = \text{Pure gas} + \text{Aqueous tension}$

→ Aqueous tension depends only upon temperature. Therefore it varies with temperature $760 \text{ mm Hg at } 100^\circ\text{C}$

Q31. A closed container contains O_2 gas & some $H_2O(l)$ at $P_T = 640 \text{ mm Hg}$. If aqueous tension of water at this ^{and} depth is 40 mm Hg . Find the total pressure in mm Hg.

- i) Volume of container is doubled at some temp
- ii) Volume of container is halved at some temp.

$$i) P_T = P_{O_2} + P_{H_2O}$$

$$\therefore 640 = P_{O_2} + 40$$

$$\therefore P_{O_2} = 600 \text{ mm Hg}$$

$$\text{Volume of } O_2 = V$$

$$\text{mole of } O_2$$

$$PV = nRT$$

$$\frac{600V}{RT} = n$$

~~at pressure double~~

~~at double Volume,~~

$$PV = nRT$$

$$P \times 2V = \frac{600V}{RT} \times RT$$

$$P = \frac{600}{2}$$

$$P_{O_2} = 300 \text{ mm Hg}$$

$$P_T = P_{O_2} + P_{H_2O}$$

$$P_T = 300 + 40$$

$$\boxed{P_T = 340 \text{ mm Hg}}$$

ii) at half volume

$$P \times \frac{V}{2} = \frac{600V}{RT} \times RT$$

$$P = \frac{600 \times 2 \times V}{V}$$

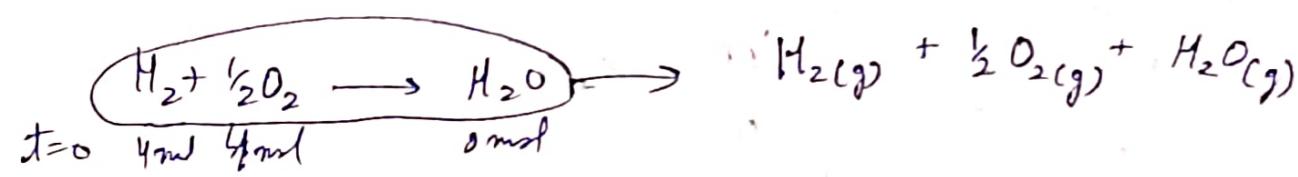
$$P_{O_2} = 1200 \text{ mm Hg.}$$

$$P_T = P_{O_2} + P_{H_2O}$$

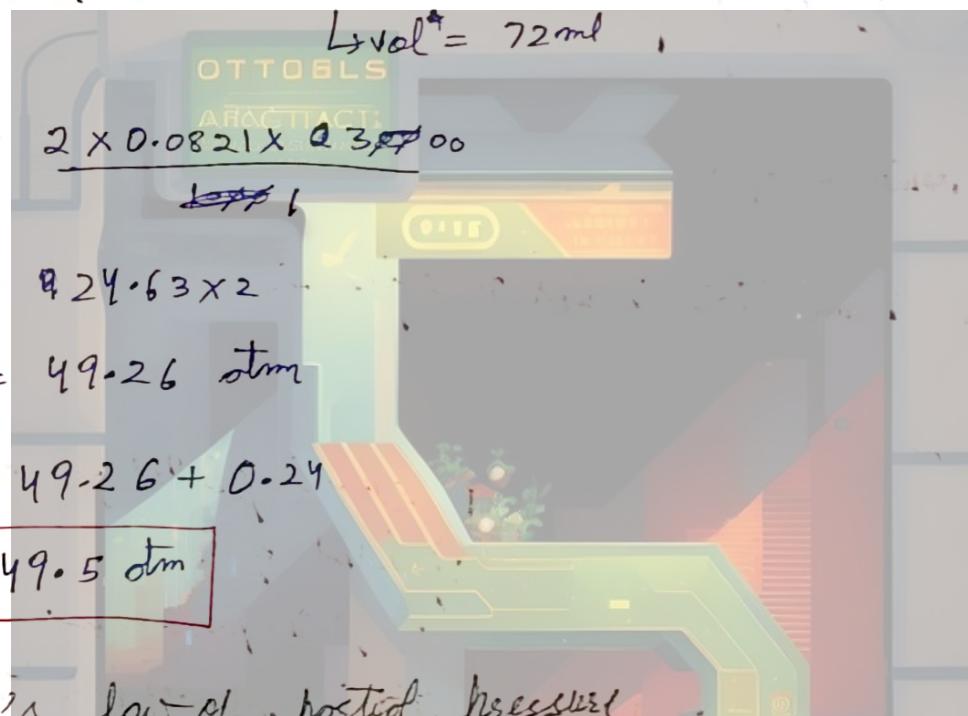
$$P_T = 1200 + 40$$

$$\boxed{P_T = 1240 \text{ mm Hg}}$$

(Q32.) If 4 moles of each H_2 & O_2 react in a vessel of volume 1072 ml at high temperature. After the reaction vessel is maintained at 27°C. find final pressure of all gases in ATM. (Given:- ~~atm~~ at Tension at 27°C = 0.24 atm)



$$t=t \quad 0\text{mol} \quad 2\text{mol} \quad 4\text{mol}$$



$$P_{O_2} = \frac{2 \times 0.0821 \times 23.00}{72.00}$$

$$P_{O_2} = 424.63 \times 2$$

$$P_{O_2} = 49.26 \text{ atm}$$

$$P_T = 49.26 + 0.24$$

$$P_T = 49.5 \text{ atm}$$

Amagat's law of partial pressure

→ According to this law, the total volume of non-reacting mixture of gases at constant pressure & Temperature should be equal to the sum of individual partial volume of constituent gases.

→ at const P, T

$$V_A = \frac{n_A RT}{P} = \text{partial volume of gas A} \quad \text{--- (1)}$$

$$V_B = \frac{n_B RT}{P} = \text{partial volume of gas B} \quad \text{--- (2)}$$

$$V_C = \frac{n_C RT}{P} = \text{partial volume of gas C} \quad \text{--- (3)}$$

Ques of Dalton's law

$$V_T = V_A + V_B + V_C$$

$$V_T = (n_A + n_B + n_C) \frac{RT}{V} \quad \text{--- (4)}$$

$$\textcircled{1} \div \textcircled{4}$$

$$\frac{V_A}{V_T} = x_A$$

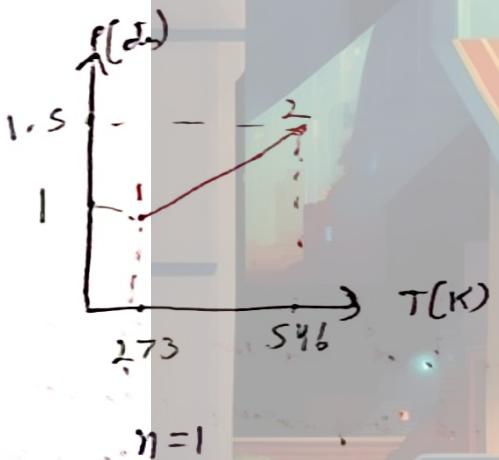
$$\frac{V_B}{V_T} = x_B$$

$$V_A = x_A \cdot V_T$$

~~Volume~~ Note \rightarrow

Labeled Volume = Total Volume × mole fraction

Q.33.



PT curve is plotted for one mole of ideal gas.

- i) Is the process ~~not~~ isochoric
- ii) Volume of point (I)

$$V_1 = \frac{1 \times 273 \times 0.0821}{1}$$

$$V_1 = 22.4 \text{ L} \quad \text{ii)}$$

$$V_2 = \frac{1 \times 546 \times 0.0821}{1.5}$$

$$V_2 \neq V_1 \neq 22.4$$

not isochoric i)

Q.34. The best vacuum as far attained is 10^{-10} mm Hg. What is the no. of molecules gas remain per cc at 20°C in this vacuum.

$$PV = nRT$$

$$n = \frac{PV}{RT}$$

$$n = \frac{10^{-10} \times 56.23}{10^3 \times 293}$$

$$m = 10^{-10} \times 10^{-3}$$

$$n_2 = \frac{10^{-10} \times 6.022 \times 10^{23}}{56.23 \times 293}$$

$$n_2 = \frac{6.022 \times 10^{23}}{56.23 \times 293} \times 10^{-10}$$

$$PV = nRT$$

$$m = \frac{PV}{RT}$$

$$n = \frac{10^{-3} \times 10^{-10}}{62.36 \times 293} \times 6.022 \times 10^{23}$$

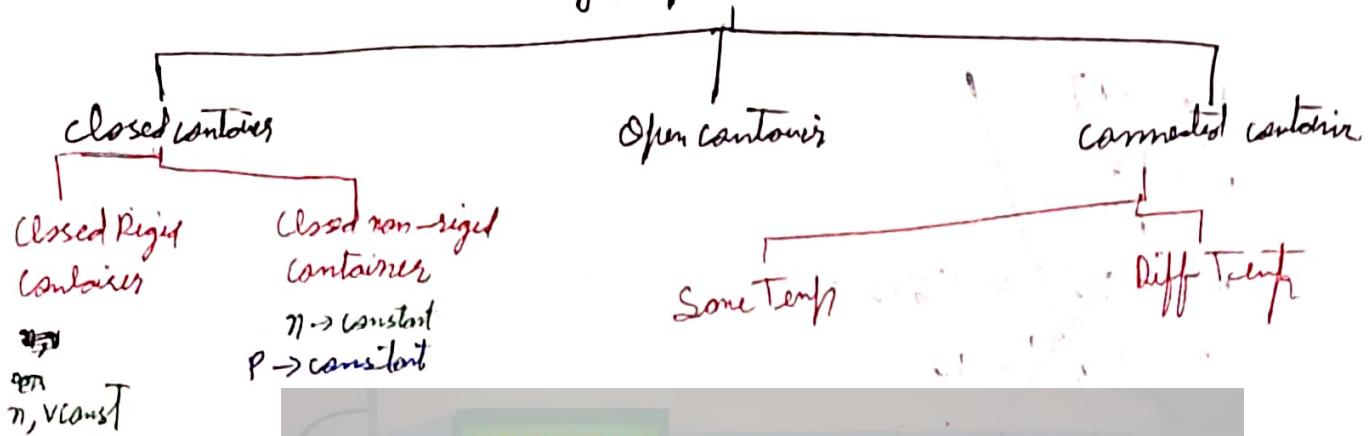
$$n = \frac{6.022 \times 10^{23}}{6236 \times 293}$$

$$n = \frac{3011}{3118 \times 293} \times 10^9$$

$$n = 3.2 \times 10^6$$

Problems related with diff type of containers

types of container



~~flow~~

Closed Rigid Vessel

$$n, V \rightarrow \text{constant}$$

$$PV = nRT$$

$$P \propto T (K)$$

$$\frac{P_1}{P_2} = \frac{T_1}{T_2}$$

→ On increasing temp, pressure also increases until max pressure is reached. After it explosion occurs.

e.g. gas cylinder

Closed non-rigid vessel $n, P \Rightarrow \text{constant}$

$$PV = nRT$$

$$V \propto T (K)$$

$$\frac{V_1}{V_2} = \frac{T_1}{T_2}$$

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

→ On increasing temperature, volume also increases until maximum volume is obtained. After this the vessel will burst.

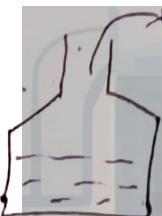
e.g. air bubble, balloon.

Q35. A balloon is inflated one-fifth of its maximum volume at 27°C. Find the temp. at which the balloon will burst.

$$\frac{V}{5} \times \frac{1}{300} = \frac{N}{T}$$

$$T = 1500 \text{ K}$$

Open rigid container



OTTOBLS
ARACTACT
MECHANISCHE
WIRKUNGEN

V \Rightarrow fixed

P \Rightarrow fixed maintained at 1 atm

$$T \uparrow \quad n_i - n_f = n_{\text{escaped}}$$

$$T \downarrow \quad n_f - n_i = n_{\text{entered}}$$

$$PV = nRT$$

V, P \rightarrow const

$$\Rightarrow n_1 T_1 = n_2 T_2$$

\rightarrow When air is heated in an open vessel/container, pressure is always atmospheric pressure (P \rightarrow const) & volume is constant.

Q36. An open vessel at 27°C contains air. Find the temperature upto which it should be heated so that

- $\frac{1}{3}$ of air in container measured initially escaped out
- $\frac{1}{3}$ of air left measured finally escaped out.

$$i) \quad n \times 300 = \frac{2m}{3} T_2 \quad ii) \quad \frac{4m}{3} \times 300 = n \times T$$

$$T = 450 \text{ K} \quad i)$$

$$T = 400 \text{ K} \quad ii)$$

Q37. Calculate the volume of an open container. It is heated from 27°C to 227°C & volume of escaped air was

i) $200\text{ ml at }27^{\circ}\text{C}$

ii) $200\text{ mlt }127^{\circ}\text{C}$

$$n_i \times 300 = n_f \Rightarrow x 500$$

$$n_f = \frac{3}{5} n_i$$

$$n_{\text{escaped}} = \frac{2}{5} n_i$$

$$PV = n RT$$

$$\text{or } n = \frac{PV}{RT}$$

$$n = \frac{1 \times 0.2}{0.0821 \times 300}$$

$$n = \frac{0.2}{24.63}$$

$$n = \frac{2}{246.3} \text{ mol}$$

$$n_f = \frac{5 \times 2}{246.3} \div \frac{5}{246.3} \text{ mol}$$

$$PV = n RT$$

$$V = \frac{5}{246.3} \times \frac{0.0821 \times 300}{1}$$

$$V = \frac{24.63 \times 5}{246.3 \times 10} = 0.5$$

$$\boxed{V = 500 \text{ ml}} \quad \text{i)}$$

$$n = \frac{PV}{RT}$$

$$n = \frac{1 \times 0.2}{0.0821 \times 500}$$

$$n_i = \frac{5}{2} \times \frac{0.2}{0.0821 \times 500}$$

$$V = \frac{5 \times 0.2}{0.0821 \times 1000} \times 0.0821 \times 500$$

$$V = 0.1 \text{ l}$$

$$V = 0.4 \text{ l}$$

$$\boxed{V = 400 \text{ ml}} \quad \text{ii)}$$

$$V = \frac{500}{3} \text{ ml}$$

$$V = \frac{2000}{3} \text{ ml}$$

$$V = \frac{2}{3} \text{ ml}$$

$$\boxed{V = \frac{2000}{3} \text{ ml}} \quad \text{iii)}$$

$$n_{\text{escape}} = \frac{0.2}{0.0821 \times 400}$$

$$n_1 = \frac{0.5}{0.0821 \times 400}$$

$$\cancel{P} V = \frac{0.5}{0.0821 \times 400} \times \frac{0.0821 \times 300}{1}$$

$$V = \frac{300}{400 \times 2}$$

$$V = \frac{3}{8}$$

$$V = \frac{3000}{8}$$

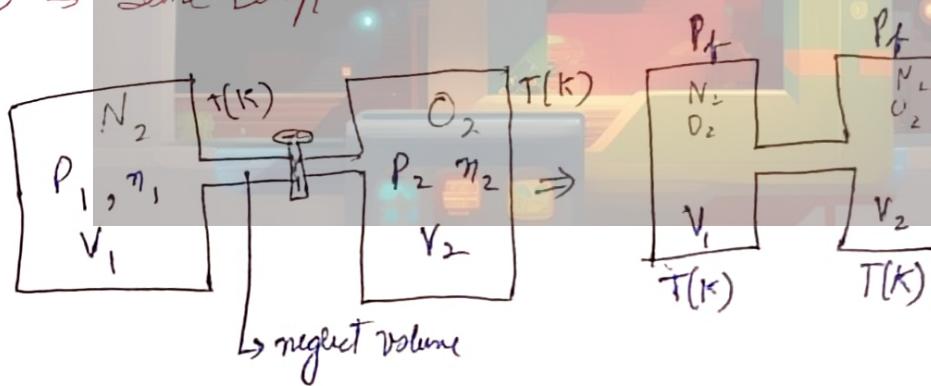
$$V = \frac{1500}{4}$$

$$V = \frac{750}{2}$$

$$\boxed{V = 375 \text{ ml}} \quad \text{ii)}$$

Connected Container

Case ① → Same Temp



$$n_T = n_1 + n_2$$

$$\cancel{P} \boxed{P_f V_f = P_1 V_1 + P_2 V_2}$$

$$P_{N_2} \times V_i = (P_b)_{N_2} \times V_f$$

$$(P_f)_{N_2} = ?$$

$$P_{O_2} \times V_2 = (P_b)_{O_2} \times V_f$$

$$(P_f)_{O_2} = ?$$

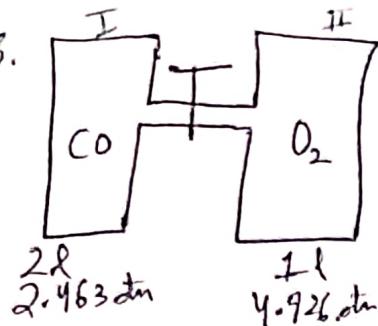
$$P_f = (P_b)_{O_2} + (P_f)_{N_2}$$



Ideal Gas

(Contd.)

Q 38.



Q. Determine final pressure if valve is opened for long time. (No reaction & tank is const.)

$$n_{O_2} = \frac{P_2 V_2}{RT}$$

$$P_f(O_2) = \frac{P_2 V_2 \times RT}{V_f}$$

$$P_f(O_2) = \frac{4.926 \times 1}{3}$$

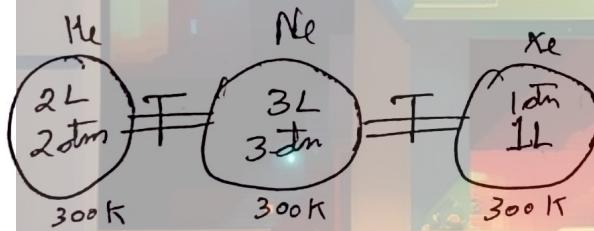
$$n_{CO} = \frac{P_1 V_1}{RT}$$

$$P_f(CO) = \frac{P_1 V_1}{RT} \times \frac{RT}{V_f}$$

$$P_f(CO) = \frac{2 \times 2.463}{3}$$

$$P_f = \frac{4.926 + 2.463}{3} = \frac{9.852}{3} = 3.285 \text{ dm}$$

Q 39.



find final pressure.

$$n_{He} = \frac{2 \times 2}{RT}$$

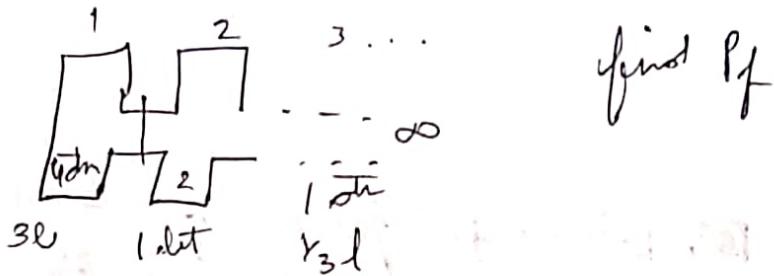
$$P_f(He) = \frac{9}{6}$$

$$P_f(He) = \frac{4}{6}$$

$$P_f(Ne) = \frac{1}{6}$$

$$P_f = \frac{14}{6} = \frac{7}{3} = 2.33 \text{ dm}$$

Q40.



find P_f

$$P_f = \frac{4 \times 3 + 2 \times 1 + 1 \times Y_3 \dots}{3 + 1 + Y_3 \dots}$$

$$P_f = 12 + \frac{12}{6} + \frac{12}{12} \dots \infty$$

OTTO CYCLE

$$= 3 + \frac{3}{3} + \frac{3}{9} \dots \infty$$

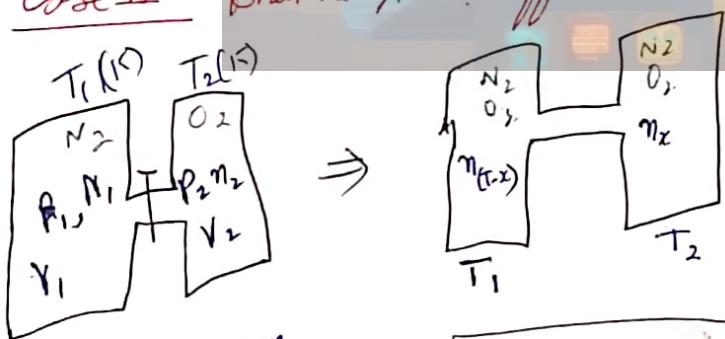
$$P_f = \frac{12 \times 6}{5}$$

$$P_f = \frac{3 \times 3}{2}$$

$$= \frac{12 \times 6 \times 2}{5 \times 3 \times 3}$$

$$P_f = \frac{16}{5} = 3.2 \text{ atm}$$

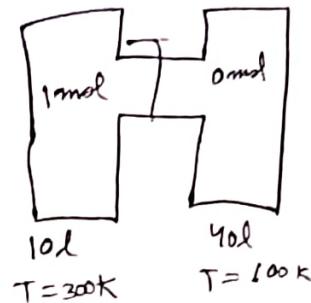
Case II when temp is different



$$\eta_T = \eta_1 + \eta_2$$

$$\frac{V_1}{(m_1 - x) T_1} = \frac{V_2}{x T_2}$$

Q41.



A 10L container contains 1 mol gas initially. When valve is opened equilibrium is attained

- find the moles of gas in small container
- find pressure

$$n_T = 1$$

ii)

$$PV = nRT$$

$$P_f = \frac{1}{10} \times 0.0821 \times 300$$

$$P_f = 0.821 \text{ atm}$$

$$\frac{10}{300(1-x)} = \frac{4x^2}{600x}$$

2 TTOBLS

ANACTIC

$$10x = 20 - 20x$$

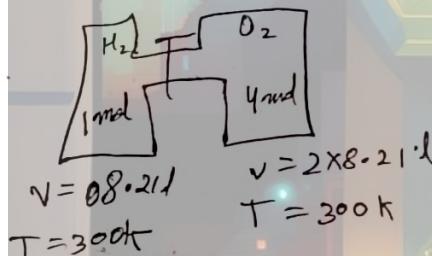
$$30x = 20$$

$$x = \frac{2}{3}$$

~~10x = 20
x = 2/3~~

$$\boxed{\text{in Small} = \frac{1}{3} \text{ mol}} \quad \text{i)}$$

Q42.

i) find P_{Total}ii) P_{H₂} & P_{O₂}iii) P_{O₂} find moles of O₂ gas in large container.

$$\frac{10}{300(5-x)} = \frac{2x}{300x}$$

$$n_T = 5$$

$$\frac{8.21}{300(5-x)} = \frac{2 \times 8.21}{300x}$$

$$x = 10 - 2x$$

$$x = \frac{10}{3}$$

$$\text{i) } P_f = \frac{10}{3} \times \frac{0.0821 \times 300}{8.21 \times 2} = 5 \text{ atm}$$

$$\boxed{P_f = 5 \text{ atm}} \quad \text{i)}$$

$$\text{ii) } P_{H_2} = \frac{1}{3} \times \frac{0.0821 \times 300}{8.21} = 1 \text{ atm}$$

$$\boxed{P_{H_2} = 1 \text{ atm}} \quad \text{ii)}$$

$$\boxed{P_{O_2} = 64 \text{ atm}} \quad \text{ii)}$$

$$\text{mole in large container} = \frac{10}{10} \cdot \frac{10}{3}$$

$$\text{mole } O_2 = \frac{3}{10} \times \frac{1}{5} \times 4 = \frac{12}{50}$$

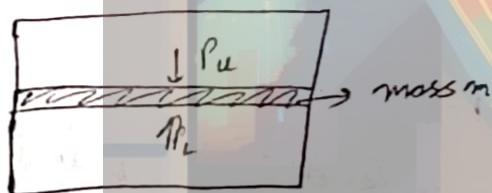
$$\text{mole } O_2 = \frac{10}{3} \times \frac{1}{5} \times 4 = \boxed{\frac{8}{3} \text{ mol}} \quad \text{iii)}$$

Problem related to piston



$$P_L = P_R$$

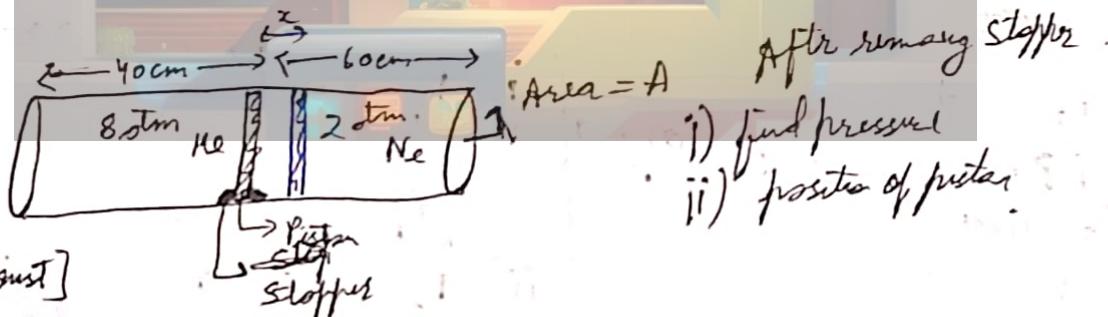
$$P_u = P_L$$



$$P_u + P_{\text{piston}} = P_{\text{air}}$$

Q43.

$$[T = \text{const}]$$



He: Boyle's law

$$P_1 V_1 = P_2 V_2$$

$$8(40A) = P \times A \times (40+x) \quad \text{---} \textcircled{1}$$

Ne $P_1 V_1 = P_2 V_2$

$$32 \times A \times 60 = P \times A \times (60-x) \quad \text{---} \textcircled{2}$$

$$\textcircled{1} \div \textcircled{2}$$

$$\frac{16 \times 8}{320} = \frac{40+x}{60-x}$$

$$480 - 8x = 120 + 3x$$

$$360 = 11x$$

$$x = \frac{360}{11} \text{ cm} \quad \text{ji})$$

$$P = \frac{8 \times A \times 40}{A \times (40+x)}$$

$$P = \frac{320}{440 + 360}$$

$$P = \frac{320 \times 11}{800}$$

$$P = \frac{22}{5} \text{ atm} \quad \text{ji})$$

Trick -1



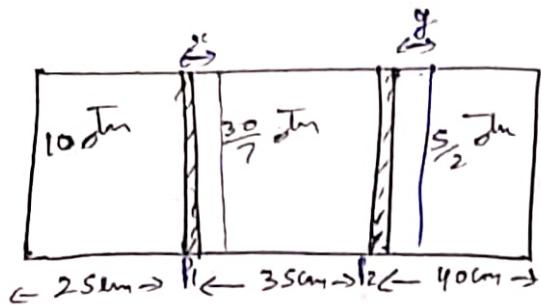
$T = \text{const}$

$$n_T = n_1 + n_2$$

$$P_T V_T = n_1 P_1 V_1 + n_2 P_2 V_2$$

$$P_T = \frac{P_1 l_1 + P_2 l_2}{l_1 + l_2}$$

Q44.



- find find Pressure
- find position of interface after removal.

$$P_f = \frac{P_1 l_1 + P_2 l_2 + P_3 l_3}{l_1 + l_2 + l_3}$$

$$10 \times 25 = 5 \times (25 + x)$$

$$50 = 25 + x$$

$$P_f = \frac{10 \times 25 + \frac{30}{7} \times 35 + \frac{5}{2} \times 40}{100}$$

$$x = 25 \text{ cm}$$

$$P_f = \frac{250 + 150 + 100}{100}$$

$$\frac{5}{2} \times 40 = 5 \times (40 - y)$$

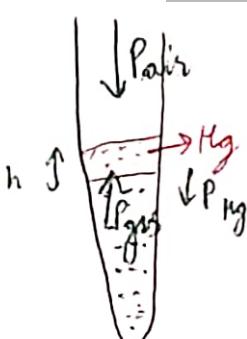
$$40 - y = 20$$

$$y = 20$$

$$P_f = 5 \text{ dm} \quad \boxed{i)$$

$$\boxed{\begin{array}{l} \text{listar}_1 = 50 \text{ cm} \\ P_2 = 80 \text{ cm} \end{array}} \quad \boxed{ii)}$$

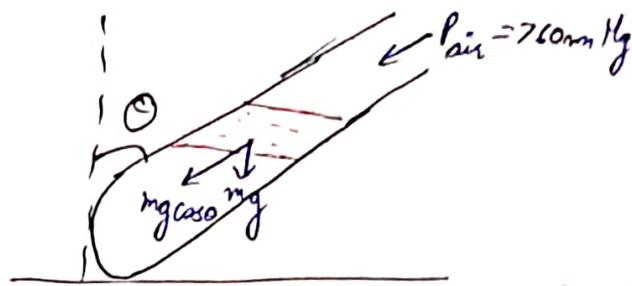
* Prof related to Mercury Tube.



$$P_{\text{atm}} + P_{\text{Hg}} = P_{\text{gas}}$$

$$760 + h = P_{\text{gas}}$$

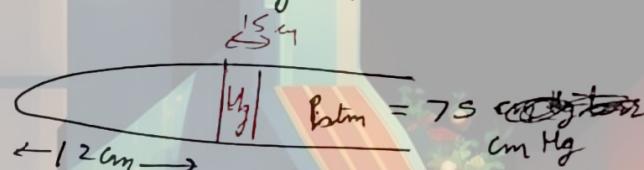
$$\boxed{P_{\text{gas}}(\text{mmHg}) = 760 + h}$$



$$P_{\text{gas}} = P_{\text{air}} + h g$$

$$P_{\text{gas}} (\text{mm Hg}) = 760 + h \cos \theta$$

Q45. An air column of length 12 cm was trapped by Hg columns shown in diagram.



- find length of air column when tube is held vertically with open end up.
- find length of air column when tube is vertically with open end down.

$$P_{\text{air}} = 750 + 150 \text{ mm Hg}$$

$$P_{\text{air}} = 900 \text{ mm Hg}$$

$$PV \rightarrow \text{Const}$$

$$P \cdot 120 \text{ cm} \times 120 \text{ cm} \leftarrow$$

$$PV = K$$

$$K = 120$$

$$V = \frac{K}{P}$$

$$PV = K$$

$$K = 120 \times 750$$

$$\leftarrow$$

$$P = 900$$

$$V = \frac{120 \times 750}{900}$$

$$V = \frac{12 \times 75}{9} = \frac{300}{3} = 100 \text{ cm}^3$$

$$V_1 = 10 \text{ cm}^3$$

a)

$$b) P_{air} = 750 - 150$$

$$P_{air} = 600 \text{ mm Hg}$$

$$V_2 = \frac{K}{P}$$

$$V_2 = \frac{120 \times 750}{600} = \frac{9 \times 75}{2} = 150$$

$$V_2 = 150 \text{ cm}^3$$

c) At 30° from vertical.

$$P_{air} = 750 + 150 \times \frac{\sqrt{3}}{2}$$

$$P_{air} = 750 + 75\sqrt{3}$$

$$V = \frac{120 \times 750}{750 + 75\sqrt{3}}$$

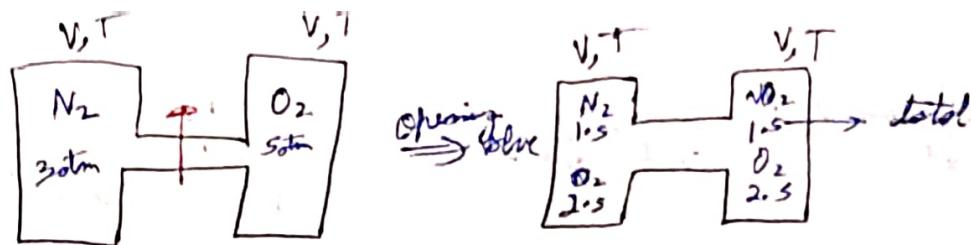
$$V = \frac{1200}{10 + \sqrt{3}}$$

$$V = \frac{120}{10 + \sqrt{3}} \text{ cm}^3$$

$$\underline{V = 10.22 \text{ cm}^3}$$

Diffusion & Effusion:

① **Diffusion** :- It is the process of gradual intermixing of gases due to their molecular motion.



→ when the valve is opened, nitrogen & oxygen will try to equalise its partial pressure in both vessels.

~~Effusion~~

Effusion - It is the process of forcing a gas through a pinhole, orifice or aperture from one compartment to another empty vacuum compartment.



$$\text{rate of diffusion} (\text{r}) = \frac{PA_0}{(2\pi M RT)^{1/2}} \rightarrow \text{symbols not indicated.}$$

~~A → Area~~

P → Pressure of gas
 A₀ → area of Aperture
 M → molar mass of gas

Graham's law of diffusion / effusion -

→ Under similar condition of temperature and pressure, rate of diffusion of different gases is inversely proportional to square root of molar mass of gas.

too

$$\text{rate of diffusion} (r) \propto \frac{1}{\sqrt{M}} \propto \frac{1}{\sqrt{d}} \propto \frac{1}{\sqrt{V \cdot D}} \Rightarrow r = \frac{PM}{RT}$$

$P, R, T \rightarrow \text{constant}$

$$r \propto \frac{1}{\sqrt{M}} \propto \frac{1}{\sqrt{d}} \propto \frac{1}{\sqrt{V \cdot D}}$$

$\Rightarrow r \Rightarrow \text{rate of diffusion}$

$d \Rightarrow \text{density of gas}$

$M \Rightarrow \text{molar mass of gas}$

$$\frac{r_1}{r_2} = \sqrt{\frac{M_2}{M_1}} = \sqrt{\frac{d_2}{d_1}} = \sqrt{\frac{V D_2}{V D_1}}$$

→ Under condition of same temperature but different pressure

$$r \propto \frac{P}{\sqrt{m}}$$

$$\frac{r_1}{r_2} = \frac{P_1}{P_2} \sqrt{\frac{m_2}{m_1}}$$

→ If both the gases are present in some container at constant temperature

$$\frac{r_1}{r_2} = \frac{n_1}{n_2} \sqrt{\frac{m_2}{m_1}}$$

* Expression of rate of diffusion/effusion.

$$\text{Rate} = \frac{\text{Volume of gas effused}}{\text{Time Taken}} = \frac{V}{t}$$

$$\text{Rate} = \frac{\text{moles of gas diffused}}{\text{Time Taken}} = \frac{n}{t}$$

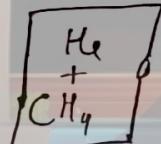
$$\text{Rate} = \frac{\text{decrease in pressure of gas}}{\text{Time Taken}} = \frac{P}{t}$$

~~Rate = distance travelled by gas in a horizontal tube of uniform cross section~~

~~Rate = Distance travelled by gas in a horizontal tube of uniform cross section~~

Time Taken

Q16.



Nothing given:-

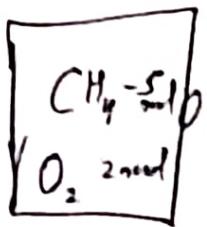
P, T, n → Constant

$$\frac{r_{H_2}}{r_{CH_4}} = ?$$

$$\frac{r_{H_2}}{r_{CH_4}} = \sqrt{\frac{M_{CH_4}}{M_{H_2}}} = \sqrt{\frac{16}{4}} = 2$$

Helium $\overset{2x}{\text{speed}}$ se niklegi compound
to CH₄

Q4 7.



P, T \Rightarrow constant

$$\frac{r_{\text{CH}_4}}{r_{\text{O}_2}} = \frac{n_{\text{CH}_4}}{n_{\text{O}_2}} \sqrt{\frac{M_{\text{O}_2}}{M_{\text{CH}_4}}}$$

$$= \frac{5}{2} \times \sqrt{\frac{32}{16}}^2$$

$$\boxed{= \frac{5\sqrt{2}}{2}}$$

Note:- If area of cross-section of small ~~orifice~~ ^{hole} is changed then (keeping other parameters same)

$$\boxed{r \propto A}$$

A - area of hole/orifice.

Q48. 32 ml He diffused through a fine orifice in 60 s. What volume of CH₄ will be effused in 60 s under similar conditions.

$$\frac{r_{\text{CH}_4}}{r_{\text{He}}} = \sqrt{\frac{M_{\text{He}}}{M_{\text{CH}_4}}} = \sqrt{\frac{4}{16}} = \frac{1}{2}$$

$$r_{\text{He}} = \frac{32}{60}.$$

$$r_{\text{CH}_4} = \frac{2 \cdot 32}{60} \times \frac{1}{2}$$

$$r_{\text{CH}_4} = \frac{16}{60}$$

$$\text{Vol}_{\text{CH}_4} = \frac{16}{60} \times 60 \text{ s}$$

$$\boxed{\text{Vol} = 16 \text{ ml}}$$

Q49. A mixture of H_2 & O_2 in 2:1 molar ratio is allowed to diffuse through an orifice. Calculate the composition of gases coming out initially ($\frac{n'_{H_2}}{n'_{O_2}} = ?$)

$$\frac{n_{H_2}}{n_{O_2}} = \frac{2}{1}$$

$$\frac{n'_{H_2}}{n'_{O_2}} = \frac{r_{H_2}}{r_{O_2}} = \frac{n_{H_2}}{n_{O_2}} \sqrt{\frac{M_{O_2}}{M_{H_2}}} \\ = \frac{2}{1} \times \sqrt{\frac{32}{2}} \\ = 8$$

Q50. 1 mol N_2 at 0.8 atm takes 38 sec through a fine hole. where 1 mol of an unknown compound I of Xenon with fluorine at 1.6 atm takes 57 s to diffuse through the same hole. Determine molecular formula of compound I ($Xe = 131$)

$$\frac{r_1}{r_2} = \frac{1/38}{1/57} = \frac{0.8}{1.6} \sqrt{\frac{M}{28}}$$

$$\frac{57 \times 1.6}{0.8 \times 38} = 9$$

$$XeF_n \quad \cancel{XeF_6}$$

$$131 + \frac{19}{9}n = 252$$

$$19n = 121$$

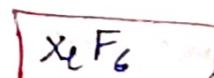
$$n = \frac{121}{19}$$

$$n = 6$$

$$\frac{M}{28} = 9$$

$$M = 28 \times 9$$

$$M = 252$$



Q 51. Pure O₂ diffuse through an aperture in 224 s whereas mixture of O₂ and another gas containing 75% O₂ by moles takes 336 sec to effuse out some volume. What is the molecular mass of gas.

$$\frac{x}{224} \times \frac{336}{x} = \sqrt{\frac{M}{32}}$$

2

$$\frac{9}{4} = \frac{M}{32}$$

$$M = 9 \times 8$$

$$M = 72$$

~~$$75 \times 32 + x \times 25 = 7200$$~~

~~$$25x = 2400$$~~

$$25x = 4800$$

$$x = \frac{48 \times 100}{25}$$

$$x = 192$$

Q 52. A class contain 13 equidistant rows of bench. A teacher release the laughing gas (N₂O) from first row, while a student release tear gas (C₂H₈OBr) from last. find no. of bench from first row at which student starts laughing & weeping simultaneously.

$$\frac{r_c N_2 O}{r_c C_6 H_8 O Br} = \sqrt{\frac{M_2}{M_1}} = \sqrt{\frac{176}{44}} = \sqrt{\frac{88}{22}} = 2$$

$$2x = 13 - x$$

~~20~~

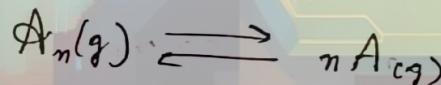
$$3x = 13$$

$$x = \frac{13}{3}$$

$$\begin{aligned} x &= 4 \\ x &= 4 \\ 2x &= 13 \\ 2x &= \frac{26}{3} \\ 2x &= 8.666 \end{aligned}$$

$$2x \approx 9$$

Q53. At a particular fixed temperature the gas ~~at~~ ^{at} 'A_n' is 52%. dissociated according to following reaction.



The equilibrium mixture effuses $\frac{5}{4}$ times slower than the pure O₂. Under identical conditions, if atomic weight of A is 32. find n?

$$\begin{aligned} r_2 &= r_1 - \frac{5r_1}{4} \\ \frac{r_{O_2}}{r_{A_n}} &= \frac{4}{5} = \sqrt{\frac{m}{32}} \\ \frac{16}{32} \times 32 &= M \\ 25 & M = \frac{32 \times 16}{25} \end{aligned}$$

$$\frac{r_m}{r_{02}} = \frac{4}{5} = \sqrt{\frac{32}{M}}$$

$$\frac{16}{2s} = \frac{32}{M}$$

$$M = 50$$

$$50 = \frac{32}{1 + (n-1)0.52}$$

$$50 + 26(n-1) = 32n$$

$$26n - 26 = 32n - 50$$

$$n = \frac{8}{26}$$

$$\frac{r_m}{r_{02}} = \frac{4}{5} = \sqrt{\frac{32}{M}}$$

$$\frac{32}{M} = \frac{16}{2s}$$

$$M = 50$$

$$\lim A_n \rightarrow A$$

$t=0$	100
$t=1$	48
	52

$$32n(48) + n32(52) = 5000$$

$$48n + 52n = \frac{5000}{32}$$

$$n = \frac{50}{32}$$

$$\frac{r_m}{r_{02}} = \frac{4}{5} = \sqrt{\frac{32}{M}}$$

$$\frac{32}{M} = \frac{16}{2s}$$

$$M = 50$$

$$50 = \frac{32n}{1 + (n-1)0.52}$$

$$50 + 26(n-1) = 32n$$

$$26n - 26 = 32n - 50$$

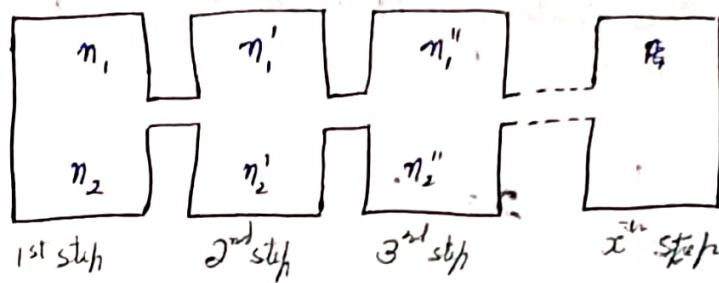
$$24 = 6n$$

$$n = \frac{24}{6}$$

$$\boxed{n=4}$$

Successive Effusion

→ used for separation of gases



Step 1

$$\frac{r_1}{r_2} = \frac{n_1}{n_2} \sqrt{\frac{M_2}{M_1}} \Rightarrow \frac{n_1/t}{n_2/t} = \frac{n_1}{n_2} \left(\frac{M_2}{M_1}\right)^{1/2}$$

$$\frac{n_1'}{n_2'} = \frac{n_1}{n_2} \left(\frac{M_2}{M_1}\right)^{1/2} \quad \dots \quad \textcircled{1}$$

enrichment or factor
Isotopic separation factor

Step 2

initial moles:- n_1' & n_2'

$$\frac{r_1}{r_2} = \frac{n_1'}{n_2'} \left(\frac{M_2}{M_1}\right)^{1/2}$$

$$\left(\frac{n_1'/t}{n_2'/t}\right) = \frac{n_1'}{n_2'} \left(\frac{M_2}{M_1}\right)^{1/2}$$

$$\frac{n_1''}{n_2''} = \frac{n_1'}{n_2'} \left(\frac{M_2}{M_1}\right)^{1/2}$$

$$\frac{n_1''}{n_2''} = \left(\frac{n_1}{n_2}\right) \left(\frac{n_2}{n_1}\right)^{1/2} \left(\frac{M_2}{M_1}\right)^{1/2}$$

$$\frac{n_1''}{n_2''} = \left(\frac{n_1}{n_2}\right) \left[\left(\frac{M_2}{M_1}\right)^{1/2}\right]^2$$

Put $\frac{n_1'}{n_2'}$ from $\textcircled{1}$

Step - x

$$\left(\frac{n_1}{n_2}\right)_{x^{\text{th}} \text{ step}} = \left(\frac{n_1}{n_2}\right) \left[\frac{M_2}{M_1}\right]^{\frac{x}{2}}$$

Q.54. A mixture of Nitrogen (N_2) & Hydrogen (H_2) has initially mass ratio of 196:1. Then find how many steps we can obtain a mixture containing 1:14 mole ratio of N_2 & H_2 ?

mole ratio initial

$$\frac{196}{28} : \frac{1}{2}$$

$$2 = \frac{x}{2}$$

$$2 \times 2 = \frac{x}{2} \times 2$$

$$\frac{1}{14} = \frac{14}{1} \left(\frac{2}{28}\right)^{\frac{x}{2}}$$

$$\frac{1}{14 \times 14} = \left(\frac{1}{14}\right)^{\frac{x}{2}}$$

$$\left(\frac{1}{14}\right)^2 = \left(\frac{1}{14}\right)^{\frac{x}{2}}$$

$$2 \times 2 = x$$

$$x = 4$$

4 steps

Note:- enrichment factor

$$f = \left(\frac{M_2}{M_1}\right)^{\frac{x}{2}} = \frac{\text{find mole (After x steps)}}{\text{initial mole}}$$

Q.55. The no. of effusion steps needed to convert the mole ratio of SO_2 & SO_3 from 16:25 to 5:4.

$$\frac{5}{4} = \frac{16}{25} \left(\frac{80}{64}\right)^{\frac{x}{2}}$$

$$\frac{x}{2} = 3$$

$$x = 6$$

$$\frac{125}{64} = \left(\frac{5}{4}\right)^{\frac{x}{2}}$$

* Kinetic Theory of Gases (KTG)

Assumptions or postulates:

1. → In a sample of ideal gas, the volume occupied by the gas particles is negligible as compared to the volume of container in which the gas is kept i.e. the gas particle are considered to be point masses.
This assumption explains greater compressibility of gases.
2. → There are no force of attraction between gas particles that's why gases occupy all the available space.
3. → In a gaseous sample, the gas particle are in a state of constant random motion. These particle travel in straight line. (Gravity ilm han mass ept nahi horegi)
Gravity gayi hao h moj.
- If the particles were at rest, then occupied fixed position & a gas would have fixed a shape which is not observed..
4. → All the collisions occurring between particles of gaseous sample are considered to be elastic collisions.
This means that the total energy of ~~molecules~~ gaseous sample before & after collision remains same, there may be exchange of energies for individual particle.
5. → At any instant, different particles in the gas have different speed, hence different kinetic energy.

→ This assumption is reasonable because as the particle collide we expect their speed will change but at the same time the distribution of speed of molecule remains constant at a particular temperature.

6. → Average Kinetic Energy of gaseous particle depends only on absolute temperature of gas.

$$KE_{\text{one particle}} = \frac{3}{2} kT$$

$k \Rightarrow$ Boltzmann constant

$T \Rightarrow$ Kelvin

$$k = \frac{R}{N_A} = 1.38 \times 10^{-23} \text{ J/K}$$

Kinetic gas Eq:-

$$PV = \frac{1}{3} m N u_{\text{rms}}^2$$

$P \Rightarrow$ Pressure exerted by gas

$V \Rightarrow$ Volume of gas / vol of container

$m \Rightarrow$ mass of one particle of gas

$N \Rightarrow$ no. of gas particles

$U_{\text{rms}} \Rightarrow$ root mean square speed. \rightarrow

$$\sqrt{\frac{u_1^2 + u_2^2 + u_3^2 + \dots}{N}}$$

$$U_{\text{rms}} \Rightarrow \sqrt{\frac{\sum_{i=1}^n (u_i)^2}{n}}$$

absolute temp

from Maxwell Eqn

$$U_{\text{rms}} = \sqrt{\frac{3RT}{M}}$$

→ molar mass

$$PV = \frac{1}{3} m N \frac{3RT}{M}$$

$$PV = \frac{m N R T}{M}$$

$$PV = (m N_A) \frac{N}{N_A} \times \frac{RT}{M}$$

$$PV = M \times n \times \frac{RT}{M} \Rightarrow$$

$$PV = nRT$$

Hence, prove

$$KE_{\text{molecule}} = \frac{1}{2} m u^2$$

$$\begin{aligned}\text{avg } KE_{\text{molecules}} &= \frac{1}{2} m \sum u^2 \\ &= \frac{1}{2} m N \bar{u}^2 \\ &= \frac{1}{2} m N \left(\frac{3RT}{M} \right)\end{aligned}$$

$$KE_{\text{mole}} = \frac{1}{2} m N_A \times \frac{N}{N_A} \times \frac{3RT}{M}$$

$KE_{\text{mole}} = \frac{3}{2} RT$

ABSTRACT
Molecular motion

$$KE_{\text{mol}} = \frac{3}{2} RT$$

$$KE_{\text{particle}} = \frac{3}{2} \times \frac{R}{N_A} \times T$$

$$KE_{\text{particle}} = \frac{3}{2} k T$$

Place braces

Maxwell Boltzmann speed distribution:-

→ According to Maxwell Equation, no. of molecules moving in a range of speed remains constant with time at constant at a particular temperature.

$dN = 4\pi N \left(\frac{M}{2\pi kT} \right)^{3/2} \cdot u^2 e^{-\frac{Mu^2}{2kT}} \cdot du$

good ratio term

$dN \Rightarrow$ no. of particles with speed b/w u & $(u+du)$

$N \Rightarrow$ total no. of gas particle inside container.

$M \Rightarrow$ Molecular wt of gas $\left[\text{SI units} \right]$

$T \Rightarrow$ Temp on Kelvin scale

$$\left(\frac{dn}{N} \right) = 4\pi \left(\frac{m}{2\pi RT} \right)^{3/2} u^2 e^{-\frac{mu^2}{2RT}} du$$

→ fraction of gas particles having speed b/w u to $(u+du)$

→ different types of molecular speed can be calculated from Maxwell eqn.

* Diff Types of molecular speed

OTTOBLIS

AERACTIA

① U_{rms} (Root mean Square speed)

$$U_{rms} = \sqrt{\frac{3RT}{M}} = \sqrt{\frac{3kT}{m}}$$

$M \rightarrow$ molar mass
 $m \rightarrow$ mass of one particle

$$d = \frac{PM}{RT}$$

$$\frac{RT}{M} = \frac{P}{d}$$

$$U_{rms} = \sqrt{\frac{23P}{d}}$$

② U_{avg} (Average speed)

$$U_{avg} = \frac{u_1 + u_2 + \dots}{N}$$

$$U_{avg} = \sqrt{\frac{8RT}{12N}} = \sqrt{\frac{8kT}{\pi dm}} = \sqrt{\frac{8P}{Rd}}$$

③ U_{mp} (most probable speed)

→ It is speed possessed by max fraction η of gas particle

$$U_{mp} = \sqrt{\frac{2RT}{m}} = \sqrt{\frac{2PKT}{m}} = \sqrt{\frac{2P}{d}}$$

Note:- ① for some gas at const temp

$$U_{rms} : U_{avg} : U_{mp}$$

$$\sqrt{3} : \sqrt{8/3} : \sqrt{2}$$

~~$$1.73 : 0.92 : 1.41$$~~

$$1.73 : 1.59 : 1.404$$

$$U_{rms} > U_{avg} > U_{mp}$$

Note:- use SI units for formula of $K T G_i$

$$R = 8.314 = \frac{2S}{3} \text{ J/mol K}$$

Q 56. Calculate V_{rms} of H_2 under given conditions

a) 2 mol H_2 at $27^\circ C$

b) 3 mol of H_2 in slit at 10^5 Pa

c) 4 mol H_2 at $d = 1 \text{ g/ml}$ at 10^5 Pa

~~$$d) V_{rms} = \sqrt{\frac{2RT}{m}} = \sqrt{\frac{2 \times 8.314 \times 300}{3}}$$~~

~~$$e) V_{rms} = \sqrt{\frac{2RT}{m}} = \sqrt{\frac{3 \times 2S \times 300}{2 \times 10^{-3}}} = \frac{3750}{2500} \times 10^{-3}$$~~

$$V_{rms} = \sqrt{3750000} = 100\sqrt{375} = 500\sqrt{15} = 1936.4916731027 \text{ m/s}$$

~~$$f) V_{rms} = \sqrt{\frac{5 \times 10^{-3}}{2S}} = \sqrt{\frac{5}{2S} \times T}$$~~
$$T = \frac{5}{2S} \times 10^2$$
$$T = 20 \text{ K}$$

$$V_{rms} = \sqrt{\frac{2 \times 25}{3} \times \frac{25}{2}} = \sqrt{\frac{500}{3} \times 1000} = \sqrt{100 \cdot \frac{50}{3}} = \sqrt{500 \cdot \frac{2}{3}}$$

c) $10^5 \times 8 \times 10^{-6} = 4 \times \frac{25}{3} \times T$

$$T = \frac{0.8 \times 3}{100}$$

$$T = 24 \times 10^{-3}$$

$$V_{rms} =$$

$$\sqrt{\frac{2 \times 25}{3} \times \frac{24}{2} \times 10^{-3}}$$

$$V_{rms} = 10\sqrt{25}$$

$$V_{rms} = 10\sqrt{25}$$

$$V_{rms} = \sqrt{\frac{3P}{d}}$$

$$= \sqrt{\frac{3 \times 10^5}{6 \cdot 2}} \times 5$$

$$= 100 \sqrt{\frac{50}{2}}$$

$$= 6 \times 10^{-3}$$

$$d = 1000 \text{ kg/m}^3$$

$$d = \sqrt{\frac{3 \times 10^5}{10^3}}$$

$$d = \sqrt{300} = 10\sqrt{3}$$

!) $d = \frac{6}{5} \text{ kg/m}^3$

$$V_{rms} = \sqrt{\frac{3 \times 10^5}{\frac{6}{5}}} = \sqrt{\frac{5}{2} \times 10^5} = 500 \text{ m/s}$$

(Q57) Two containers A & B of equal capacity are maintained at 300 K & 600 K respectively. A contains H₂ while B contains CH₄.

- a) $\frac{P_A}{P_B}$
- b) $\frac{\text{(Total KE)}_A}{\text{(Total KE)}_B}$
- c) $\frac{\text{(Molar KE)}_A}{\text{(Molar KE)}_B}$
- d) $\frac{(V_{RMS})_A}{(V_{RMS})_B}$

a) $P_A = \frac{m}{2} \times R \times 300$ $\frac{P_A}{P_B} = \frac{150}{600} \times \frac{16}{4} = \boxed{4}$

$P_B = \frac{m}{16} \times R \times 600$

c) $KE_{\text{mol}} = \frac{3}{2} RT$
 ~~$KE_A = \frac{3}{2} R \times 300$~~
 $KE_B = \frac{3}{2} R \times 600$

$\frac{KE_A}{KE_B} = \frac{1}{2}$

d) $\sqrt{\frac{3R \times 300}{2}} = \sqrt{\frac{16 \times 300}{600 \times 2}} = \boxed{2}$

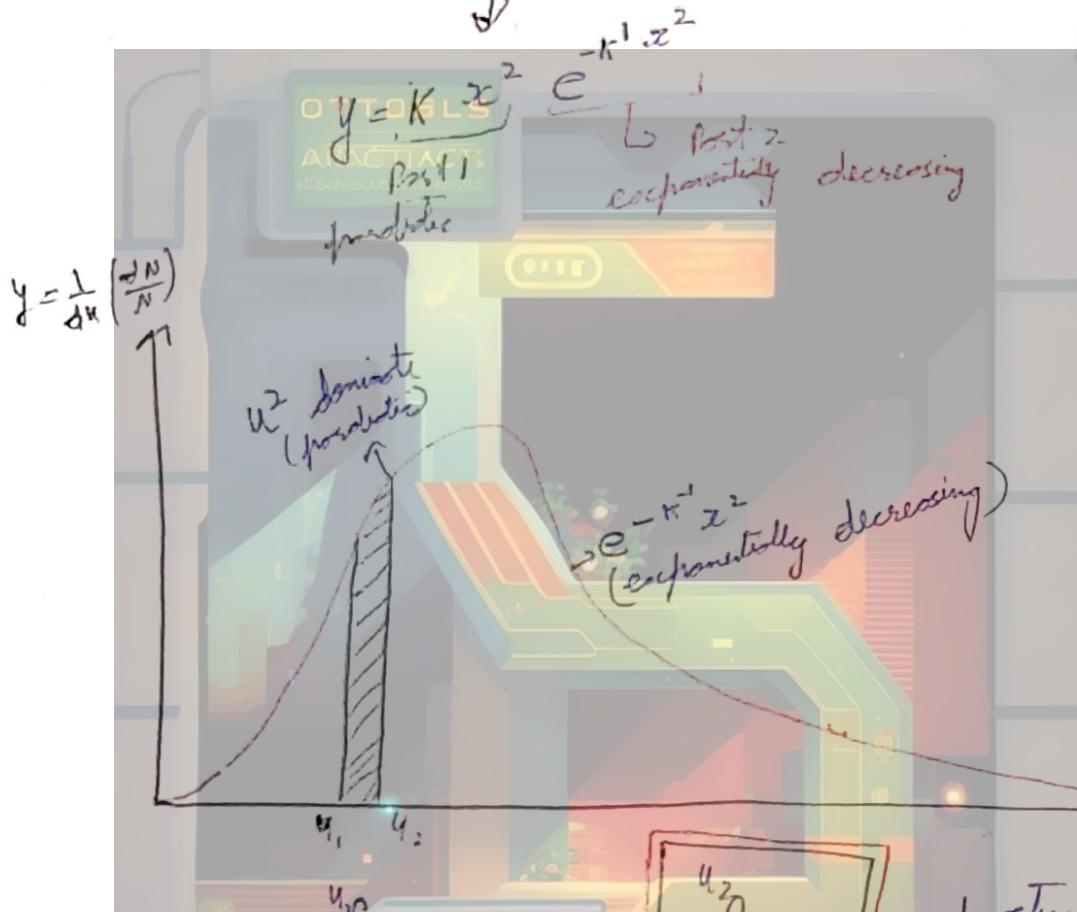
b) $n_A = \frac{P_A V}{R \times T_{300}}$ $n_B = \frac{P_B V}{R \times 600}$

$$\frac{KE_{\text{mol}} \times n_A}{KE_{\text{mol}} \times n_B} = \frac{\frac{3}{2} R \times 300 \times \frac{P_A V}{T_{300}}}{\frac{3}{2} R \times 600 \times \frac{P_B V}{T_{600}}} = \frac{P_A}{P_B} = \boxed{4}$$

Graphical Representation of Maxwell Eqⁿ

$$\frac{dN}{N} = \frac{4\pi}{M} \left(\frac{M}{2\pi RT} \right)^{3/2} u^2 e^{-\frac{Mu^2}{2RT}} \cdot du$$

$$\left(\frac{1}{du} \frac{dN}{du} \right) = \left(\frac{4\pi}{M} \left(\frac{M}{2\pi RT} \right)^{3/2} u^2 e^{-\frac{Mu^2}{2RT}} \right) du$$



① Area of Graph = $\int_{u_1}^{u_2} \frac{1}{du} \frac{dN}{du} du = \boxed{\int_{u_1}^{u_2} \frac{dN}{N} du}$ → factor of particle between u_1 & u_2 , which is showing the

② Total Curve area = $\int_0^\infty \frac{dN}{N} du = 1$

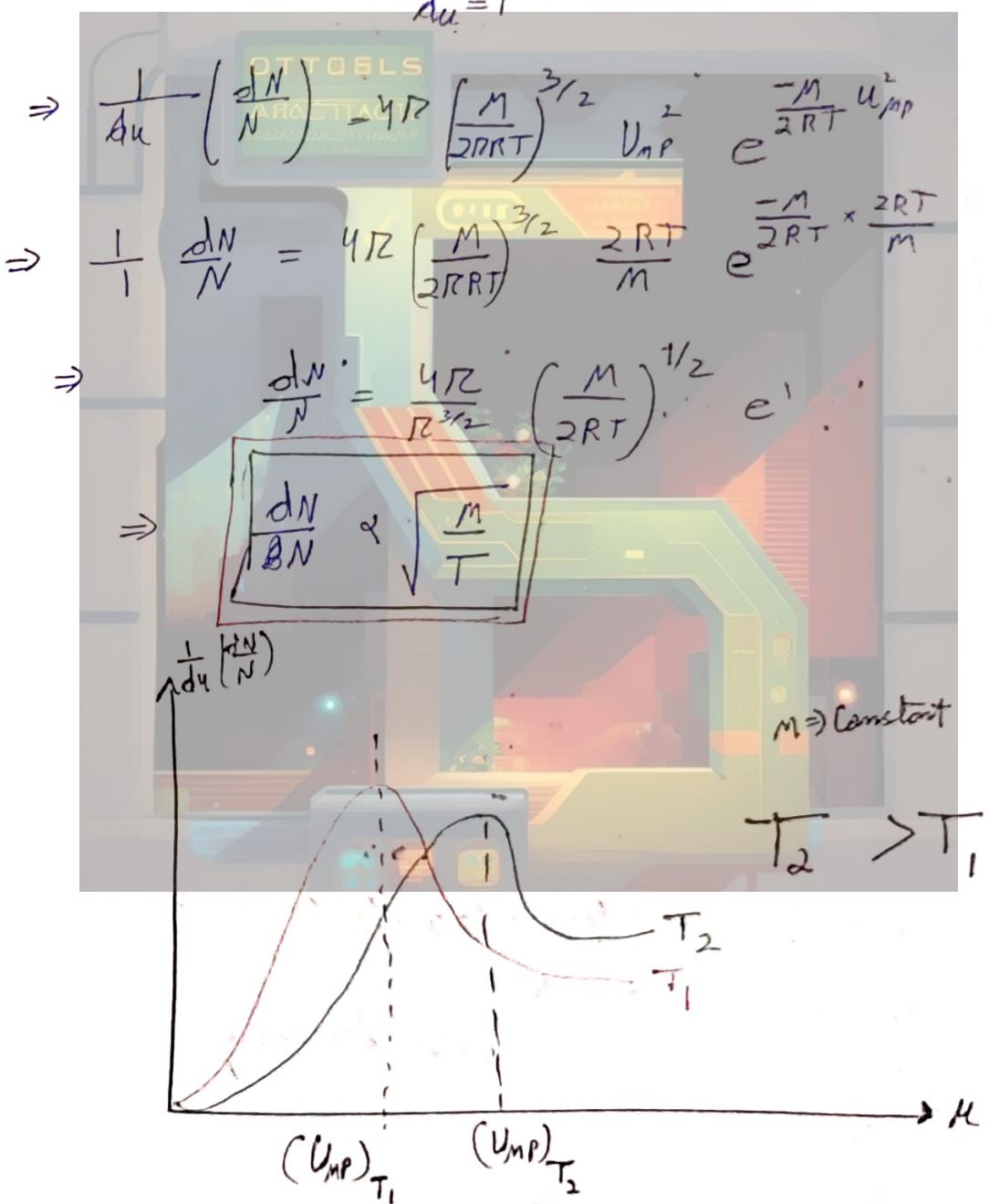
Total Area = 1

③ from graph we can observe the particles moving with very low speed or very high speed are small in no.

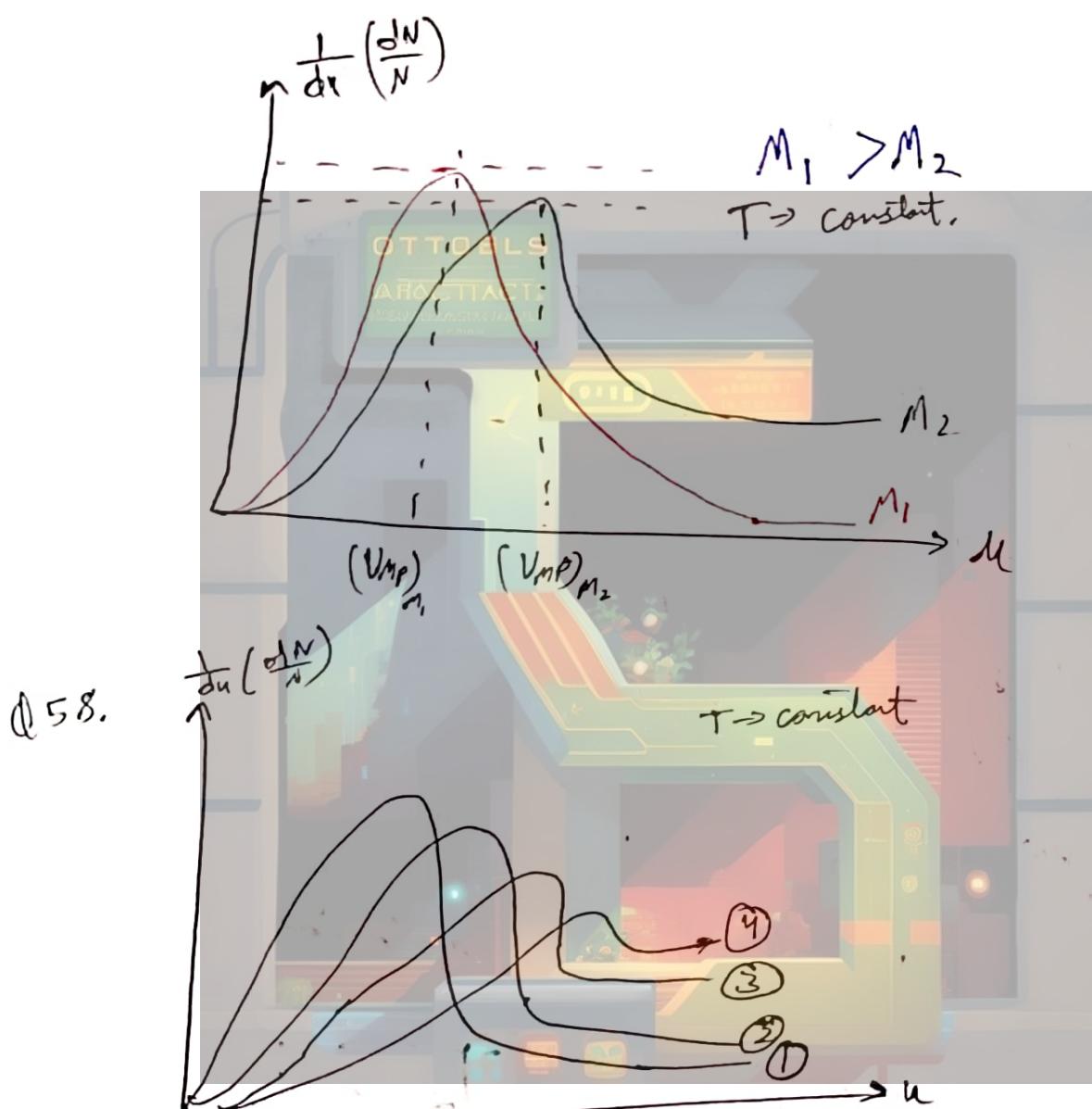
$$④ U_{mp} = \sqrt{\frac{2RT}{m}} \Rightarrow U_{mp} \propto \sqrt{T}$$

→ Fraction of particle moving with U_{mp} to $U_{mp} + 1$.

$$du = 1$$



~~A A A~~
 T ↑ $4\pi \left(\frac{M}{2\pi RT} \right)^{3/2} u^2 \downarrow$ $e^{-\frac{M}{2RT} u^2} \uparrow$ $\frac{dN}{du} \downarrow$
 U_{mp} ↑ M ↓ U_{Avg} ↑



which eqⁿ is for which gas, H₂, CH₄, O₂ & SO₂

- ① → Heaviest → SO₂
 - ② → O₂
 - ③ → CH₄
 - ④ → H₂
- mass decreasing,

Note - When temp is increased, keeping molar mass constant

v_{mp} increases

Fraction of particles moving with v_{mp} decreases

v_{avg} increases

Curve becomes wider

But Area Enclosed by curve total is always 1.

* Collision Theory of Gases

→ We only consider Bimolecular collisions as Trimolecular & Tetratomic are very rare.

Assumptions:

1. → Molecules are considered as hard, rigid & Spherical shape.
2. → All the molecules are moving with the same speed i.e. v_{avg} .
3. → Mass, shape & size of Molecules will not be changed after collision.
4. → Molecules can collide at any angle ranges from ($0^\circ \rightarrow 180^\circ$) with equal probability therefore the average 90° is considered for relative speed calculation

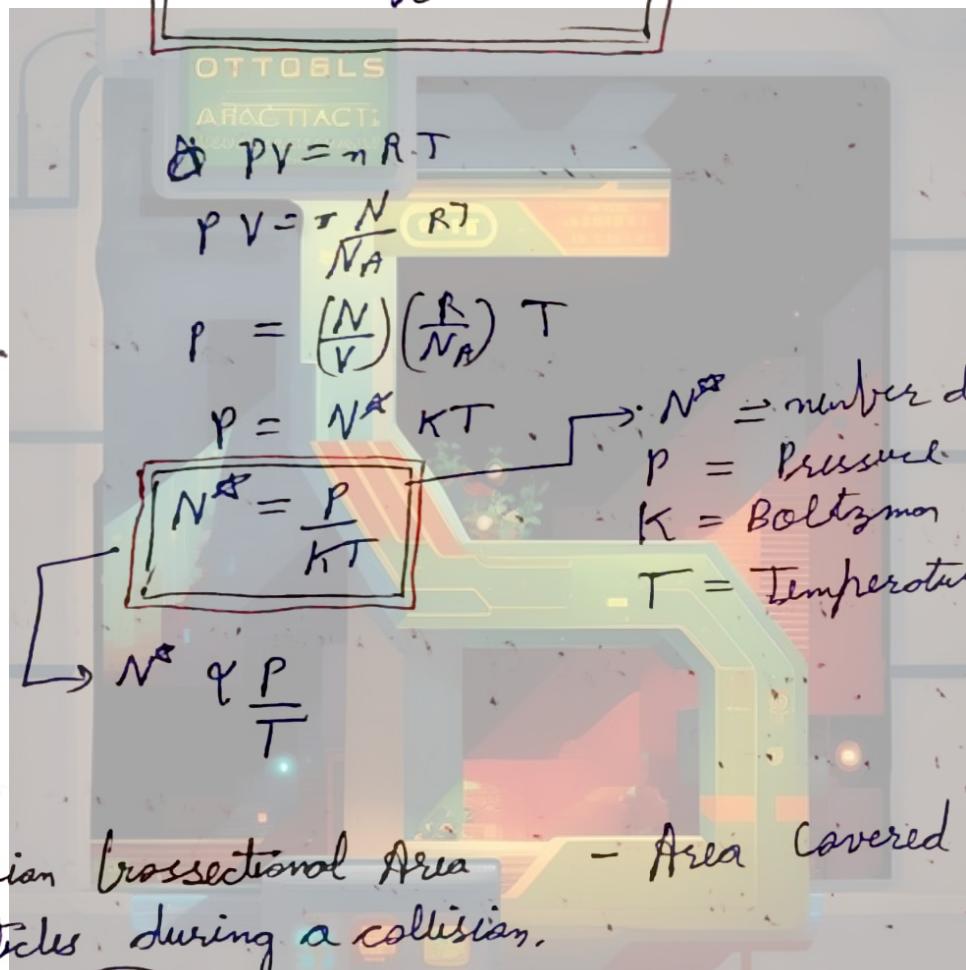
$$v_{rel} = \sqrt{(v_{avg})^2 + (v_{avg})^2}$$
$$v_{rel} = \sqrt{2} v_{avg}$$

5. \rightarrow Only Bimolecular Collisions are considered.

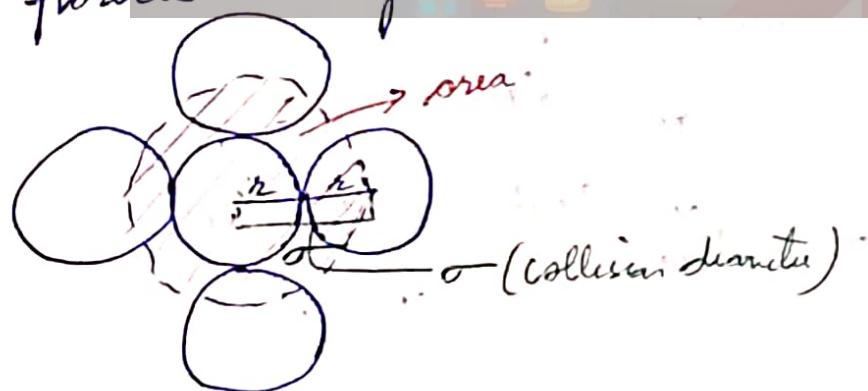
Imp. Terms for Collision Theory

① Number density (N^*) - It is defined as no. of particles per unit volume.

$$N^* = \frac{\text{no. of particles}}{\text{Volume}}$$



② Collision cross sectional Area - Area covered by two particles during a collision.

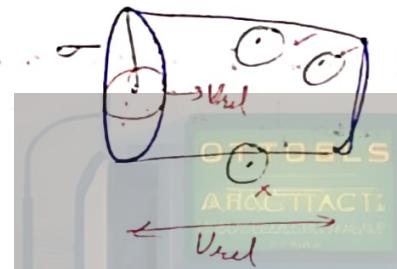


$$\text{Area} = \pi(2r)^2$$
$$\text{Area} = \pi \sigma^2$$

3. Collision Number (Z_1) :- Total no. of collisions made by one particle per unit time.

no. of Collisions = no. of particles in vessel

Distance travelled in unit time = Height of vessel
= V_{rel}



$$\text{Volume of Vessel} = \text{Area} \times \text{height} \\ = (\pi r^2)^2 (V_{rel})$$

Per unit volume contains $\rightarrow N^*$ particles

$$\text{no. of Particles} = \text{Volume} \times N^*$$

$$Z_1 = \cancel{n} \pi r^2 V_{rel} N^*$$

$$Z_1 = n(\infty)^2 \sqrt{2} \frac{\sqrt{8kT}}{\sqrt{2\pi}} \cdot \frac{P}{kT}$$

#

$$Z_1 \propto \frac{P}{\sqrt{T}}$$

For a particular gas.

~~Total Collision~~

4. Collision Frequency (Z_{11}) :- Total no. of Bimolecular collisions per unit time per unit volume is called collision frequency.
Total no. of collisions = $\frac{Z_1 N}{2}$

$$Z_{11} = \frac{1}{2} \frac{(Z_1)(N)}{V}$$

$$Z_{11} = \frac{1}{2} Z_1 N^*$$

$$Z_{11} = \frac{\pi r(\infty)^2 U_{avg} (N^*)^2}{\sqrt{2}}$$

②

$$Z_{11} \propto \frac{P^2}{T^{3/2}}$$

5. Mean free path (λ):-

→ The distance between two successive collisions of a particle is free path.

→ Average distance covered by particles between two successive collisions.

$$\lambda = \frac{V_{AVG}}{Z_1}$$

Distance Traveled Per unit time (V_{AVG})
no. of collision per unit time (Z_1)

$$\lambda = \frac{V_{AVG}}{\frac{R \times \sqrt{2} V_{AVG} N}{\text{unit}}} = \frac{1}{\sqrt{2 R \rho^2}} \times \frac{kT}{P}$$

$$\lambda \propto \frac{kT}{P}$$

at constant Pressure -

$$T \uparrow \quad Z_1 \downarrow \quad Z_1 \propto \frac{1}{T}$$

$$Z_{11} \downarrow \quad \lambda \uparrow \quad Z_{11} \propto \frac{1}{T^{3/2}}$$

$$\lambda \propto T$$

at Constant Volume

$$T \uparrow \quad Z_1 \uparrow \quad Z_{11} \uparrow \quad Z_1 \propto \sqrt{T} \quad Z_{11} \propto \sqrt{T}$$

$$\lambda =$$

$$\lambda = \text{constant}$$

Q. 59. Two containers A & B contains equal mass of neon(20) and argon⁽⁴⁰⁾ respectively. Ratio of volume 3:1 & temp is 600K & 400K respectively. Calculate ($Z_{Ne} = \sigma_{Ar}$)

- i) ratio of moles vi) ratio of KE per mol ix) ratio of Z_1
- ii) ratio of N^* vii) ratio of total KE x) ratio of λ
- iii) ratio of P viii) ratio of V_{rms}
- iv) ratio of U_{avg} ix) ratio of Z_2

$$i) \frac{n_1}{n_2} = \frac{\frac{m}{M} \cdot \frac{N_A}{20}}{\frac{m}{M} \cdot \frac{N_A}{40}} = \frac{40}{20} = 2 \quad \boxed{i)$$

$$ii) \frac{N_1^*}{N_2^*} = \frac{N_A}{N_A}$$

iii) ratio of P

$$\frac{P_1}{P_2} = \frac{\frac{nRT}{V}}{\frac{nRT}{V}} = \frac{n_1 V_2 T_1}{n_2 V_1 T_2} = 2 \times \frac{1}{3} \times \frac{600}{400} = \frac{2}{3} = \boxed{\frac{2}{3}} \quad \boxed{iii)}$$

$$iv) \frac{N_1^*}{N_2^*} = \frac{\frac{P}{kT}}{\frac{P}{kT}} = \frac{T_1 T_2}{P_2 T_1} = \frac{2}{3} \times \frac{400}{600} = \frac{4}{9} = \boxed{\frac{2}{3}} \quad \boxed{iv)}$$

$$v) \frac{U_{avg1}}{U_{avg2}} = \sqrt{\frac{\frac{3}{2}RT}{\frac{5}{2}RT}} = \sqrt{\frac{T_1 M_2}{T_2 M_1}} = \sqrt{\frac{600 \times 40}{400 \times 20}} = \sqrt{3} = \boxed{\sqrt{3}} \quad \boxed{v)}$$

$$vi) \frac{KE_1}{KE_2} = \frac{600}{400} = \frac{3}{2} = \boxed{\frac{3}{2}} \quad \boxed{vi)}$$

$$vii) \frac{V_{mp1}}{V_{mp2}} = \sqrt{\frac{RT_1 M_2}{T_2 M_1}} = \sqrt{\frac{600 \times 40}{400 \times 20}} = \sqrt{3} = \boxed{2\sqrt{3}} \quad \boxed{vii)}$$

$$viii) \frac{P_1 \sqrt{V_2}}{P_2 \sqrt{V_1}} = \sqrt{\frac{V_2}{V_1}} = \sqrt{\frac{2}{3}} = \boxed{\sqrt{\frac{2}{3}}}$$

~~$$i) \left(\frac{P_1}{P_2}\right)^2 \cdot \left(\frac{T_2}{T_1}\right)^{3/2} = \left(\frac{600}{6900}\right)^{3/2} = \left(\frac{2}{3}\right)^{3/2} = \sqrt[3]{\frac{8}{27}} = \frac{2}{3} \sqrt[3]{\frac{2}{3}}$$~~

~~$$x) \frac{T_1}{T_2} \times \frac{P_2}{P_1} = \frac{600}{400} = \frac{3}{2}$$~~

~~$$viii) \frac{\pi \sigma^2 U_{Avg} N^A}{\pi \sigma^2 U_{Avg} N^B} = \frac{1}{4} \times \sqrt{3} \times \frac{2}{\sqrt{3}} = \boxed{\frac{1}{2\sqrt{3}}} \quad viii)$$~~

~~$$ix) \frac{Z_1 N^A}{Z_2 N^B} = \frac{2}{3} \times \frac{1}{2\sqrt{3}} = \boxed{\frac{1}{3\sqrt{3}}} \quad ix)$$~~

~~$$x) \frac{U_A v_{G_1} Z_2}{U_B v_{G_2} Z_1} = \sqrt{3} \times 2\sqrt{3} = \boxed{6} \quad x)$$~~

Relative Humidity (R.H.)

$$\boxed{y. R.H. = \frac{\text{Actual Pressure (H}_2\text{O) in air at T}}{\text{Vapour Pressure of H}_2\text{O at T}} \times 100}$$

CASE I

$$T = 30^\circ C$$

$$\text{Vapour Pressure H}_2\text{O} \rightarrow 40 \text{ mm Hg}$$

Case I

$$P_{H_2O} = 30 \text{ mm Hg}$$

$$y. R.H. = \frac{30}{40} \times 100$$

$y. R.H. \Rightarrow 75\%$
unsaturated air

Case II

$$P_{H_2O} = 40 \text{ mm Hg}$$

$$y. R.H. = \frac{40}{40} \times 100 \\ = 100\%$$

saturated air

Case III

$$P_{H_2O} = 50 \text{ mm Hg}$$

$$y. R.H. = \frac{50}{40} \times 100$$

$$= 125\%$$

super-saturated air

