

NEET Physical Chemistry Crash Course

GASEOUS STATE

IN 1 SHOT



Flow Chart of Study Physical Chemistry



1

Mole Concept

2

Gaseous State

3

Liquid Solution

4

Chemical Kinetics

5

Solid State

6

Thermodynamics

7

Chemical Equilibrium

8

Ionic Equilibrium

9

Redox Reaction

10

Electro Chemistry

11

Atomic Structure

12

Surface Chemistry

Today's Goal



IDEAL GAS LAWS



IDEAL GAS EQUATION



PARTIAL PRESSURE (DALTONS LAW)



GRAHAMS LAW OF DIFFUSION



KINETICS THEORY OF GASES



REAL GAS EQUATIONS



IDEAL GAS LAWS



Boyle's Law (Pressure-Volume Relationship)

- At constant temperature, the pressure of a fixed amount (i.e., number of moles n) of gas varies inversely with its volume. This is known as Boyle's law.
- Mathematically, it can be written as

$$P \propto \frac{1}{V} \quad (\text{Constant } T \text{ and } n)$$

P, V, n, T → ④ variable

B.L. ⇒ $P \propto \frac{1}{V}$ at Const T, & n

$$\Rightarrow P = \frac{k}{V} \Rightarrow [PV = k]$$



Charles' Law (Temperature - Volume Relationship)

- According to Charles' law the volume occupied by a fixed amount of gas is directly proportional to its absolute temperature.

$$V \propto T$$

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

$$P, V, \gamma, T$$

↓ ↓
α x

$$\eta = \text{Const}$$

$$\text{mole} = \frac{\omega t}{M \cdot \omega t}$$

$V \propto T$ at Const $P \& \gamma$

$$V = kT$$

$$\boxed{\frac{V}{T} = k}$$



Gay Lussac's Law (Pressure Temperature Relationship)

It states that at constant volume, pressure of a fixed amount of a gas varies directly with the temperature.

$$P \propto T$$

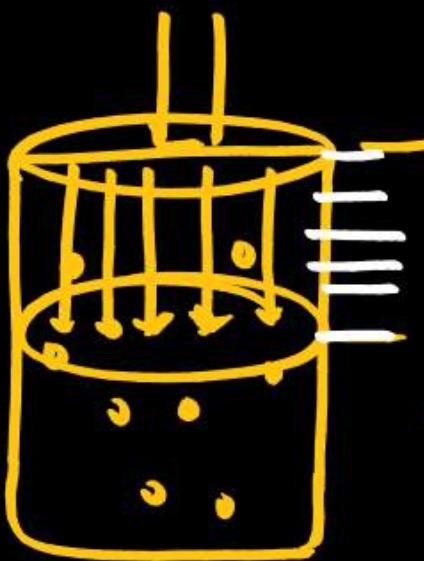
$$\Rightarrow \frac{P}{T} = \text{Constant} = k$$

$$P, n, V, T$$

\downarrow \downarrow
 \times \times

$P \propto T$ at Const n, V

$$\boxed{\frac{P}{T} = K}$$



initial state (P_1, V_1, T_1, η)

final state (P_2, V_2, T_2, η)

Concept-1

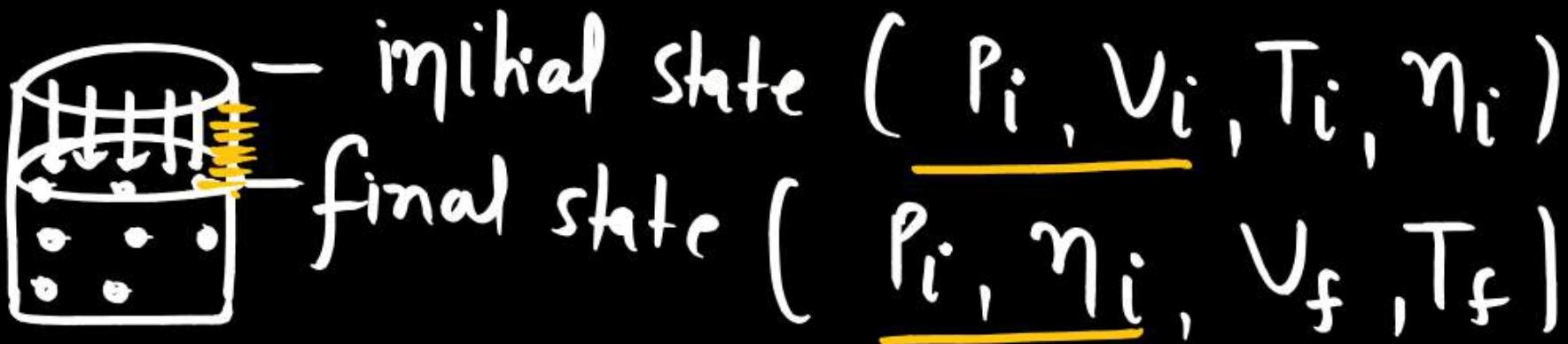
B.L. = Temp \rightarrow const
mole {

$PV = K$ (any point PV Ki value)

hamesha same (const)
Rahegi)

$$P_1 V_1 = P_2 V_2$$

C.L.



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

Concept-2

$\hookrightarrow \left(\frac{V}{T}\right)$ Ratio always

Same rahega
har point pr.

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



Avogadro Law (Volume - Amount Relationship)

It states that equal volumes of all gases under the same conditions of temperature and pressure contain equal number of molecules,
Mathematically we can write

$$V \propto n \quad \text{where } n \text{ is the number of moles of the gas.}$$

$$\Rightarrow V = kn$$

$$P, n, V, T$$

x x

Concept

$$V \propto n$$

\checkmark

$\left(\frac{V}{n}\right)$ Ratio always const

hota hai { $P = \text{Const}$
 $T = \text{Const}$

$$\boxed{\frac{V}{n} = k}$$

Concept \Rightarrow ideal Gas laws

$$\eta_i = \eta_f$$

Mole of Gas
before process

* Chemical Reactⁿ. $\Rightarrow \text{X}$
Mole of Gas
After process.
(Complete process)



A vessel of 120 mL capacity contains a certain amount of gas at 35°C and 1.2 bar pressure. The gas is transferred to another vessel of volume 180 mL at 35°C. What would be its pressure?

(a) 1.2 bar

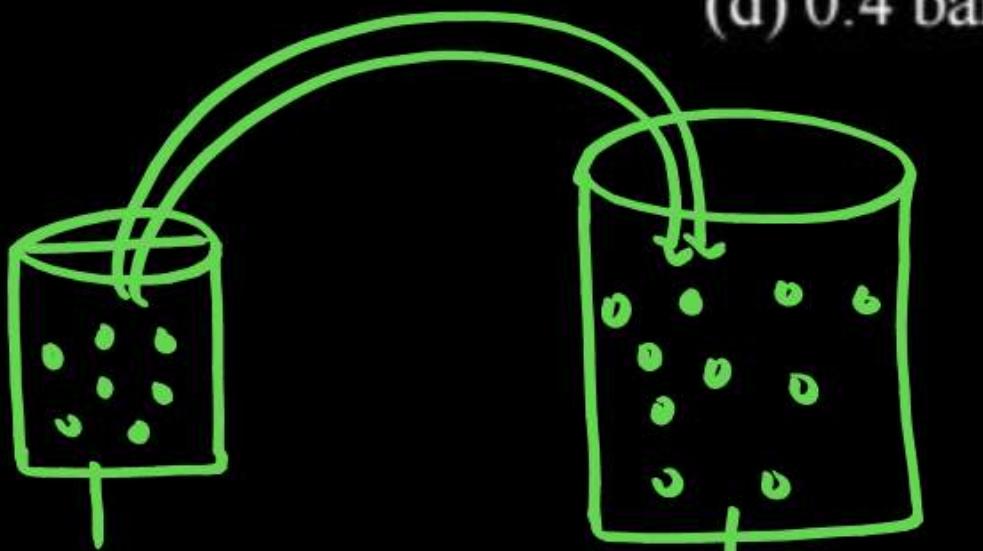
(c) 2.0 bar

(b) 0.8 bar

(d) 0.4 bar

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

$$\eta_i = \frac{P_i V_i}{R T_i}$$



120mL

35°C

1.2 bar

η_i

180mL

35°C

$P_f = ?$

η_f

$$\eta_i = \eta_f$$

$$\frac{P_i V_i}{R T_i} = \frac{P_f V_f}{R T_f}$$

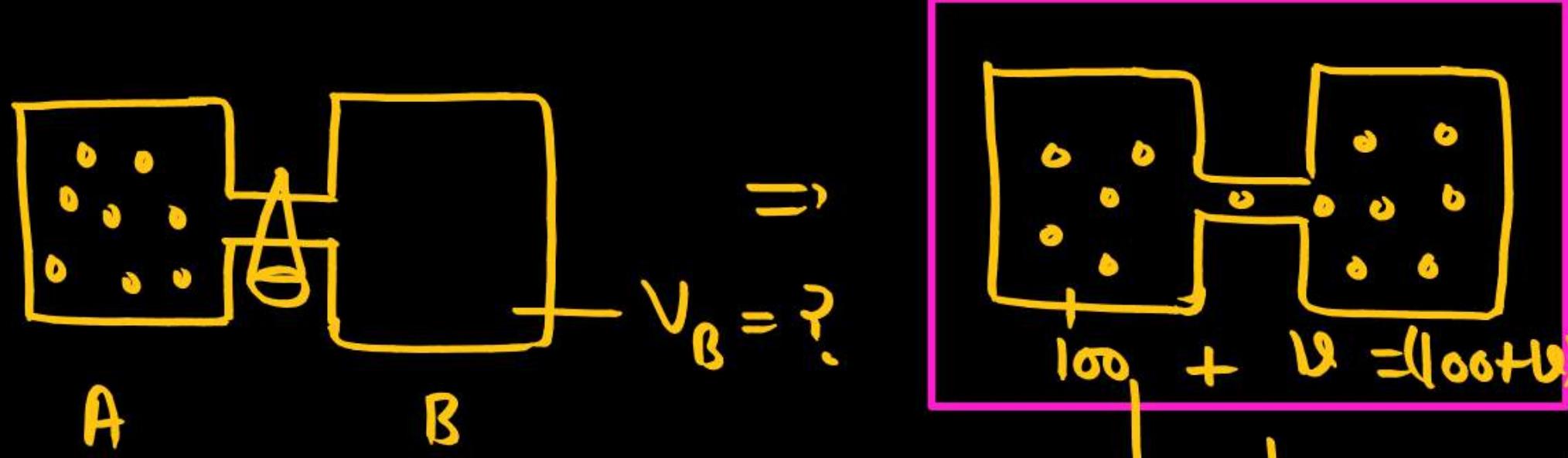
$$\frac{1.2 \times 120}{R \times (35+273)} = \frac{180 \times P_f}{R \times (35+273)}$$

$$P_f = \frac{1.2 \times 120}{180} = \frac{2.4}{3} = 0.8 \text{ bar}$$

Q. Two glass bulbs A and B are connected by a very small tube having a stop-cock. Bulb A has a volume of 100 cm^3 and contains a gas while bulb B is empty. On opening the stop-clock, the pressure falls down to 40%. The volume of the bulb B must be

- (a) 75 cm^3
- (b) 125 cm^3
- (c) 150 cm^3 ✓
- (d) 250 cm^3

Sol.



A

B

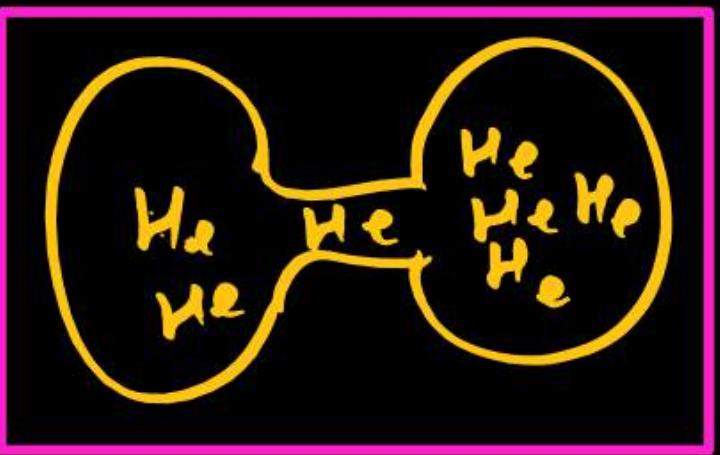
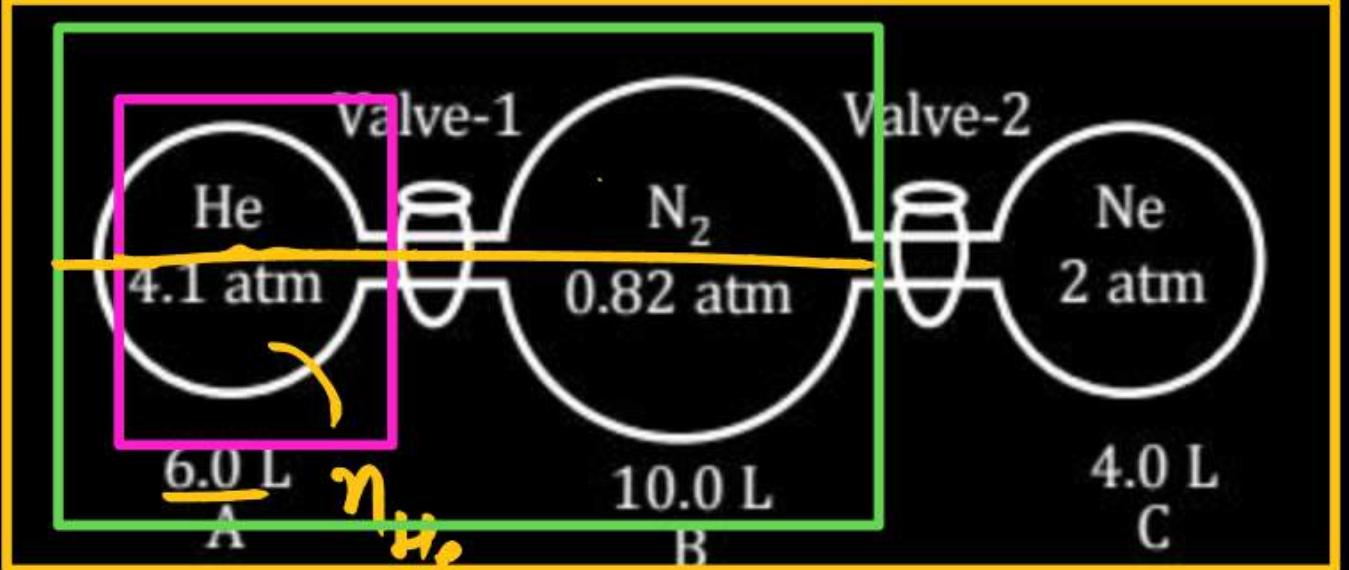
$$\frac{100 \text{ cm}^3}{n_i}$$

$$\frac{100 \times P}{R \times T} = \frac{(100+V) \times 40P}{R \times T} n_f$$

$$1000 = 400 + 4V$$

$$V = \frac{600}{4} = 150 \text{ ml}$$

Q.



than Calculate

- (a) the pressure of He gas after open Valve-1
- (b) The pressure of He gas after open Valve-1 and Valve-2 both

$$\underline{\text{SOLN.}} \quad (\eta_i)_{\text{He}} = (\eta_f)_{\text{He}}$$

(a)

$$\frac{6 \times 4.1}{RT} = \frac{P_f \times 16}{RT}$$

$$24.6 = P_f \times 16$$

$$P_f = \frac{24.6}{16} \text{ atm}$$

$$(b) \quad (\eta_i)_{He} = (\eta_f)_{He}$$

$$6 \times 4.1 = 20 \times P_f$$

$$P_f = \frac{24.6}{20}$$

$$\underline{P_f = 1.23 \text{ atm}}$$



Q. Two closed vessels of equal volume containing air at pressure P_1 and temperature T_1 are connected to each other through a narrow tube. If the temperature in one of the vessels is now maintained at T_1 and that in the other at T_2 , what will be the pressure in the vessels

(a) $\frac{2P_1T_1}{T_1 + T_2}$

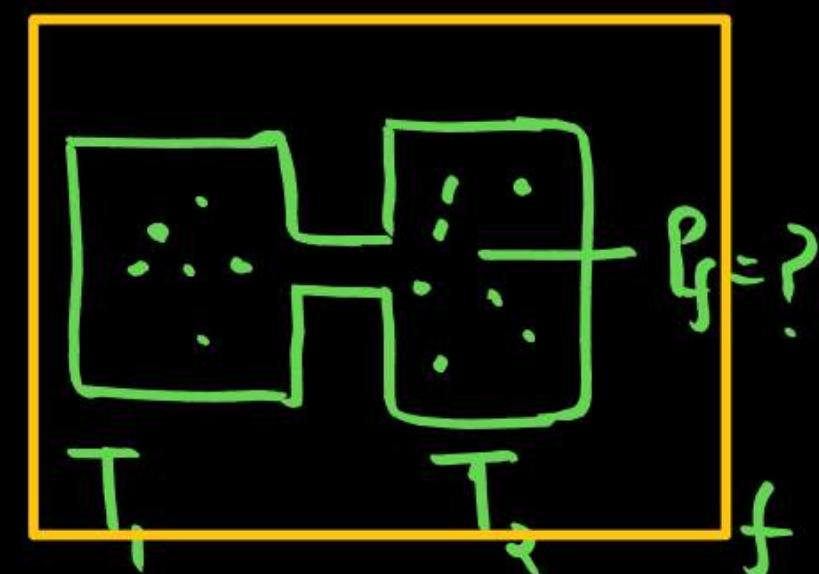
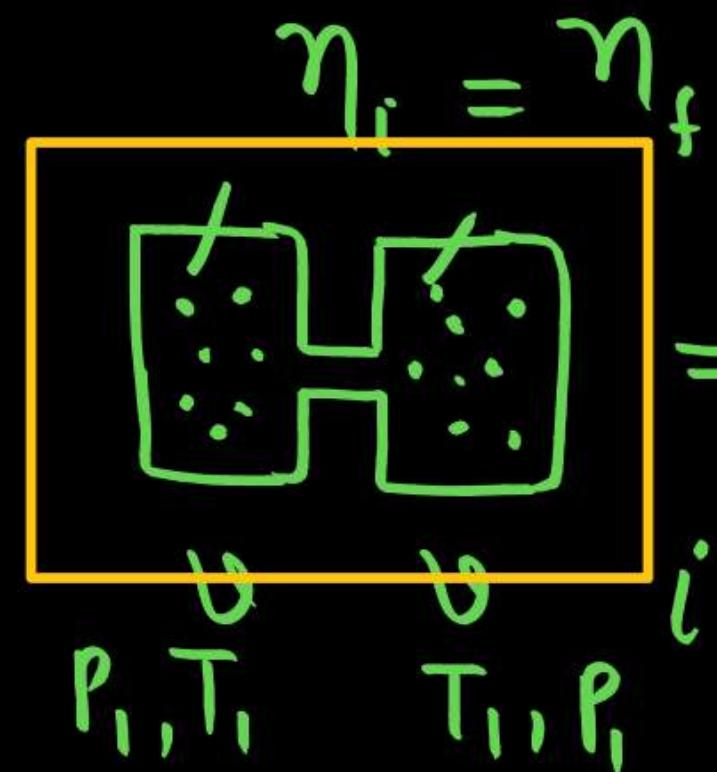
(c) $\frac{2P_1T_2}{T_1 + T_2}$

(b) $\frac{T_1}{2P_1T_2}$

(d) $\frac{2P_1}{T_1 + T_2}$

$$\eta_i = \eta_f$$

$$\frac{P_1 V}{RT_1} + \frac{P_1 V}{RT_1} = \frac{P_f V}{T_1 R} + \frac{P_f V}{T_2 R}$$



$$2 \frac{P_1}{T_1} = P_f \left(\frac{1}{T_1} + \frac{1}{T_2} \right)$$

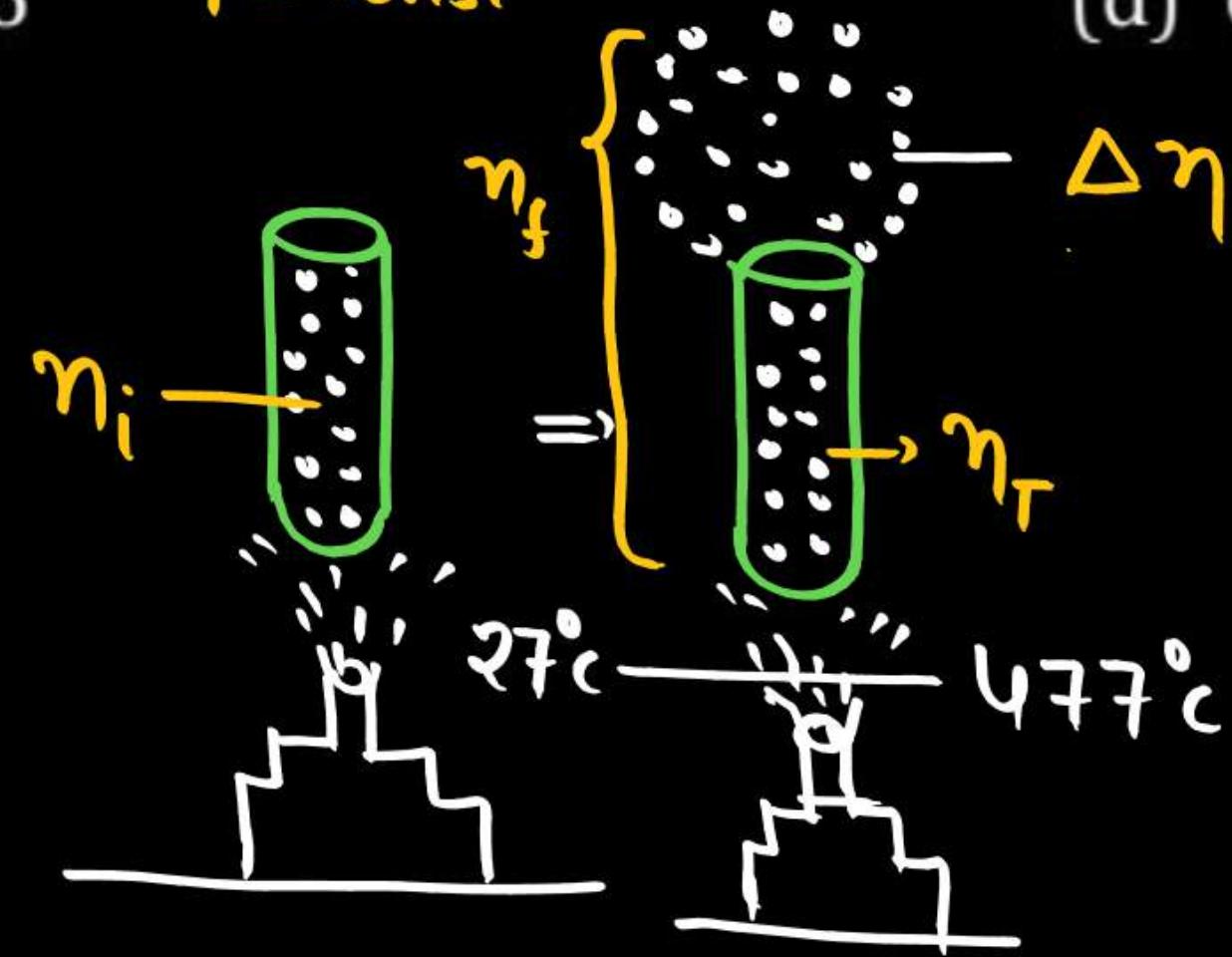
$$P_f = \frac{2P_1 T_1 T_2}{T_1 (T_1 + T_2)} = \frac{2P_1 T_2}{(T_1 + T_2)}$$

Q. A student forgot to add the reaction mixture to the round bottomed flask at 27°C but instead he/she placed the flask on the flame. After a lapse of time, he realized his mistake and using a pyrometer he found the temperature of the flask was 477°C . What fraction of air would have been expelled out?

- (a) $5/3$
 (c) $3/5$

$$\checkmark \quad P = \text{const}$$

- (b) $5/6$
 (d) $6/5$



$$\frac{\Delta n}{n_i} = \text{fraction of Air expelled out}$$

$$n_i = n_T + \Delta n$$

$$1 = \frac{n_T}{n_i} + \frac{\Delta n}{n_i}$$

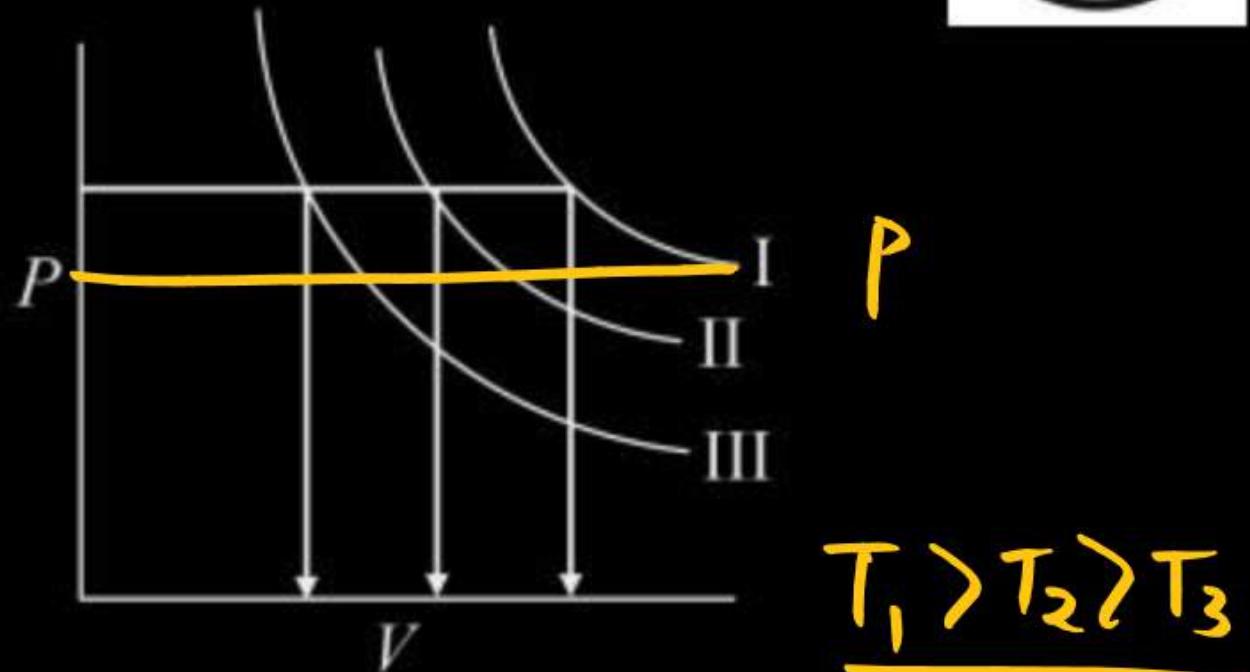
$$\frac{\Delta n}{n_i} = 1 - \frac{n_f}{n_i} = 1 - \frac{PxV | R \times 750}{PxV | R \times 300}$$

$$\frac{477}{273} \quad | \\ 27$$

$$= 1 - \frac{300}{750} \\ = \frac{9}{750} = \frac{9}{15} = \textcircled{\frac{3}{5}}$$

Q. I, II and III are three isotherms respectively at T_1 , T_2 and T_3 temperatures. The order of temperature will be

- (a) $T_1 = T_2 = T_3$
- (b) $T_1 < T_2 < T_3$
- ~~(c) $T_1 > T_2 > T_3$~~
- (d) $T_1 > T_2 = T_3$



$$PV = nRT = k$$

Graph.

$$PV = nRT$$

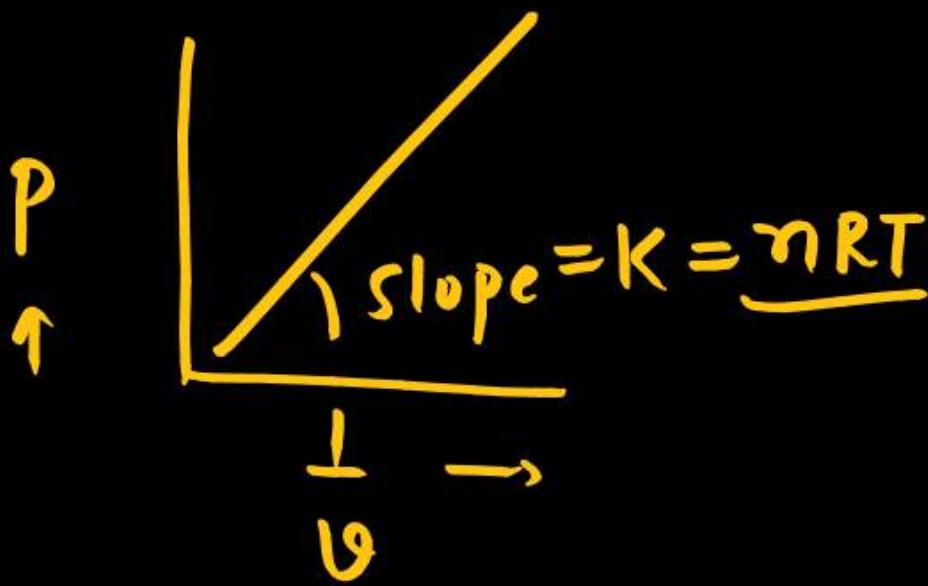
$$B.L. \Rightarrow PV = K$$

$$K = nRT$$

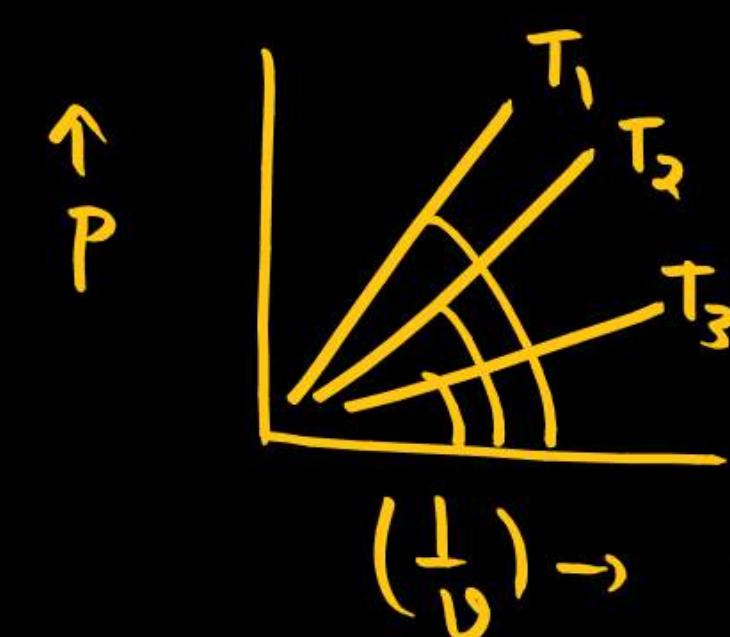
$$P = \frac{K}{V}$$

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

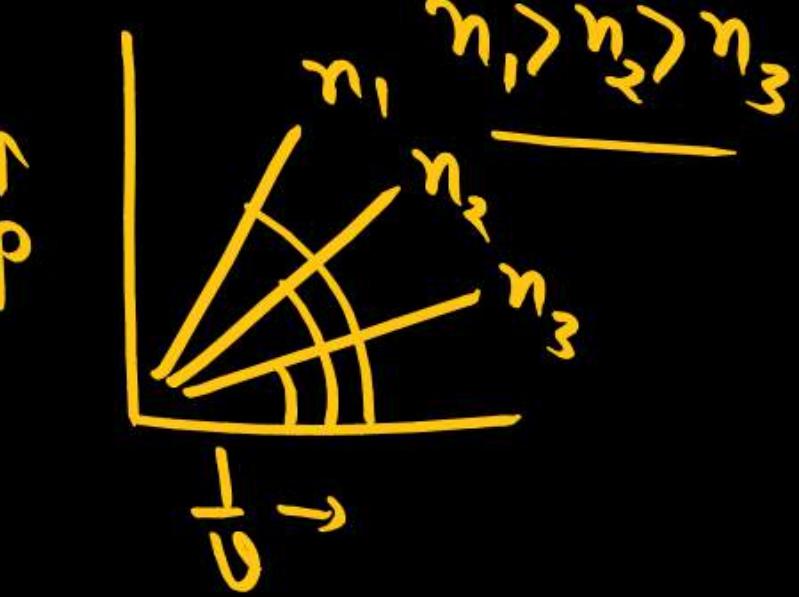
$$P \propto \left(\frac{1}{V} \right)$$

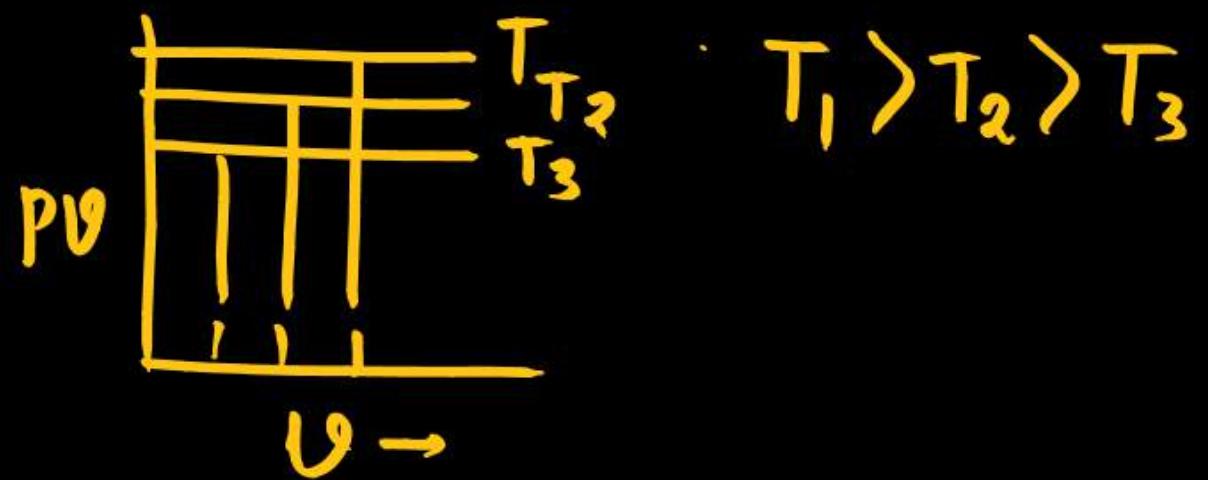
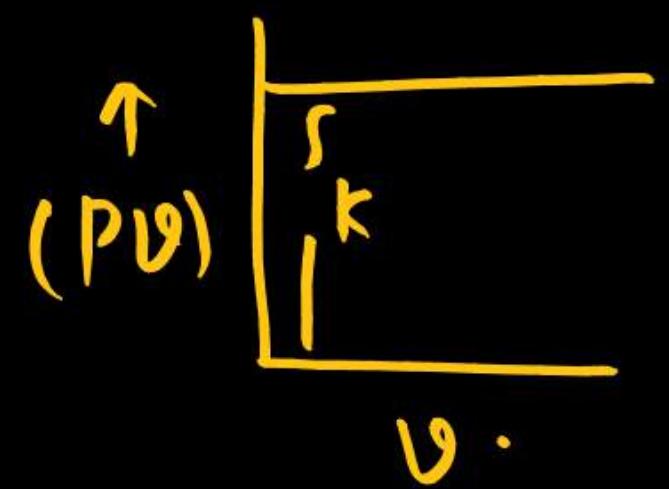


$$T_1 > T_2 > T_3$$



$$\text{slope} = nRT$$





$$PV = K = nRT$$

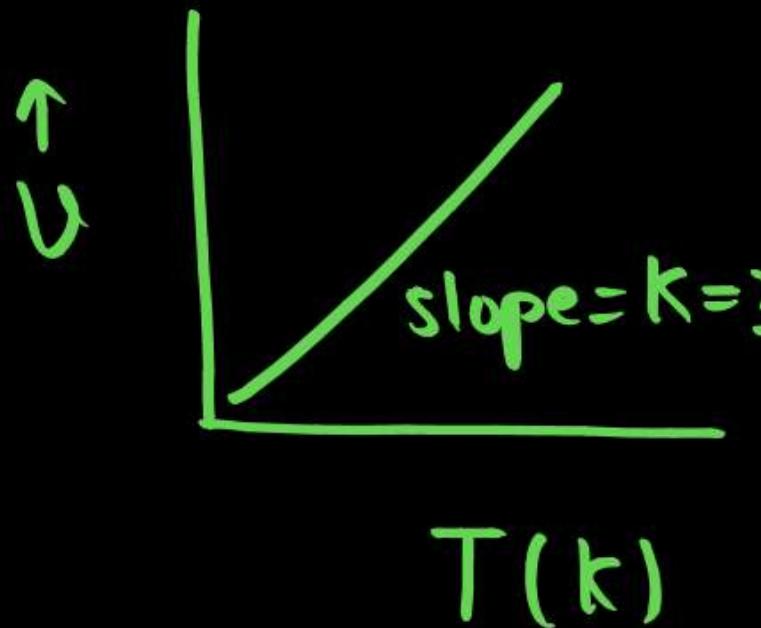


$$PV = \underline{K} = nRT$$

C.L.

$$PV = nRT$$

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



$$\text{slope} = k = \frac{nR}{P}$$

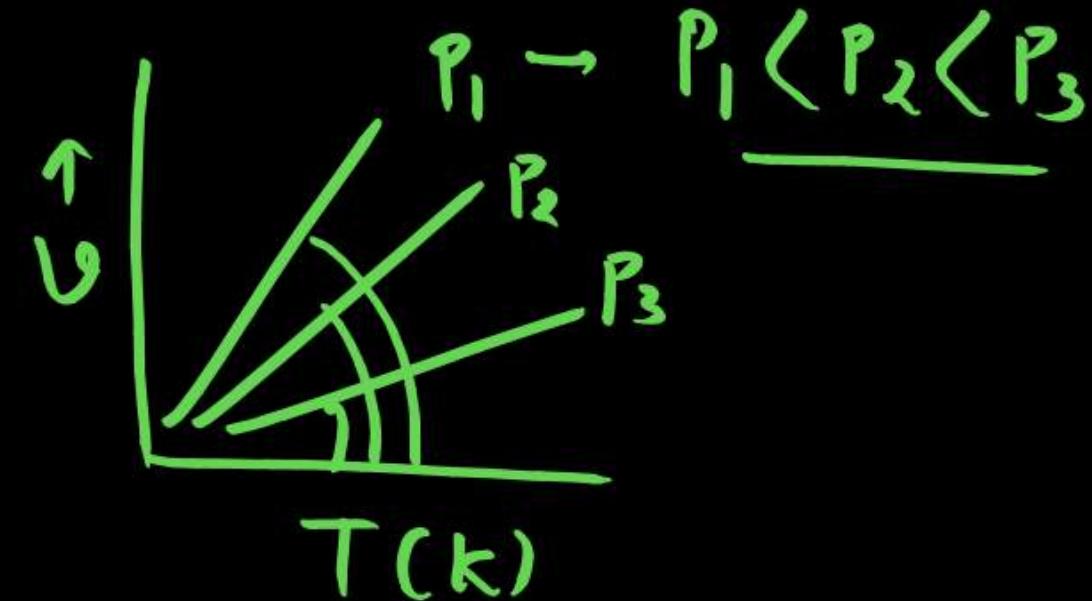
$$V = KT$$

$$y = mx$$

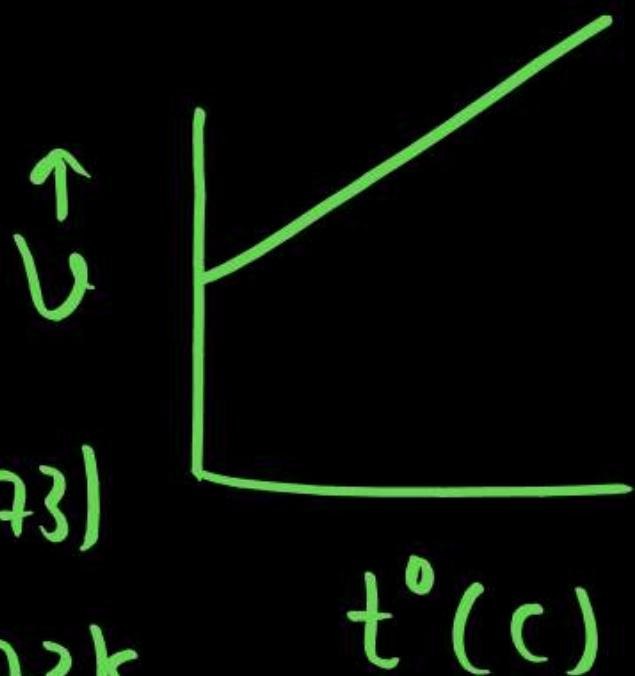
$$V = K(t^\circ + 273)$$

$$V = Kt^\circ + 273K$$

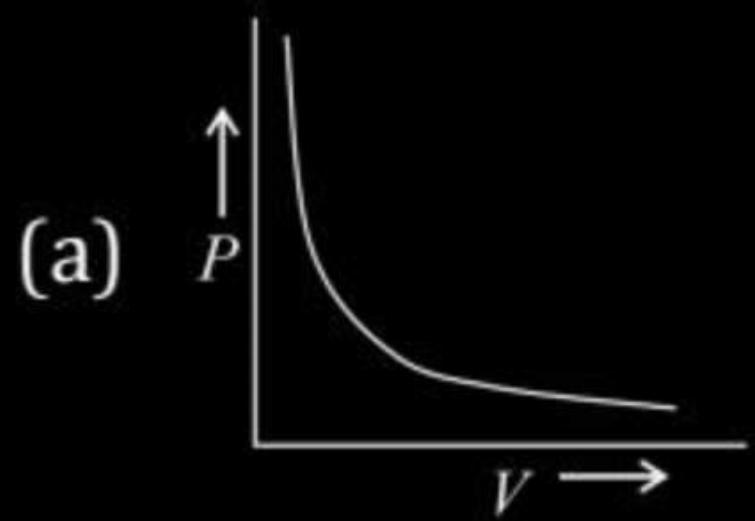
$$y = mx + c$$



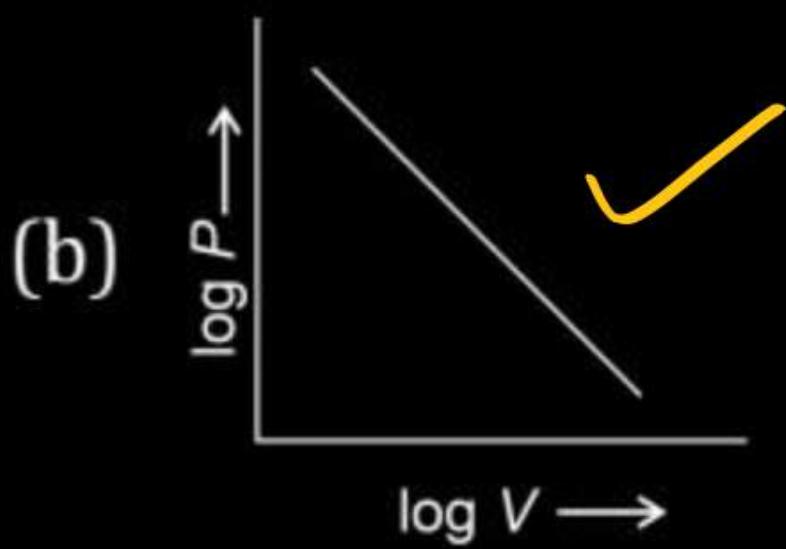
$$P_1 \rightarrow P_1 < P_2 < P_3$$



Q. Which curve does not represent Boyle's law ?



✓

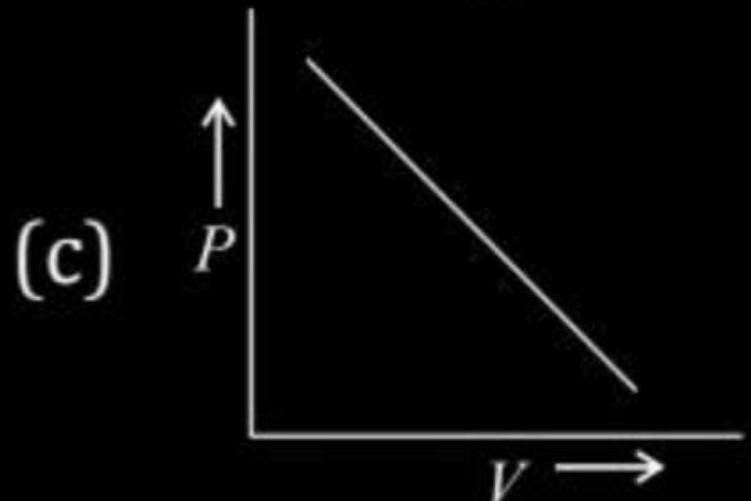


✓

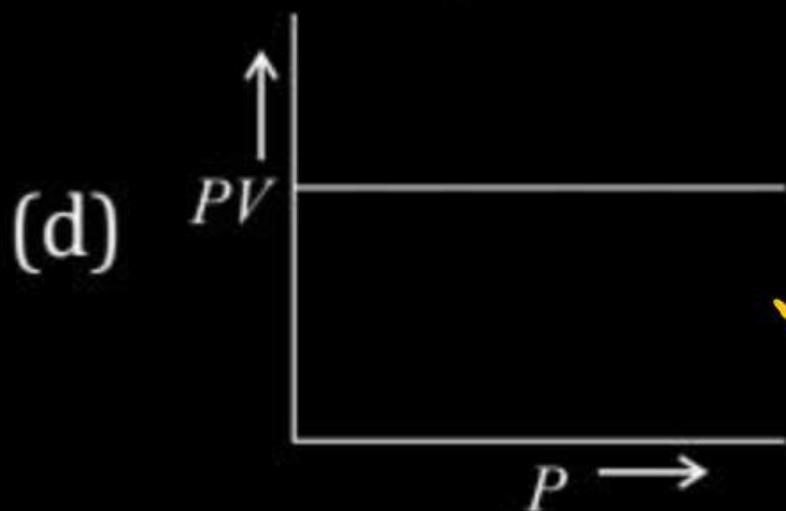
$$PV = K$$

$$\log P + \log V = \log K$$

$$\frac{\log P}{\log V} = -1 + \frac{\log K}{\log V}$$



✗



✓

IDEAL GAS EQUATION



- The three laws which we have learnt till now can be combined together in a single equation which is known as ideal gas equation.

At constant T and n; $V \propto \frac{1}{P}$ Boyle's Law

At constant p and n; $V \propto T$ Charles' Law

At constant p and T; $V \propto n$ Avagadro Law Thus,

$$V \propto \frac{nT}{p} \Rightarrow V = R \frac{nT}{p}$$

$$\Rightarrow R = \frac{pV}{nT}$$

$$pV = nRT$$

$PV = nRT \rightarrow$ ideal gas Eq.

$$PV = \frac{W}{M \cdot \text{wt}} \times R \times T$$

$$M \cdot \text{wt} = \frac{W}{PV} \times R \times T$$

$$M \cdot \text{wt} = \frac{d}{P} \times R \times T$$

CASE-I $\left. \begin{array}{l} d \rightarrow \text{gas} \\ P - \text{gas} \end{array} \right\} \rightarrow M \cdot \text{wt of gas}$

CASE-II

$d \rightarrow$ gas mixture

$P \rightarrow$ gas mixture

$$\left(M \cdot \text{wt} \right)_{\text{Avg}} = \frac{d}{R} \times R \times T$$

$$\begin{aligned} \left(M \cdot \text{wt} \right)_{\text{Avg}} &= \frac{\sum M_i x_i}{\sum x_i} \\ &= \frac{M_1 x_1 + M_2 x_2}{x_1 + x_2} \end{aligned}$$

Note ->

$$PV = nRT$$

→ gas mixture

Concept - 4

Gas - A Gas - B

v $v - v$ v

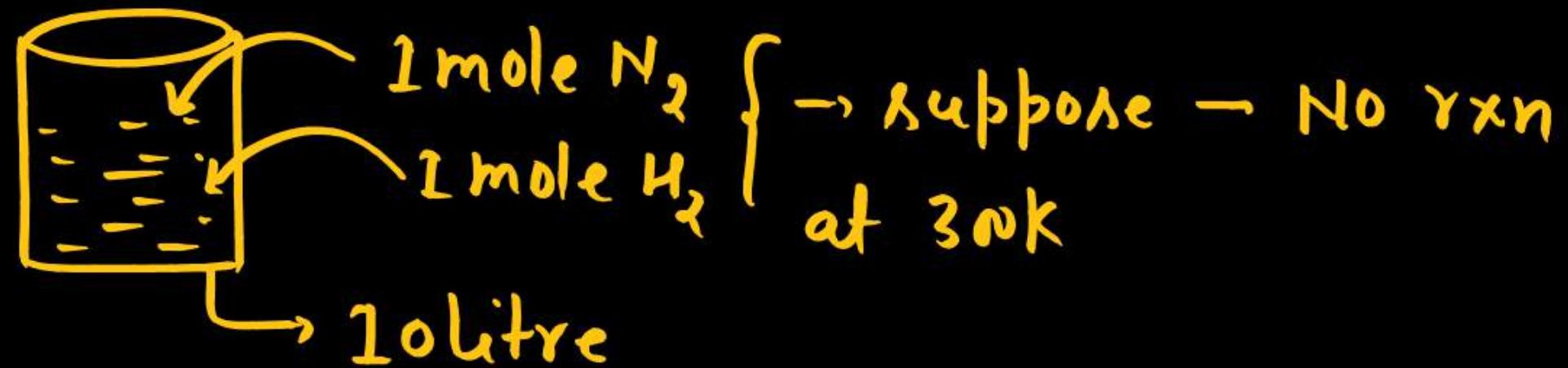
T $T \checkmark$ T

P_A $P_B \checkmark$ $P_A + P_B$

n_A n_B $n_A + n_B$

total in vessel

Q



Calculate P_T of vessel = ?

$$\text{Soln} = P_T V_T = n_T R T$$

$$P_T \times 10 = (1+1) \times R \times 300$$

$$P_T = \frac{2 \times 300 R}{10}$$

$$P_T = 60 R \text{ atm}$$

Q



3 mole H_2

1 mole N_2

at 10 litre vessel at 300K

Calculate total pr. After rxn.

$$P_T V_T = n_T RT$$

$$P_T \times 10 = 2 \times R \times 300$$

$P_T = 60R$



1 mole 3 mole 0 to

0 0 = 2 mole

After rxn

PARTIAL PRESSURE (DALTONS LAW)



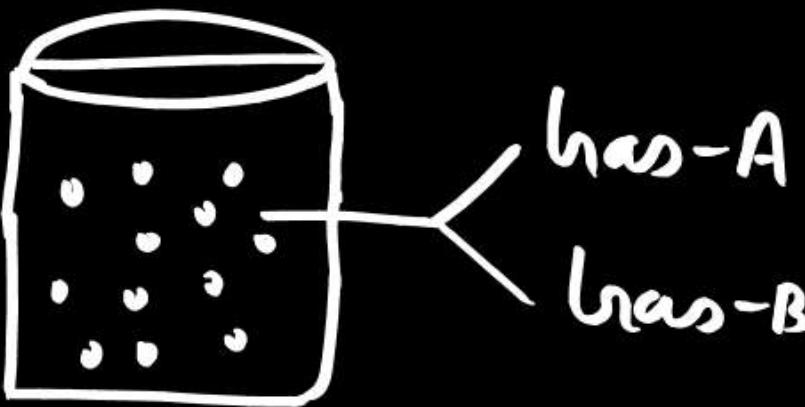
The law was formulated by Johan Dalton in 1801. It states that the total pressure exerted by the mixture of non-reactive gages is equal to the sum of the partial pressures of individual gases.

In a mixture of gases, the pressure exerted by the individual gas is called partial pressure. Mathematically

$$P_{\text{Total}} = P_1 + P_2 + P_3 + \dots \quad (\text{at constant } T, V)$$

Gases are generally collected over water and therefore are moist. Pressure of dry gas can be calculated by subtracting vapour pressure of water from the total pressure of the moist gas which contains water vapours also.

Concept -5



Gas-A Gas-B total value
in vessel

XXXX

$$P_T = P_A + P_B + \dots$$

$$\frac{P_A}{P_B} = \frac{n_A}{n_B}$$

Jo mole Ka ratio
wali pressure Ka
ratio hota hai

V	V	V
T	T	T
n_A	n_B	$n_A + n_B$
P_A	P_B	$P_A + P_B$

partial pressure = Mole fraction \times total pressure



Q. 4 g of H_2 and 32 g of SO_2 are present in a gaseous mixture at N.T.P.
The partial pressure of H_2 is

- (a) equal to that of SO_2 (b) equal that of SO_2
(c) three times that of SO_2 (d) ~~four times that of SO_2~~

Sol.

$$n_{\text{H}_2} = \frac{4}{2} = 2 \text{ mole}$$

$$n_{\text{SO}_2} = \frac{32}{64} = \frac{1}{2} \text{ mole}$$

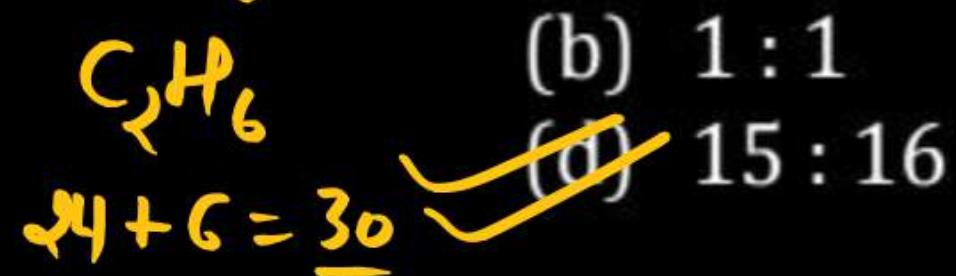
$$\frac{P_{\text{H}_2}}{P_{\text{SO}_2}} = \frac{n_{\text{H}_2}}{n_{\text{SO}_2}} = \frac{2}{\frac{1}{2}} = 4$$

$$P_{\text{H}_2} = 4 \times P_{\text{SO}_2}$$



Q. Equal weights of ethane and hydrogen are mixed in an empty container at 25°C. The fraction of total pressure exerted by hydrogen is?

- (a) 1 : 2
(c) 1 : 16



- (b) 1 : 1

- (d) 15 : 16

$$\frac{P_{H_2}}{P_T} = ?$$

Ans

$$\frac{P_{H_2}}{P_T} = \frac{\gamma_{H_2}}{\gamma_T} = \frac{\frac{1}{2}}{\frac{1}{2} + \frac{1}{30}} = \frac{\frac{1}{2}}{\frac{16}{30}} = \frac{1 \times 30}{2 \times 16} = \boxed{\frac{15}{16}}$$

GRAHAM'S LAW OF DIFFUSION



At constant temperature and pressure, the rate of diffusion is inversely proportional to the square root of the density.

$$r \propto \frac{1}{\sqrt{d}} \quad (\text{at constant T and P})$$

$$r \propto \frac{1}{\sqrt{VD}}$$

$$r \propto \frac{1}{\sqrt{M_w}} \quad \frac{r_1}{r_2} = \frac{v_1}{v_2} \times \frac{t_2}{t_1} = \sqrt{\frac{d_2}{d_1}} = \sqrt{\frac{M_2}{M_1}}$$

At constant temperature rate of diffusion is proportional to $\frac{P}{\sqrt{d}}$

$$\frac{r_1}{r_2} = \frac{v_1}{v_2} \times \frac{t_2}{t_1} = \frac{P_1}{P_2} \sqrt{\frac{d_2}{d_1}} = \sqrt{\frac{M_2}{M_1}}$$

$$\text{Rate of diffusion} = \frac{A \cdot P}{\sqrt{d}}$$

$\gamma \propto A$ (Area of orifice)

$\gamma \propto P$ (pressure of gas)

$$\gamma \propto \frac{1}{\sqrt{\text{vapour density}}}$$

$$\text{M.wt (M)} = 2 \times \text{V.D.}$$

$$\boxed{\gamma \propto \frac{1}{\sqrt{M - \text{M.wt of gas}}}}$$

$\gamma \propto \frac{1}{\sqrt{M}}$ → jada hoga
rate of diffusion
Kam hoga.

→ Concept - 6.



Q.

Equal weights of ethane and hydrogen are mixed in an empty Two balloons are filled with equal moles of hydrogen and helium. Which balloon will contract first, if the same size holes are made in both of them?

- (a) Balloon filled with hydrogen gas contract first. ✓
- (b) Balloon filled with helium gas contract first. ✗
- (c) Both will contract at the same time ✗
- (d) Hydrogen filled balloon will contract but helium filled balloon will not contract.

$$\gamma \propto \frac{1}{\sqrt{M}}$$

$$M_H = 2 \quad \gamma_H > \gamma_{He}$$
$$M_{He} = 4$$

Q. A bottle of dry NH_3 and bottle of dry HCl connected through a long tube are opened simultaneously at both ends, the white (NH_4Cl) ring first formed will be

- (a) at the center of the tube
- (b) near the HCl bottle
- (c) near the ammonia bottle
- (d) throughout the length of the tube



$$\gamma \propto \frac{1}{\sqrt{M}}$$

$$M_{\text{NH}_3} = 14 + 3 = 17$$

$$M_{\text{HCl}} = 1 + 35.5 = 36.5$$



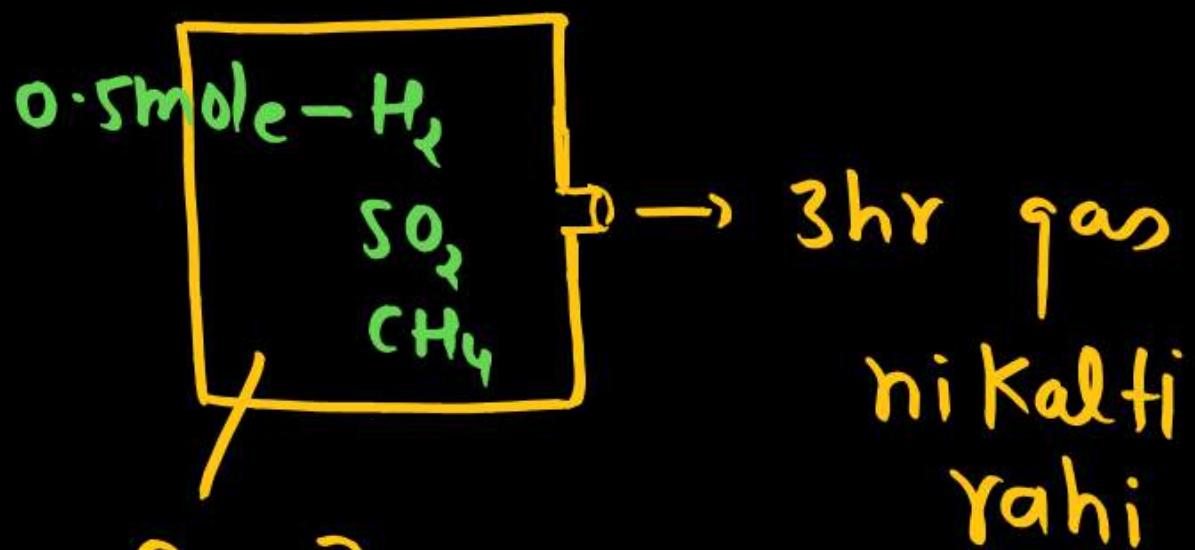
Q.

0.5 mole of each of H_2 , SO_2 and CH_4 are kept in a container. A hole was made in the container. After 3 hours, the order of partial pressures in the container will be

- (a) ~~$P_{SO_2} > P_{CH_4} > P_{H_2}$~~
- (c) $P_{CH_4} > P_{SO_2} > P_{H_2}$

- (b) $P_{H_2} > P_{SO_2} > P_{CH_4}$
- (d) $P_{CH_4} > P_{H_2} > P_{SO_2}$

$$\underline{P_{H_2} = P_{CH_4} = P_{SO_2} \rightarrow \text{initial}}$$



$$P = ?$$

$$M = 2$$

$$SO_2 = 64$$

$$CH_4 = 16$$

$$\gamma \propto \frac{1}{\sqrt{M}} \rightarrow K_m$$

jada

$$P_{H_2} < P_{CH_4} < P_{SO_2}$$

two gas $\rightarrow \frac{\gamma_1}{\gamma_2} = \sqrt{\frac{M_2}{M_1}}$ at Const T, P, A



$$\frac{\gamma_1}{\gamma_2} = \frac{P_1}{P_2} \sqrt{\frac{M_2}{M_1}} \text{ at Const } T, A$$

Note \rightarrow yadi question me

{ Mole of gas
Mass of gas
Mole ratio
Mass ratio } \Rightarrow pressure variable

$$\frac{n_1}{n_2} = \frac{P_1}{P_2}$$

① Rate of d. in term of length $\Rightarrow \frac{l_1}{t_1} \times \frac{t_2}{l_2} = \sqrt{\frac{M_2}{M_1}}$

② Rate in term of mole $= \frac{n_1}{t_1} \times \frac{t_2}{n_2} = \sqrt{\frac{M_2}{M_1}}$

③ Rate in term of vol. of gas $= \frac{V_1}{t_1} \times \frac{t_2}{V_2} = \sqrt{\frac{M_2}{M_1}}$

④ Rate in term of mass of gas $= \frac{W_1}{t_1} \times \frac{t_2}{W_2} = \sqrt{\frac{M_1}{M_2}}$ ⭐⭐⭐



Q. 4 : 1 molar mixture of He and CH₄ is contained in a vessel at 20 bar pressure. Due to a hole in the vessel, the gas mixture leaks out. What is the composition of the mixture effusing out initially?

- (a) 8 : 1 ✓
(b) 3 : 1
(c) 5 : 4
(d) 6 : 2

$$\frac{n_{He}}{n_{CH_4}} = ?$$

$$\frac{n_{He}}{n_{CH_4}} \times \frac{t_2}{t_1} = \frac{P_1}{P_2} \sqrt{\frac{M_{CH_4}}{M_{He}}}$$

$$\frac{n_{He}}{n_{CH_4}} \times \frac{t}{t_1} = \frac{P_{He}}{P_{CH_4}} \sqrt{\frac{M_{CH_4}}{M_{He}}}$$

$$\begin{aligned}\frac{n_{He}}{n_{CH_4}} &= \frac{4}{1} \sqrt{\frac{16}{4}} \\ &= \frac{8}{1}\end{aligned}$$

KINETIC THEORY OF GASES



$$\begin{aligned} \text{K.E. per molecule} &= \frac{3}{2} kT & \left\{ \begin{array}{l} k = \frac{R}{N_A} \\ \text{boltzmann const} \end{array} \right. \\ \text{K.E. per mole} &= \frac{3}{2} RT \end{aligned}$$

Note → K.E. of ideal gas depend upon temp.

Pressure \propto $\frac{1}{V}$ \rightarrow K.E. \rightarrow Const

$$\text{K.E. of } n \text{ mole} = \frac{3}{2} n R T$$

$$V_{rms} = \sqrt{\frac{3RT}{M}} = \sqrt{\frac{3PV}{M}} = \sqrt{\frac{3P}{d}} \rightarrow \text{molar density}$$

$$V_{avg.} = \sqrt{\frac{8RT}{\kappa M}} = \sqrt{\frac{8PV}{\kappa M}} = \sqrt{\frac{8P}{\kappa dm}}$$

$$V_{mp} = \sqrt{\frac{2RT}{M}} = \sqrt{\frac{2PV}{M}} = \sqrt{\frac{2P}{dm}}$$

V_{rms}, V_{avg}, V_{mp}

$\sqrt{3}, \sqrt{\frac{8}{\kappa}}, \sqrt{2}$

$V_{rms} > V_{avg} > V_{mp}$



Q. The rms speed of hydrogen is $\sqrt{7}$ times the rms speed of nitrogen. If T is the temperature of the gas

(a) $T(H_2) = T(N_2)$

(b) $T(H_2) > T(N_2)$

(c) $T(H_2) < T(N_2)$

(d) $T(H_2) = \sqrt{7} T(N_2)$

Sol.
$$\frac{\gamma_{H_2}}{\gamma_{N_2}} = \sqrt{7} \cdot \frac{\gamma_{N_2}}{\gamma_{N_2}}$$

$$\gamma_{H_2} = \sqrt{\frac{3RT_H}{2}}$$

$$\gamma_{N_2} = \sqrt{\frac{3RT_{N_2}}{28}}$$

$$\left(\frac{\gamma_{H_2}}{\gamma_{N_2}} \right)^2 = \frac{\frac{3RT_{H_2}}{2}}{\frac{3RT_{N_2}}{28}}$$

$$x = \frac{T_{H_2} \times 28}{T_{N_2} \times 2}$$

$$2T_{H_2} = T_{N_2}$$



Q. The temperature of a sample of SO_2 is raised from 27°C to 327°C . The average K.E. of the gas molecule is?

- (a) Doubled ✓
- (b) Raised to power 2
- (c) Halved
- (d) Multiplied by a factor of $327 / 27$

$$(\text{K.E.})_{\text{Avg}} = \frac{3}{2} RT$$

$$(\text{K.E.})_{327^\circ\text{C}} = 2 \times (\text{K.E.})_{27^\circ\text{C}}$$

$$(\text{K.E.})_{27^\circ\text{C}} = \frac{3}{2} R \times 300$$

$$(\text{K.E.})_{327^\circ\text{C}} = \frac{3}{2} \times R \times 600$$

$$\frac{(\text{K.E.})_{327^\circ\text{C}}}{(\text{K.E.})_{27^\circ\text{C}}} = \frac{1}{2}$$

REAL GAS EQUATIONS



$$PV = nRT \quad \dots \dots (1) \text{ ideal gas equation}$$

Two major corrections are required for real gases.

- (i) The intermolecular force of attraction between molecules is not negligible.

$$F_{att} \neq 0 \text{ so } P_{act.} = \left(P_{real} + \frac{n^2 a}{V^2} \right)$$

- (ii) The volume of a molecule is not negligible in comparison of total volume of gas.

$$V_1 \neq 0 \text{ so } P_{act.} = (V - nb)$$

$$b = \text{covolume} = \text{excluded volume} = 4 \times \frac{4\pi r^3}{3}$$

From equation (1)

$$\left(P + \frac{an^2}{V^2} \right) (V - nb) = nRT$$

$PV = nRT \rightarrow$ ideal gas

$\frac{PV}{nRT} = 1 \rightarrow$ ideal gas

$$\boxed{\frac{PV}{nRT}}$$

$\neq 1$ - Real gas.

$Z \neq 1$ - Real gas

$$Z = \frac{PV}{\boxed{nRT}}$$

\rightarrow const

compressibility factor

(measure deviation of ideal gas)

$$Z \neq 1$$

$Z > 1 \rightarrow$ Repulsion
force domination
 $V_m > 22.4 \text{ L}$

$$Z < 1$$

Attraction force
domination

$$V_m < 22.4 \text{ litre}$$

$$\frac{\left(P + \frac{n^2a}{V^2}\right) (V - nb)}{T} = nRT \text{ for } n \text{ mole of gas.}$$

↓
Correction
in volume

→ Van der Waal Gas Equation

↓
Correction
in pressure

(force of Attraction
| Repulsion b/w
Molecule)

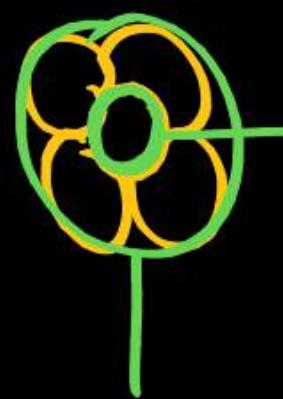
very small size
Vessel used:
or
gas bahut jad

Where $b \rightarrow$ excluded volume for 1 mole of gas.

$$b = 4 \times \text{Actual vol. of gas} \times N_A$$

$$= 4 \times \frac{4}{3} \pi r^3 \times N_A$$

↳ Radius of Atom /molecule



Actual
vol. (V)

Excluded vol. (b)

Note $\rightarrow b \rightarrow$ Represent
|
Size of Atom
|molecule



Where $a \Rightarrow$ Represent \Rightarrow Force \leftarrow Attraction force (\swarrow)
Repulsion force

$a \propto$ Attraction force b/w two molecule/atom

$a \propto$ easily liquified

$$\left(P + \frac{a}{V^2}\right) (V - b) = RT \quad \underline{\text{Concept-8}}$$

low pressure

(जादा \rightarrow volume)

$$\left(P + \frac{a}{V^2}\right) V = RT$$

$$PV + \frac{a}{V} = RT$$

$$\frac{PV}{RT} = 1 - \frac{a}{VR^T}$$

$$Z = 1 - \frac{a}{VR^T}$$

high pressure

$$P(V - b) = RT$$

$$PV = RT + Pb$$

$$\frac{PV}{RT} = 1 + \frac{Pb}{RT}$$

A.F.

$$Z < 1$$

$Z > 1 \rightarrow$ Repulsion force.

high temp \Rightarrow low pressure

high temp \rightarrow high K.E. \rightarrow A.F. \downarrow

$$P + \frac{a}{V^2} \approx P$$

low pressure \Rightarrow जादा volume

$$V - b \leq V$$

$\boxed{PV = RT}$ - ideal gas.



Q. The compressibility of a gas is less than unity at STP. Therefore,

- (a) $V_m > 22.4$ litre
- ~~(b)~~ $V_m < 22.4$ litre
- (c) $V_m = 22.4$ litre
- (d) $V_m = 44.8$ litre

$Z < 1 \rightarrow$ Attraction force domination



Q. In van der Waals equation of state for a non-ideal gas, the term that accounts for intermolecular forces is

- (a) $(V - b)$
- (b) RT
- (c) $P + \frac{a}{V^2}$
- (d) $(RT)^{-1}$

✓ A yellow circle highlights the term $P + \frac{a}{V^2}$ from the list of options.



Q. The values of van der Waals constant 'a' for the gases O_2 , N_2 , NH_3 and CH_4 are 1.360, 1.390, 4.170 and 2.253 $L^2 \text{ atm mol}^{-2}$ respectively. The gas which can most easily be liquified is

- (a) O_2
- (b) N_2
- (c) NH_3
- (d) CH_4

✓

liquified $\propto a$



Q. There is more deviation in the behaviour of a gas from the ideal gas equation ($PV = nRT$) at

- (a) high temperature and low pressure → *ideal gas*
- (b) low temperature and high pressure ✓
- (c) high temperature and low pressure
- (d) low temperature and low pressure



Q. For three different gases, values of Vander Waal's constant 'a' and 'b' are given. What is the correct order of liquefaction of gases:

Gases	'a'	'b'
X ₂	1.3	0.090
Y ₂	4.1	0.023
Z ₂	2.2	0.075

- (a) X₂ > Y₂ > Z₂ ✓ (b) Y₂ > Z₂ > X₂
(c) Z₂ > Y₂ > X₂ (d) X₂ > Z₂ > Y₂

Y₂ > Z₂ > X₂ liquefied &a



Q. If 'V' is the volume of one molecule of a gas under given condition, then Vander Waal's constant 'b' is

(a) $4V$

(b) $\frac{4V}{N_0}$

(c) $\frac{N_0}{4V}$

(d) $4VN_0$

$$b = 4 \times \text{Actual vol. of gas} \times N_A$$

$$= \underline{4 \times V \times N_A}$$



Q. Van der Waal's equation for CH_4 at low pressure is

(a) $PV = RT - Pb$

(b) $PV = RT - \frac{a}{V_0}$

jada volume

(c) $PV = RT + \frac{a}{V}$

(d) $PV = RT + Pb$

$$\left(P + \frac{a}{V^2}\right)(V) = RT$$

$$PV + \frac{a}{V} = RT$$

$$PV = RT - \frac{a}{V}$$



Q. Match gases under specific conditions listed in Column I with their properties / laws in Column II. Indicate your answer by darkening the appropriate bubbles of the 4×4 matrix given in the ORS.

Column I

- (a) Hydrogen gas ($P = 200$ atm, $T = 273$ K)
- (b) Hydrogen gas ($P \sim 0$, $T = 273$ K)
- (c) CO_2 ($P = 1$ atm, $T = 273$ K)
- (d) Real gas with very large molar volume

Column II

- (P) Compressibility factor $\neq 1$
- (Q) Attractive forces are dominant
- (R) $PV = nRT$
- (S) $P(V - nb) = nRT$



Thank You

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session from PW App.*