CH1201 MID-SEMESTER EXAMINATION

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Q1. **Reaction**: $N_2O_4 \rightleftharpoons 2NO_2$

$(1-\alpha) \qquad 2\alpha = (1+\alpha)$

$$\alpha = \frac{D_0 - D}{(2-1)D} = \frac{D_0 - D}{D}$$

D_0: Expected vapour density from the formula weight

D: Actual vapour density at the given T and P.

The calculated density of N_2O_4 : $D_0 = \frac{M}{2} = 46$

Observed Density : $D = 30.2$

Hence, $\alpha = \frac{46 - 30.2}{30.2} = \underline{\underline{0.523}}$

Hence, the fracn of gram-moles of N_2O_4 decomposed $= 0.523$

Thus, percentage of NO_2 molecules by wt. $= \underline{\underline{52.3\%}}$

Now, the ratio of grammoles of NO_2 & N_2O_4 in the mixture

$\Rightarrow \frac{2\alpha}{1+\alpha} : \frac{1-\alpha}{1+\alpha}$ (This is same as the ratio of their volumes)

Therefore, % age of NO_2 by volume $= \frac{2 \times 0.523}{1 + 0.523} \times 100\%$

$= \underline{68.7\%}$

Q2. 400g H_2 + 1400g N_2 ($P = 200$ atm)

$P = P_{H_2} + P_{N_2}$

H_2 : 200 mol and N_2 : 50 mol.

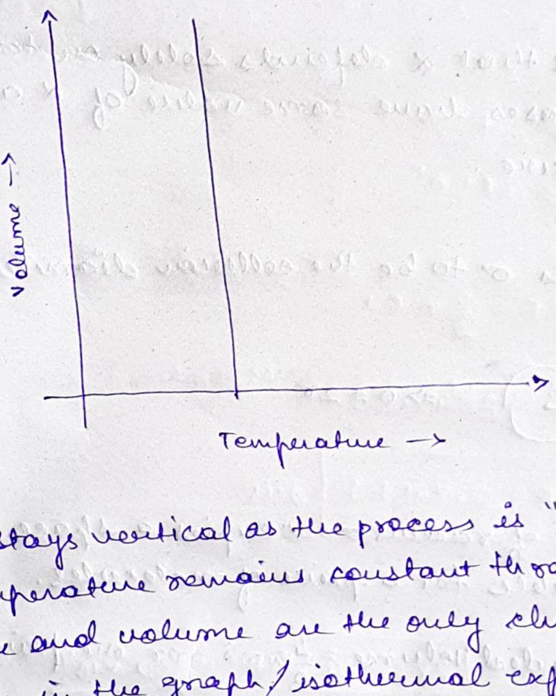
$\therefore P_{H_2} = \frac{200}{250} \times 200$ atm. $\left(P_a = \frac{n_a}{n} \times P\right)$

$= 160$ atm

$P_{N_2} = \frac{50}{250} \times 200$ atm

$= 40$ atm.

Q3. (i) Volume vs. Temperature Graph for Isothermal Expansion of a gas.



The graph stays vertical as the process is "isothermal" i.e., the temperature remains constant throughout. the pressure and volume are the only changing parameters in the graph/isothermal expansion.

(ii) α: Coefficient of thermal expansion.

According to definition,

$$\alpha = \frac{1}{V}\left(\frac{\partial V}{\partial T}\right)_P$$

For 1 mol ideal gas, $PV = RT$

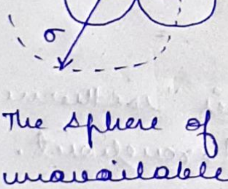
Hence, $\left(\frac{\partial V}{\partial T}\right)_P = \frac{R}{P}$

So, $\alpha = \frac{1}{V} \times \frac{R}{P} = \frac{R}{RT} = \frac{1}{T}$

Or, $\boxed{\alpha = \frac{1}{T}}$

This proves that α depends solely on temperature and all gases have same value of α at a given temperature.

Q4. Consider σ to be the collision diameter.



$\Rightarrow \sigma = 2r$

The sphere of radius σ occupies a space unavailable for a pair of molecules.

Thus, Excluded Volume $= \frac{4}{3}\pi\sigma^3$ for one pair of molecules.

$\Rightarrow$ Effective Volume of a single molecule $= \frac{1}{2} \times \frac{4}{3}\pi\sigma^3$

$$= \frac{2}{3}\pi\sigma^3$$

and $b = \frac{2}{3}\pi N_A \sigma^3$

(b: Van der Waal's Volume correction factor) which is the effective volume of Avogadro no. of molecules present in 1 mol gas.

Thus, $b = \frac{2}{3}\pi N_A \sigma^3 = 4 \times \frac{4}{3}\pi N_A r^3$

$\therefore$, Effective volume "b", is four times the actual volume of 1 mol gas molecules.

Q5. $T = 40^\circ C = 273 + 40 = 313K$

$PV = nRT$

$n = \frac{100}{44} = 2.2\dot{7}\dot{2}$

$V = 5L \Rightarrow P = \frac{nRT}{V} \simeq 11.68 \text{ atm}$ (Ideal).

$\left(P_i + \frac{an^2}{V^2}\right)(V_i - nb) = nRT$ ($a = 3.59$ atm $L^2 mol^{-2}$
$b = 0.43$ L mol^{-1})

$\Rightarrow$ Substituting all values, we get,

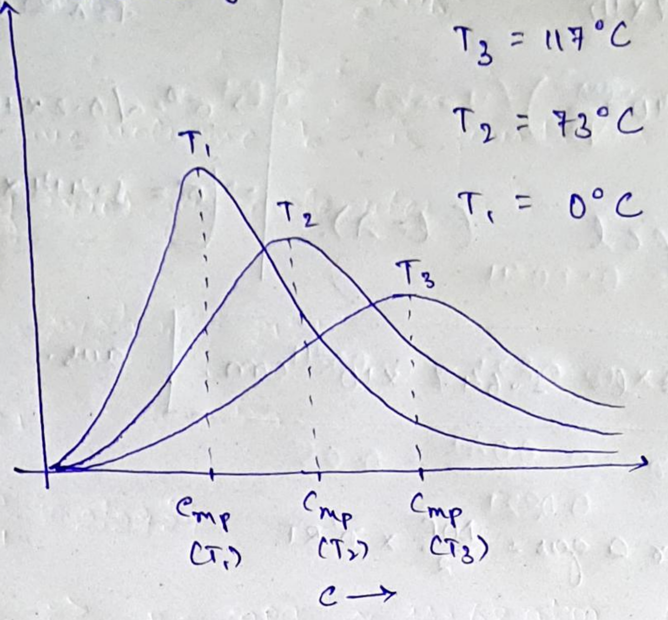
$P_{real} = 13.7765$ atm (Real)

Q7. $c_{mp} = \sqrt{\dfrac{2RT}{M}} = \sqrt{\dfrac{2 \times 8.314 \times 300 \times 10^7}{32}}$

$\simeq 89482 \ cm s^{-1}$

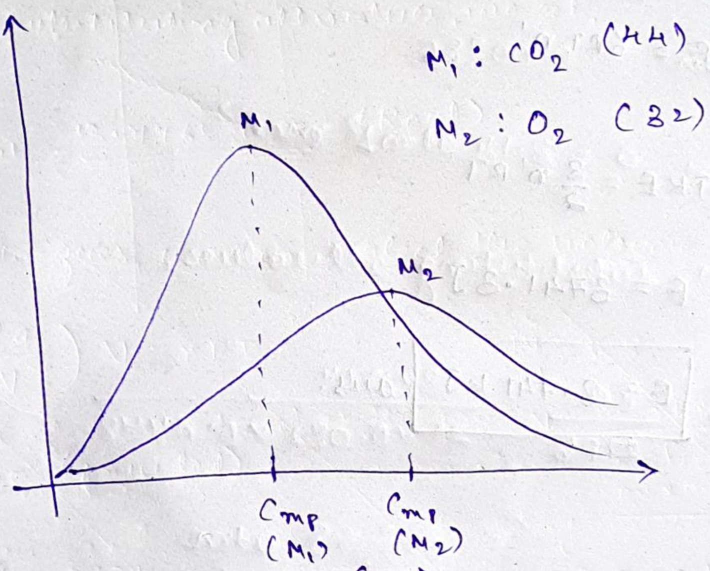
$\simeq \underline{894.83 \ m s^{-1}}$ (ans.

Q8. (a)



c: speed.
F(c): Maxwell's speed distribution function

(b)



Q9. Given

$\eta = 8.4 \times 10^{-5}$ poise

$\bar{c}_{avg} = 1.7 \times 10^{5}$

$\rho = 9 \times 10^{-5}$

$\eta = \frac{1}{3} \rho \bar{c} l \quad (l = \lambda).$

$\Rightarrow \boxed{\lambda = l = 1.647 \times 10^{-5} \text{ cm.}}$ ans.

$l = \frac{RT}{\sqrt{2}\pi\sigma^2 P N_A}$

$\Rightarrow \sigma^2 = \frac{RT}{\sqrt{2}\pi\, l\, P N_A}$

$\Rightarrow \sigma = \sqrt{0.2 \times 10^{-23}}$

$\Rightarrow \boxed{\sigma = 1.414 \times 10^{-12} \text{ cm}}$

Q10. KE for a gas = $\frac{DOF}{2} \times n' RT$

$n' = \frac{8.5}{17}$ Molar Mass of $NH_3 = 17$.

$TKE = \frac{3}{2} RTn'$

$RKE = \frac{3}{2} RTn'$

$VKE = 6RTn'$

$\therefore TKE = \frac{3}{2} n' RT$

$\Rightarrow E = 3741.3 J$

$\Rightarrow \boxed{E = 3.741 kJ}$ ans.

Q11. Rise in Capillary Tube

T: Surface Tension

ρ: density

r: radius $= \frac{0.21}{2}$ mm

$\simeq 0.01$ cm

$$H = \frac{2T}{\rho r g}$$

$g = 980 \text{ cms}^{-2}$

$H = 6.30$ cm

$$6.30 = \frac{2 \times T}{0.79 \times 0.01 \times 980}$$

$$\Rightarrow \boxed{T = 24.33 \text{ dyne cm}^{-1}}$$ ans.

Q12. $\left[P + \frac{0.00786}{V^2}\right](V - 0.0024) = 0.0041\,(273 + t)$

We know,

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

$nR = 0.0041$

$\Rightarrow n \times 0.0821 = 0.0041$

$\Rightarrow n = \frac{0.0041}{0.0821} = 0.05$

$nb = 0.00224$

$\Rightarrow b = \frac{0.00224}{0.05} = 0.0448\ L\,mol^{-1}$

$an^2 = 0.00786$

$\Rightarrow a = 3.14\ atm\,L^2\,mol^{-2}$

Now, substituting all values,

$$T_c = \frac{8a}{27Rb} = \frac{8 \times 3.14}{27 \times 0.082 \times 0.0448}$$

$$= \underline{253.58\ atm}$$

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

$\Rightarrow Z = 0.5$

$T = 273K$

$Z = \frac{P}{P_i} \Rightarrow ZP_i = P$

$\Rightarrow ZP_i = \left(P_i + \frac{an^2}{V^2}\right)$

$\Rightarrow \boxed{a = 1.255}$ ans.