

MAINS+ADVANCED

TOPIC

STATE OF MATTER

SOLUTIONS

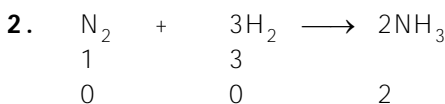
STATE OF MATTER

Exercise-01

1. Let initial temperature and pressure are T_1 & P_1 (ekuk ikjfehkdk rki o nkc T_1 o P_1 g)

$$P_2 = \left(P_1 + \frac{0.4}{100} P_1 \right) \quad T_2 = 3(T_1 + 1)$$

$$\frac{P_1}{P_2} = \frac{T_1}{T_2} \Rightarrow \frac{100}{100.4} = \frac{T_1}{(T_1 + 1)} \quad T_1 = 250 \text{ K}$$



$$\frac{V_{\text{initial}}}{V_{\text{final}}} = \frac{4}{2} \Rightarrow \frac{2}{1}$$

3. SO_2 replaced by O_2 (SO_2 , O_2 l s i f r L F k f i r g k r h g s)
 $P, V, T \Rightarrow$ same
 $n \Rightarrow$ constant

$$n_{\text{O}_2} = n_{\text{SO}_2}$$

$$\frac{W_{\text{O}_2}}{32} = \frac{W_{\text{SO}_2}}{64} \quad W_{\text{O}_2} = \frac{1}{2} W_{\text{SO}_2}$$

4. At const pressure (fu; r nkc ij) $V \propto T$

5. $V \propto T \quad \frac{V_2}{V_1} = \frac{T_2}{T_1}$

$$T_2 = \frac{3}{3.75} \times 3.8 \Rightarrow 246.4 \text{ K} \quad T_2 = -26.6^\circ\text{C}$$

6. $P_{\text{N}_2} \propto n_{\text{H}_2} \quad P_{\text{total}} \propto (n_{\text{H}_2} + n_{\text{CH}_4})$

$$\frac{P_{\text{H}_2}}{P_{\text{total}}} = \frac{w/2}{w/2 + w/16} \Rightarrow \frac{8}{9}$$

7. $PV = nRT \quad n = \frac{10^{-10}}{760} \times \frac{10^{-3}}{0.082 \times 293}$
 number of molecules (v.kvksa dh l a; k) =

$$\frac{10^{-10} \times 10^{-3}}{760 \times 0.082 \times 293} \times 6.023 \times 10^{23} = 3.29 \times 10^6$$

8. $PV = \frac{w}{M_w} RT$

$$M_w = \frac{wRT}{PV} \Rightarrow \frac{2.8 \times 0.082 \times 400}{1 \times 1}$$

9. $M_w = 91.84 = 92 \quad \text{C}_7\text{H}_8$
 $V_A = 0.5 \text{ dm}^3, \quad V_B = 1 \text{ dm}^3$
 $d_A = 3 \text{ g/dm}^3, \quad d_B = 1.5 \text{ g/dm}^3$
 $M_A = \frac{1}{2} M_B \quad P_A = \frac{d_A RT}{M_A}, \quad P_B = \frac{d_B RT}{M_B}$

$$\frac{P_A}{P_B} = \frac{d_A}{d_B} \times \frac{M_B}{M_A} \Rightarrow \frac{3}{1.5} \times 2 = 4$$

10. $P = \frac{3 \times 0.082 \times 400}{20} \quad P = 4.92 \text{ atm}$

11. $PV = \frac{w}{M_w} RT \quad \frac{P}{WT} = \text{const.}$
 $\frac{4.05}{w \times 300} = \frac{P_2}{\frac{w}{2} \times 285}$

$$P_2 = 1.92 \text{ MPa}$$

12. $PV = \frac{w}{M_w} RT$
 $M_w = \frac{wRT}{PV} \Rightarrow \frac{1 \times 0.082 \times 273}{2 \times 0.350} \quad M_w = 32$

The mass of one atom (, d i j e k . k q d k æ 0 ; e k u)
 $= 16 \text{ amu} \Rightarrow 2.64 \times 10^{-23} \text{ g}$

13. $PV = nRT$
 $n = \frac{PV}{RT} \Rightarrow \frac{7.6 \times 10^{-10}}{760} \times \frac{1}{0.082 \times 273}$
 $n \Rightarrow 0.0446 \times 10^{-12}$
 The no. of oxygen molecule (vkd l ht u v . k q d k l a; k)
 $= 0.0446 \times 10^{-12} N_A \Rightarrow 2.7 \times 10^{-10}$

14. $\frac{\text{vol. of O}_2 \text{ molecule (O}_2 \text{ v.kqdk vk; ru)}}{\text{vol. of O}_2 \text{ molecule at STP (STP ij O}_2 \text{ v.kqdk vk; ru)}}$
 $\Rightarrow \frac{\frac{4}{3} \pi \times 8 \times 10^{-30} \times 10^3}{22.4 / N_A} = 0.09 \%$

15. $U_{\text{rms}} = \sqrt{\frac{3RT}{M_w}} \Rightarrow \sqrt{\frac{3 \times 8.314 \times 300}{2 \times 10^{-3}}}$

$$U_{\text{rms}} = 1934 \text{ m/sec.}$$

$$16. \quad U_{\text{rms}} = \sqrt{\frac{T}{M_w}} \quad T \propto M_w$$

$$\frac{T_{\text{Ne}}}{T_{\text{O}_2}} = \frac{20}{32} \quad T_{\text{O}_2} = 480 \text{ K}$$

$$17. \quad U_{\text{mp}} = \sqrt{\frac{2RT}{M}}$$

$$= \sqrt{\frac{2 \times 8.314 \times 293}{1.67 \times 10^{-27} \times 6.023 \times 10^{23}}} = 2124 \text{ m/sec.}$$

$$18. \quad U_{\text{rms}} = \sqrt{\frac{3PV}{M}} = \sqrt{\frac{3P}{d}}$$

$$= \sqrt{\frac{3 \times 1.2 \times 10^5}{4}} = 300 \text{ m/sec.}$$

$$19. \quad M_A = 2M_B, (U_{\text{rms}})_A = (U_{\text{rms}})_B$$

$$U_{\text{rms}} = \sqrt{\frac{3PV}{M}} \quad U_{\text{rms}} \propto \sqrt{\frac{P}{M}}$$

$$\frac{(U_{\text{rms}})_A}{(U_{\text{rms}})_B} = \sqrt{\frac{P_A}{P_B} \times \frac{M_B}{M_A}} \quad 4 = \frac{P_A}{P_B} \times \frac{1}{2}$$

$$\frac{P_A}{P_B} = 8 : 1$$

$$20. \quad U_{\text{rms}} = \sqrt{\frac{3RT}{M}} = \sqrt{\frac{3 \times 8.314 \times 300}{10^{-15} \times 6.023 \times 10^{23}}}$$

$$U_{\text{rms}} = \frac{3.52}{10^3} \text{ m/sec.} \Rightarrow \frac{3.52}{10} \text{ cm/sec.}$$

$$\Rightarrow 0.352 \text{ cm/sec.}$$

$$21. \quad U_{\text{Avg.}} = \sqrt{\frac{8RT}{\pi M}} \quad \frac{U_{\text{Avg.}}}{0.3} = \sqrt{\frac{1200}{300}}$$

$$U_{\text{Avg.}} = 0.6 \text{ m/sec.}$$

$$22. \quad U_{\text{rms}} = \sqrt{\frac{3RT}{M}} \quad T \propto M$$

$$23. \quad U_{\text{mp}} = \sqrt{\frac{2RT}{M}}$$

$$24. \quad E_T = \frac{3}{2} RT, E_R = RT$$

$$E_{\text{total}} = \frac{3}{2} RT + RT = \frac{5}{2} RT = \frac{5}{2} \times 300 \times 8.314$$

$$= 6235.5 \text{ J}$$

$$25. \quad \text{K.E.} = \frac{3}{2} nRT \quad x = \frac{3}{2} \times \frac{N}{N_A} \times 150 \times R$$

$$2x = \frac{3}{2} \times \frac{N'}{N_A} \times 300 \times R \quad N' = N$$

$$26. \quad \text{K.E.} = \frac{3}{2} nRT$$

$$\frac{\text{K.E.}}{\text{Molecule}} = \frac{3}{2} \times \frac{8}{16} \times \frac{300 \times 8.314}{N_A} \times 2$$

$$= 6.21 \times 10^{-21} \text{ J/molecule}$$

$$27. \quad \frac{r_1}{r_2} = \sqrt{\frac{M_2}{M_1}} = \sqrt{\frac{64}{44}} = \frac{4}{\sqrt{11}}$$

$$28. \quad \frac{V_1}{V_2} \times \frac{t_2}{t_1} = \sqrt{\frac{M_2}{M_1}}$$

$$\frac{20}{V_1} \times \frac{30}{60} = \sqrt{\frac{32}{64}}$$

$$V_2 = 14.14 \text{ lit.}$$

$$29. \quad r \propto \frac{1}{\sqrt{M}}$$

$$r_{\text{N}_2} : r_{\text{H}_2} : r_{\text{He}} :: \frac{1}{\sqrt{28}} : \frac{1}{\sqrt{2}} : \frac{1}{\sqrt{4}} :: \frac{1}{\sqrt{14}} : \frac{1}{\sqrt{1}} : \frac{1}{\sqrt{2}}$$

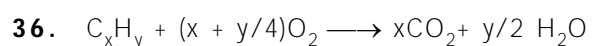
$$r_{\text{N}_2} : r_{\text{H}_2} : r_{\text{He}} :: 1 : \sqrt{14} : \sqrt{7}$$

$$30. \quad \text{Rate of diffusion (fol j.k dh nj)} \propto$$

$$\frac{1}{\sqrt{\text{molecular mass (vlf. od æ0; eku)}}$$

$$33. \quad Z = \frac{PV}{RT} \Rightarrow \frac{40 \times 0.4}{300 \times 0.082}$$

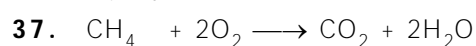
$$Z = 0.65$$



$$1.0 \qquad \qquad \qquad 10x \qquad 5y$$

$$10x = 40 \quad | \quad 5y = 50$$

$$x = 4 \quad | \quad y = 10$$



38. $C_4H_{10} + \frac{13}{2}O_2 \longrightarrow 4CO_2 + 5H_2O$
 58 gm $\frac{13}{2} \times 32$
 58 g CH_4 required vol. of O_2 at NTP = $\frac{13}{2} \times 22.4$ lit
 (NTP i j 58 g CH_4 dsfy, O_2 dk vko'; d vk; ru)

1000 g CH_4 required vol. of O_2 at NTP =
 $\frac{13}{2} \times \frac{22.4}{58} \times 1000$

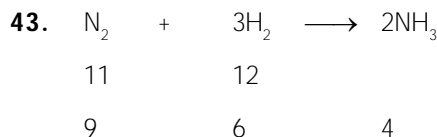
(NTP i j 1000 g CH_4 dsfy, O_2 dk vko'; d vk; ru)
 = 2510 litre

47. Extent of intermolecular hydrogen bonding increasing the viscosity.
 ('; kurk c<asi j vlrj kf. od gkbMst u cl/ku dh ek=k)

Exercise-02

7. $P_{total} = \frac{3W RT}{32 V}$ $P_{O_2} = \frac{W RT}{32 V}$ $\frac{P_{O_2}}{P_{total}} \Rightarrow \frac{1}{3}$
9. K.E. $\propto T$
11. $Z = \frac{PV_m}{PV}$ $\frac{V_m}{22.4} < 1$ $V_m < 22.4L$
12. $PV = nRT$ $P = \frac{2 \times 0.82 \times 546}{44.8}$
 $P = 2$ atm
13. $U_{rms} = \sqrt{\frac{3RT}{M_w}}$
14. $P = \frac{dRT}{M_w}$ $d_1 T_1 = d_2 T_2$
 $dT = \text{const}$ $d \times 300 = 0.75 d \times T_2$
 $T_2 = 100 \times 4 \Rightarrow 400$ K
15. $U_{rms} = \sqrt{\frac{3RT}{M_w}}$ $\frac{(U_{rms})_{O_3}}{(U_{rms})_{O_2}} = \sqrt{\frac{32}{48}} \Rightarrow \sqrt{\frac{2}{3}}$
16. Lowest pressure and highest temperature
19. $2H_2S(g) + SO_2(g) \longrightarrow 2H_2O(l) + 3S(s)$
 2.8 1.6
 H_2S is limiting reagent
 SO_2 remaining = $1.6 - 1.4 \Rightarrow 0.2$ lit
20. Rates of diffusion $\propto \frac{1}{\sqrt{\text{Molar Mass}}}$
22. $PV = nRT$ $P'V = \frac{n}{2}RT$ $P' = \frac{P}{2}$
26. $r \propto \frac{1}{\sqrt{M}}$ $r_{CH_4} = 2 r_x$
 $\frac{r_{CH_4}}{r_x} = \sqrt{\frac{M_x}{M_{CH_4}}}$ $4 = \frac{M_x}{16}$
 $M_x \Rightarrow 64$
28. $\frac{(U_{rms})_{SO_2}}{(U_{rms})_{He}} = \sqrt{\frac{M_{He}}{M_{SO_2}}} = \sqrt{\frac{4}{64}} = \frac{1}{4} = 0.25$

29. $r \propto \frac{1}{\sqrt{M}}$ $\frac{t_2}{t_1} = \sqrt{\frac{M_2}{M_1}}$
 $\frac{60}{45} = \sqrt{\frac{X}{40}} \Rightarrow \sqrt{\frac{X}{40}} = \frac{4}{3} \Rightarrow \sqrt{\frac{X}{40}} = \frac{16}{9}$
 $X = 71.11$
30. $P_1 V_1 = P_2 V_2$ $1 \times 550 = P_2 \times 600$
 $P_2 = \frac{5}{6}$ atm $P_2 = \frac{5}{6} \times 760 \Rightarrow P_2 = 633.33$ mm
 Pressure decrease $\Rightarrow 760 - 633.33 \Rightarrow 126.67$ mm
31. $P = \frac{dRT}{M_w}$ $M_w = \frac{7.71 \times 0.082 \times 309}{2.88}$
 $M_w = 67.83$ Molecular formula = ClO_2
36. rate of diffusion $\propto \frac{1}{\sqrt{\text{Molar mass}}}$
 $\frac{r_{He}}{r_{CO}} = \sqrt{\frac{M_{CO}}{M_{He}}} = \sqrt{\frac{28}{4}} = 2.65$
 $\frac{r_{He}}{r_{CO}} = \sqrt{\frac{M_{SO_2}}{M_{He}}} = \sqrt{\frac{64}{4}} = 4$
39. K.E. = $\frac{3}{2}nRT$ $nT = \text{const}$
 $0.3 \times T = 0.4 \times 400$ $T = 533.33$ K
40. $V = \frac{4}{3}\pi r^3$
 $V_m = \frac{4}{3} \times \pi \times (10^{-10})^3 \times 6.023 \times 10^{23}$
 $V_m = 2.52 \times 10^{-6} \text{ m}^3$
 $V_m = 2.52 \text{ mL}$
41. Rate of diffusion $\propto \frac{1}{\sqrt{\text{molar mass}}}$
42. $C_v = \frac{11}{2}R$; $C_p = \frac{13}{2}R$



Volume remaining after injected water

$$= 20 - 3.58 = 16.42$$

All NH_3 dissolve in water $PV = nRT$

$$P \times 16.42 = 15 \times 0.0821 \times 300$$

$$P = 22.5 \text{ atm}$$

44. Let $T_1 > T_2$; final pressure will be same, let x mole transfer from A to B vessel.

$$\therefore P_A V = (n-x) RT_1 \quad \dots(1)$$

$$\text{and } P_A V = (n+x) RT_2 \quad \dots(2)$$

$$\therefore x = \frac{n(T_1 - T_2)}{T_1 + T_2}$$

finally $P_1 \times 2V = 2nRT_1$; $V = \frac{nRT_1}{P_1}$ put eq.(1)

$$\therefore P_A \times \frac{nRT_1}{P_1} = \left(n - \frac{n(T_1 - T_2)}{T_1 + T_2} \right) RT_1$$

$$P_A = \frac{2P_1 T_2}{T_1 + T_2}$$

45. $P \propto d$; $P = kd$ and $k = \frac{1 \text{ atm}}{1 \text{ metre}}$

$$PV = nRT; kd \left(\frac{1}{6} \pi d^3 \right) = nRT;$$

$$\frac{d_1^4}{d_2^4} = \frac{n_1}{n_2}; \frac{1}{4^4} = n_1/n_2; n_2 = 256$$

46. % relative humidity

$$= \frac{\text{Partial pressure of H}_2\text{O}}{\text{Vapour pressure of H}_2\text{O}} \times 100$$

$$75 = \frac{P_{\text{H}_2\text{O}}}{30} \times 100 \Rightarrow P_{\text{H}_2\text{O}} = 22.5 \text{ torr};$$

$$\% \text{ of H}_2\text{O vapour in air} = \frac{(22.5)}{760} \times 100 = 2.96$$

$$\text{molar mass of wet air} = \frac{29 \times 97.04 + 2.96 \times 18}{100}$$

$$= \frac{2814.16 + 53.28}{100} = 28.67$$

$$\text{density of wet air} = \frac{PM}{RT} = \frac{1 \times 28.67}{0.0821 \times 300} = 1.164 \text{ g/L}$$

47. Density of air at sea level,

$$d_0 = \frac{29 \times 1}{0.0821 \times 290} = \frac{1}{0.821} \text{ g/L}$$

density at 831 m = d

$$d_0 e^{-Mgh/RT} = \frac{1}{0.821} \times e^{-\left(\frac{29 \times 10^{-3} \times 10 \times 831}{8.31 \times 290} \right)}$$

$$\Rightarrow \frac{1}{0.821} \times e^{-0.1} = \frac{.9}{0.821} \text{ g/L}$$

Let x be number of balloons

$$\therefore 10^3 \times g + x \times 40 \text{ g}$$

$$= \frac{0.9}{0.821} \times 8.21 \times g \times x \Rightarrow x = 20 \text{ balloons}$$

Exercise-03

Comprehension # 2

1. $200 < T_b < 1000$

$$\Rightarrow 200 < \frac{a}{Rb} < 1000$$

$$\Rightarrow 400 \text{ cal} < \frac{a}{b} < 2000 \text{ cal}$$

$$\Rightarrow 0.4 \text{ k cal mol}^{-1} < \frac{a}{b} < 2 \text{ k cal mol}^{-1}$$

2. $mPpnkc \{ks= ea \quad Z = 1 + \frac{Pb}{RT}$

$$\text{nkuka fclnq/ka ds fy, gy dj yrs gA} = 10^{-3} \text{ atm}^{-1}$$

3. Use $z = \frac{P_{vm}}{RT} \Rightarrow Um = \frac{zRT}{P}$

$$= 0.065 \text{ L}$$

4. $cks y rki i j] okLrfod xS de nkc \{ks= ea vkn' k' 0; ogkj n' k' h gA$

5. $Z = \frac{1 + Pb}{RT}, <ky z \frac{b}{RT} rki ds 0; \{ks= eavkn' k' h gA$

(b) $u_{avg} = \sqrt{\frac{8}{\pi} \times \frac{1.01325 \times 10^5}{1.2504}} = 454.259356$

(c) $u_{mp} = 403 \text{ m/s}$

20. Use the results :

21. $\sqrt{\frac{3RT_1}{M}} = \sqrt{\frac{8RT_2}{\pi M}} = \sqrt{\frac{2RT_3}{M}} = 1500 \text{ m/s}$

$$\begin{cases} T_1 = 2886\text{K} & \text{rms} \\ T_2 = 3399\text{K} & \text{avg.} \\ T_3 = 4330\text{K} & \text{m.p.} \end{cases}$$

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

putting $\begin{cases} u = 0.995 u_{mp} \\ du = 0.01 u_{mp} \end{cases}; \frac{1}{N} dN = 8.303 \times 10^{-3}$

23. Similar as Q.22

25.(a) $P = \left(\frac{22}{44} \right) \times \frac{0.0821 \times 298.15}{0.5} \text{ atm} = 2.479 \times 10^3 \text{ kPa}$

(b) $\left(\frac{P + \left(\frac{1}{2} \right)^2 \times 363.76}{(0.5)^2} \right) \left(0.5 - \frac{1}{2} \times \frac{42.67}{1000} \right)$

$= \frac{1}{2} \times 8.3187 \times 298.15 \text{ kPa}$

$P = 2225.55 \text{ kPa}$

26. $1.95 = \frac{800 \times 1}{nR \times 223} \dots\dots(i)$

$1.10 = \frac{200 \times V}{nR \times 373} \dots\dots(ii)$

$\Rightarrow \frac{1.95}{1.10} = \frac{800}{200} \times \frac{1}{V} \times \frac{373}{223} \quad V = 3.77 \text{ lit}$

27. $0.927 = \frac{10.1325 \times 10^5 \times 100 \times 10^{-3}}{n \times 8.314 \times 273.15}$

28. Hint : At critical temp (T_c) and critical pressure (P_c) O_2 will behave ideally.

(Økflurd rki (T_c) o Økflurd nk (P_c) i j O_2 vkn'kz 0; ogkj djxhA)

29.(i) find T_c (T_c Kkr dhft ,)

(ii) large value of b \propto largest molecular vol. (b dk vfkdre eku \propto vfkdre vkf.od vk; ru)

(iii) least value of a and b (a o b dk U; wre eku)

30. Reduced pressure. (l ekfur nk) $P_r = \frac{P}{P_c} = 2.99$

Reduced temperature (l ekfur rki) $T_r = \frac{T}{T_c} = 1.90$

31. Hint : low density (de ?kuRo) \Rightarrow high molar volume

(vfkdre ely j vk; ru) (V_m) : $V_m \xrightarrow{\text{lim}} \infty$

32. $\left(15 + \frac{9 \times 6.7}{(10)^2} \right) (10 - 3 \times 0.0564) = 3 \times 0.0821 \times T$

$\Rightarrow T = 623.5 \text{ K} \quad \Rightarrow T = 350.5^\circ\text{C}$

33.(i) $P \times 12 = 15 \times 0.0821 \times (273 + 30)n$
 $P = 31.1 \text{ atm}$

(ii) $\left(P + \frac{(15)^2 \times 0.2107}{(12)^2} \right) (12 - 15 \times 0.0171)$
 $= 15 \times 0.0821 \times (273 + 30) \quad P = 31.4 \text{ atm}$

34. $1000 \times g = e \left(\frac{nRT_2}{P} - \frac{nRT_1}{P} \right) g$

$1000 = \frac{nR \times M}{R T_1} (T_2 - T_1)$

35. $Q = C_{V1} (1000 - 500) + C_{V2} (1500 - 1000)$
 $= \left(\frac{3R}{2} + \frac{3R}{2} \right) \times 500 + \left(\frac{3R}{2} + \frac{3R}{2} + 3R \right) (500)$
 $= 1500 R + 3000 R = 4500 R$

Exercise-4(B)

1 $\rho_1 h_1 = \rho_2 h_2$,
In one hour (, d ?k. Vs ep, $h_1 = 37 \times 2 = 74 \text{ mm}$
 $1.034 \times 74 = 13.6 \times h_2$
 $h_2 = 5.626 \text{ mm of Hg}$
 $P = \frac{5.626}{760} \text{ atm/hr.} \quad PV = nRT$

$\frac{5.626}{760} \times 0.016 = n \times 0.821 \times 310$
 $n = 4.653 \times 10^{-3} \text{ mole/hr.}$
rate of O_2 consumption = $n \times 22400 \text{ cm}^3$
 $= 0.104 \text{ cm}^3/\text{m}$
(O_2 ds iz Ør gkus dh nj) = $104 \text{ mm}^3/\text{hr.}$

2. $P = 750 - 17.5 = 732.5$ torr
 $T = 20^\circ\text{C} = 293$ K
 Inhaled (xg.k dh xbj) $O_2 = 52.5 \times 0.2032$
 Exhaled (fu"dkfl r) $O_2 = 52.5 \times 0.1675$
- so at STP $\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$
- $$\frac{732.5 \times 52.5(0.2032 - 0.1675)}{293} = \frac{760 \times V}{273}$$
- $\Rightarrow V = 1.683$ L for 6 min.
 oxygen consumption per min (ifr feuV iz Ør vkØl itu) $= \frac{1.683}{6} = \frac{0.28\text{L}}{\text{min}} = 280$ mL/min
3. Let moles of water vapour initially (ekuk ikjEHk eaty ok'i ds esy) $= n_1$
 Let moles of water vapour Finally (ekuk vlr eaty ok'i ds esy) $= n_2$
- $$n_1 = \frac{17.5 \times 0.8 \times V}{R \times 293} \Rightarrow n_2 = \frac{6.5 \times V}{R \times 277}$$
- $$\frac{n_1}{n_2} = 2.036$$
- $$\frac{n_2}{n_1} = 0.491$$
- so fraction of water vapour condensed
- $$= 1 - \frac{n_2}{n_1} = 0.509$$
- (vr% lØkfur ty ok'i dh fllku)
4. Average velocity (vks r osx) $= \sqrt{\frac{8RT}{\pi M}} = 4 \times 10^2$
- $$\Rightarrow \frac{RT}{\pi M} = 2 \times 10^4 \Rightarrow RT = 2\pi M \times 10^4$$
- Total K.E. of He
- $$= \frac{6}{4} \times \frac{3}{2} RT = \frac{9}{4} RT = \frac{9}{4} \cdot 2\pi \times 4 \times 10^{-3} \times 10^4 = 180\pi\text{J}$$
- Total K.E. of Ne
- $$= \frac{12}{20} \times \frac{3}{2} RT = \frac{9}{10} RT = \frac{9}{10} \times 2\pi \times 20 \times 10^{-3} \times 10^4 = 360\pi\text{J}$$
- Average K.E. per mol (ifr esy vks r K.E.) =
- $$\frac{(360 + 180)\pi}{1.5 + 0.5} = \mathbf{807.84\text{ J}}$$
5. $V - b = RT = 100$ ($0.011075 V - b$) = 1.1075
 $V - 100b \Rightarrow V = \frac{99b}{0.0175} = 921b$

- $$\Rightarrow 920b = RT$$
- $$\Rightarrow b = 24.33 \text{ cm}^3 \text{ mol}^{-1} = 4 \times \frac{4}{3} \pi r^3 \times 6.023 \times 10^{23}$$
- $$\Rightarrow r = 13.4 \times 10^{-9} \text{ cm} = \mathbf{134\text{ pm}}$$
6. $V = \frac{RT}{P} + B = 2.058$ L. Also, for the given equation (vks nh x; h l ehdj.k ds fy,) :
- $$Z = 1 + \frac{PB}{RT} = 1 + \frac{10(-0.1814)}{0.082 \times 273} = \mathbf{0.918}$$
- From vander Waal's equation, for $Z < 1$, Z
- ok.Mj oky l ehdj.k l s $Z < 1$ dsfy,, $Z = 1 - \frac{a}{VRT}$
- $$\Rightarrow \frac{a}{VRT} = 0.082 \Rightarrow \mathbf{a = 3.77 \text{ bar L}^2 \text{ mol}^{-2}}$$
7. $\frac{-dP}{dt} = \frac{KP}{\sqrt{M}} \Rightarrow \int_{P_0}^P \frac{-dP}{P} = \frac{K}{\sqrt{M}} \int_0^t dt$
- $$\Rightarrow \ln\left(\frac{P_0}{P}\right) = \frac{Kt}{\sqrt{M}} \Rightarrow \ln 4 = \frac{4K}{\sqrt{4}} = 2K$$
- $$\ln \frac{10}{P} = \frac{K}{2} \Rightarrow \mathbf{P_{He} = 7.07 \text{ atm}}$$
- Also, $\ln\left(\frac{P_0}{P}\right)_{He} = \frac{Kt}{2}$ and $\ln\left(\frac{P_0}{P}\right)_{CH_4} = \frac{Kt}{4}$
- $$\Rightarrow \left(\frac{P_0}{P}\right)_{He} = \left(\frac{P_0}{P}\right)_{CH_4}^2 \Rightarrow \frac{10}{7.07} = \frac{100}{P_{CH_4}^2}$$
- $$\Rightarrow P_{CH_4} = 8.4 \text{ atm}$$
8. $NH_3(g) + HCl(g) \longrightarrow NH_4Cl(s)$
- | | | | |
|-------|------|------|------|
| Moles | 0.08 | 0.26 | 0 |
| | 0 | 0.18 | 0.08 |
- $$\Rightarrow Q = 0.08 \times 4300 = 3440 \text{ J}$$
- Also, $Q = nC_V \Delta T \Rightarrow \Delta T = \frac{3440}{0.18 \times 20} = 955.55$
- $$T_{\text{final}} (T_{\text{vitre}}) = 1255.55 \text{ K}$$
- $$P_{\text{final}} (P_{\text{vitre}}) = \frac{0.18 \times 0.082 \times 1255.55}{1.8}$$
- $$= \mathbf{10.3 \text{ atmosphere (ok; ø.My)}}$$
9. $b = 39.1 \text{ cm}^3 \text{ mole}^{-1} = 39.1 \times 10^{-6} \text{ m}^3 \text{ mole}^{-1} = 4V \times N_A$
- $$39.1 \times 10^{-6} = 4 \times \frac{4}{3} \pi r^3 \times 6.023 \times 10^{23}$$
- $$r = 1.57 \times 10^{-10} \text{ m}$$
- $$\sigma = 2r = 3.14 \times 10^{-10} \text{ m} = 314 \text{ pm}$$

$$u_{avg} = \sqrt{\frac{8RT}{\pi M}} = \sqrt{\frac{8 \times 8.314 \times 298}{3.14 \times 28 \times 10^{-3}}} = 474.8 \text{ m/sec.}$$

$$N^* = \frac{P}{kT} = \frac{10^{-3} \times 101325}{760 \times 1.38 \times 10^{-23} \times 298} = 3.24 \times 10^{19}$$

$$\lambda_1 = \frac{1}{\sqrt{2}\pi\sigma^2 N^*} = \frac{1}{\sqrt{2} \times 3.14 \times (3.14 \times 10^{-10})^2 \times 3.24 \times 10^{19}}$$

$$= 0.0705 \text{ m} = 7.05 \text{ cm}$$

$$Z_1 = \sqrt{2} \pi \sigma^2 u_{avg} N^* = \sqrt{2} \times 3.14 \times (3.14 \times 10^{-10})^2 \times 474.8 \times 3.24 \times 10^{19} = 6739.4 \text{ sec}^{-1}$$

$$Z_{11} = \frac{1}{\sqrt{2}} \pi \sigma^2 u_{avg} N^* = \frac{Z_1 N^*}{2} = \frac{6739.4 \times 3.24 \times 10^{19}}{2}$$

$$= 1.09 \times 10^{23} \text{ m}^{-3} \text{ sec}^{-1} = 1.09 \times 10^{17} \text{ cm}^{-3} \text{ sec}^{-1}$$

10. $\lambda = 2.6 \times 10^{-5} \text{ m}$, $\sigma = 0.26 \text{ nm} = 2.6 \times 10^{-10} \text{ m}$
 $T = 300 \text{ K}$

$$\lambda = \frac{1}{\sqrt{2}\pi\sigma^2 N^*}$$

$$2.6 \times 10^{-5} = \frac{1}{\sqrt{2} \times 3.14 \times (2.6 \times 10^{-10})^2 \times N^*}$$

$$N^* = 1.281 \times 10^{23} \text{ m}^{-3}; \quad N^* = \frac{P}{kT}$$

$$P = 1.281 \times 10^{23} \times 1.38 \times 10^{-23} \times 300$$

$$P = 530.3 \text{ Pa}$$

11. $V, n, T \rightarrow$ same (l eku) so $P \rightarrow$ also same (vr% Hkh l eku)

$\sigma \rightarrow$ same (l eku)

given $(v_{rms})_x = \frac{1}{\sqrt{6}} (v_{avg})_{CH_4}$

& $v_{rms} = \sqrt{\frac{3\pi}{8}} (v_{avg})$ so

$$\sqrt{\frac{3\pi}{8}} (v_{avg})_x = \frac{1}{\sqrt{6}} (v_{avg})_{CH_4}$$

$$\frac{(v_{avg})_x}{(v_{avg})_{CH_4}} = \sqrt{\frac{8}{3\pi}} \cdot \frac{1}{\sqrt{6}} = \frac{2}{3\sqrt{\pi}}$$

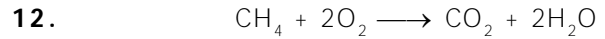
For X (ds fy,): $Z_1 = \sqrt{2}\pi\sigma^2 (v_{avg})_x N^*$

For CH_4 (ds fy,): $Z_1 = \pi\sigma^2 (v_{avg})_{CH_4} N^*$

since T, P, v, n are same, N^* will also be same.

$$\frac{Z_1(x)}{Z_1(CH_4)} = \sqrt{2} \frac{(v_{avg})_x}{(v_{avg})_{CH_4}} = \sqrt{2} \cdot \frac{2}{3\sqrt{\pi}}$$

$$Z_1(x) = Z_1(CH_4) \cdot \frac{2\sqrt{2}}{3\sqrt{\pi}}$$



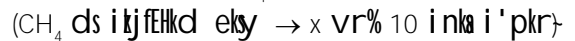
Initially (i kj EHK ea) $\frac{n_{CH_4}}{n_{O_2}} = \frac{1}{192}$

Finally (vr e) $\frac{n_{CH_4}}{n_{O_2}} = \frac{1}{6}$

$$\frac{1}{6} = \frac{1}{192} \left(\sqrt{\frac{32}{16}} \right)^n$$

$$32 = 2^{n/2}; \quad 5 = n/2 \Rightarrow n = 10 \text{ steps}$$

Let initial moles of $CH_4 \rightarrow x$ so after 10 steps



$$x(0.9)^{10} \times 100 = 1000$$

$$x = \frac{10}{0.36} = 27.78 \text{ mole}$$

moles of O_2 initially (i kj EHK ea O_2 ds esy)

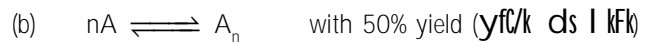
$$= 192 \times 27.78 = 5333.3 \text{ moles}$$

13.(a) Slope of P & T graph is $\frac{nR}{V}$

$$\text{so } \frac{n_{Th} R}{V} = 3.2 - 1.54 = 1.66$$

$$\frac{n_{exp} R}{V} = 2.2875 - 1.25 = 1.0375$$

$$\text{so } \frac{n_{exp.}}{n_{Th.}} = \frac{1.0375}{1.66} = 0.625$$

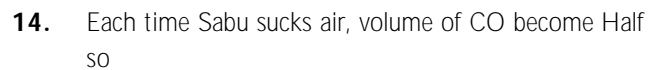


Theoretical increase in pressure with temp. should be 1.66 atm but actually it is 1.0375 only so.

(rki eku ds l kfk nkc ea of} l skurd : i l s 1.66 atm gsh pfg, yfdu okrfod : i l s; g dcy 1.0375 gB)

$$1.66 - 1.66 \times 0.5 + \frac{1.66 \times 0.5}{n} = 1.0375$$

$$0.83 + \frac{0.83}{n} = 1.0375 \Rightarrow n = 4$$



(iR; d ckj tc l kwok; qdksf[kprk gsrks CO dk vk; ru vk/k gks tkrk gS vr%

$$5 \left(\frac{1}{2} \right)^n < 0.001 \quad 5(0.5)^n < 0.001$$

$$\log 5 + n \log 0.5 < \log 10^{-3}$$

$$\log 5 - 0.3n < -3 \quad 0.3n > 3 + \log 5$$

$$n > 12.3$$

$$n = 13$$

15. $P_{\text{lower}} = P_{\text{upper}} + P_{\text{piston}}$

$$5 \times \frac{R \times 300}{V} = \frac{5R \times 300}{4} + P_{\text{piston}} \times \frac{4V}{5}$$

4V

5

1 mole

$$\frac{15}{4} \times \frac{R \times 300}{V} = P_{\text{piston}} \dots (1)$$

V

5

Initial

Temp. = 300K

$P_{\text{lower}} = P_{\text{upper}} + P_{\text{piston}}$

$$\frac{4RT}{V} = \frac{4RT}{3} + P_{\text{piston}}$$

3V

4

1 mole

$$\frac{8RT}{V} = P_{\text{piston}} \dots (2)$$

V

4

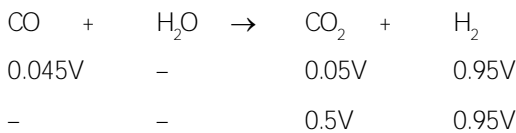
Final

Temp. = T

From equation (1) & (2)

$$\frac{15}{4} \times \frac{R \times 300}{V} = \frac{8RT}{V} \Rightarrow T = \frac{4500}{32} = 421.9 \text{ K}$$

16.(i) Let initial volume of mixture is V L then
 (ekufd feJ.k dk i k j f e h k d v k ; ru V L g s r k s)
 $H_2 \rightarrow 0.5 V$, $CO \rightarrow 0.45 V$, $CO_2 \rightarrow 0.05 V$
 On reaction with excess steam (h k k i d s v k f / k D ; d s
 I k f k f e ; k i j)



$$0.95 V = 5$$

$$V = 5.263 \text{ L}$$

(ii) Molecular mass of initial mixture (i k j f e h k d feJ.k dk
 v k f . o d æ 0 ; e k u)

$$M = 0.5 \times 2 + 0.45 \times 28 + 0.05 \times 44 = 15.8$$

$$PM = \rho RT$$

$$1 \times 15.8 = \rho \times 0.0821 \times 273$$

$$\rho = 0.7 \text{ g/L}$$

(iii) Volume of CO₂ = 0.5 V = 0.5 × 5.263 = 2.6315L

$$\text{moles of CO}_2 = \frac{2.6315}{22.4} = 0.1174$$

$$\text{moles of KOH required} = 0.1174 \times 2 = 0.2349$$

$$\text{moles of Ca(OH)}_2 \text{ required} = 0.1174$$

moles of OH – CH₂ – CH₂ – NH₂ required
 (v k o ' ; d OH – CH₂ – CH₂ – NH₂ d s e k y)
 = 0.1174 × 2 = 0.2349

17.(i) Let (ekuk) $n = mT + C$
 $2 = 300 T + C$ & $3 = 200 T + C$

On solving (gy djus ij) $m = -\frac{1}{100}$, $C = 5$

So (vr% $n = \frac{-T}{100} + 5$

(ii) $PV = nRT \Rightarrow 1 \times V = \left(\frac{-T}{100} + 5\right) RT$

$$\Rightarrow V = -\frac{RT^2}{100} + 5RT$$

(iii) For max. volume (v f / k d r e v k ; ru d s f y ,)

$$\frac{dv}{dT} = 0 \Rightarrow \frac{-2RT}{100} + 5R = 0, T = 250$$

$$V = \frac{-R(250)^2}{100} + 5 \times 250 R = -625 R + 1250 R = 625 R = 625 \times 0.0821 \text{ L} = 51.3125 \text{ L}$$

18. $PV = RT - \frac{A}{V} + \frac{2B}{V^2}$

$$V^3 - \frac{RTV^2}{P} + \frac{A}{P}V - \frac{2B}{P} = 0$$

At critical point (Ø k l r d f c l n q i j) $(V - V_c)^3 = 0$

$$V^3 - 3V_c V^2 + 3V_c^2 V - V_c^3 = 0$$

so on comparison (vr% r y u k i j)

$$3V_c^2 = A/P \dots\dots(i)$$

$$3V_c = RT/P \dots\dots(ii)$$

$$V_c^3 = 2B/P \dots\dots(iii)$$

$$\text{On } \frac{(3)}{(1)} \Rightarrow \frac{V_c}{3} = \frac{2B}{A}$$

$$= V_c = 6B/A$$

from equation (i)

$$3\left(\frac{6B}{A}\right)^2 = A/P_c \Rightarrow P_c = \frac{A^3}{108B^2}$$

from equation (ii) $T_c = \frac{3P_c V_c}{R} = \frac{3}{R} \left(\frac{A^3}{108B^2} \right) \left(\frac{6B}{A} \right)$

$$T_c = \frac{A^2}{6RB} \Rightarrow Z = \frac{P_c V_c}{RT_c} = \frac{\frac{A^3}{108B^2} \cdot \frac{6B}{A}}{R \cdot \frac{A^2}{6RB}} = \frac{1}{3}$$

19. 14 g N₂ → 0.5 mole
 T = 200 k, P = 8.21 atm

$$\frac{P_c V_c}{RT_c} = \frac{3}{8}, \quad \frac{P_r V_r}{T_r} = 2.2$$

$$P_r = \frac{P}{P_c}, \quad V_r = \frac{V}{V_c}, \quad T_r = T/T_c \text{ so,}$$

$$\frac{(P_c P_r)(V_c V_r)}{R(T_c T_r)} = \frac{3}{8} \times 2.2 \Rightarrow \frac{PV}{RT} = \frac{3}{2} \times 2.2$$

$$V = \frac{3}{8} \times \frac{2.2 \times 0.0821 \times 200}{8.21} = 1.65 \text{ L}$$

so volume of 0.5 mole N₂ (vr%0.5 ely N₂ dk vk; ru)
 = 1.65 × 0.5 = 0.825 L

Exercise-5(A)

- PV = nRT (number of moles = nV)
 ∴ n/V = P/RT
- Value of gas constant
 (R) = 0.0821 L atm K⁻¹ mol⁻¹
 = 8.314 × 10⁷ ergs K⁻¹ mol⁻¹
 = 8.314 JK⁻¹ mol⁻¹ = 1.987 cal K⁻¹ mol⁻¹

$$5. \frac{\text{K.E. of neon at } 40^\circ\text{C}}{\text{K.E. of neon at } 20^\circ\text{C}} = \frac{\frac{3}{2} \text{K} \times 313}{\frac{3}{2} \text{K} \times 293} = \frac{313}{293}$$

6. In van der waals equation 'b' is for volume correction

Exercise-5(B)

2. The expression of root mean square speed is

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

Hence,

$$\frac{U_{\text{rms}}(\text{H}_2)}{U_{\text{rms}}(\text{O}_2)} = \left[\frac{3R(50\text{K})/(2\text{g mol}^{-1})}{3R(800\text{K})/(32\text{g mol}^{-1})} \right]^{1/2} = 1$$

3. Under identical condition, $\frac{r_1}{r_2} = \sqrt{\frac{M_2}{M_1}}$

As rate of diffusion is also inversely proportional

to time, we will have, $\frac{t_2}{t_1} = \sqrt{\frac{M_2}{M_1}}$

(a) This, For He, $t_2 = \sqrt{\frac{4}{2}} (5\text{s}) = 5\sqrt{2}\text{s} \neq 10\text{s}$

(b) For O₂, $t_2 = \sqrt{\frac{32}{2}} (5\text{s}) = 20\text{s}$

(c) For CO, $t_2 = \sqrt{\frac{28}{2}} (5\text{s}) \neq 25\text{s}$

(d) For CO₂, $t_2 = \sqrt{\frac{44}{2}} (5\text{s}) \neq 55\text{s}$

4. N₂O₄(g) ⇌ 2NO₂(g)
- | | | |
|----------------|------------|-----------|
| At start | 100/92 mol | 0 |
| | = 1.08 mol | |
| At equilibrium | 80/92 mol | 20/46 mol |

= 0.86 mol = 0.43 mol
 According to ideal gas equation, at two conditions
 At 300 K;

$$P_0 V = n_0 RT_0$$

$$1 \times V = 1.08 \times R \times 300 \quad \dots (i)$$

At 600 K;

$$P_1 V = n_1 RT_1$$

$$P_1 \times V = (0.86 + 0.43) \times R \times 600 \quad \dots (ii)$$

Divide (ii) by (i),

$$\frac{P_1}{1} = \frac{1.29 \times 600}{1.08 \times 300}$$

$$P_1 = \frac{1.29 \times 2}{1.08} = 2.38 \text{ atm.} \approx 2.4 \text{ atm.}$$

6. TIPS/formulae :

Use vander Waal's equation

Real gas equation for one mole is given as

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

$$\Rightarrow P = \frac{RT}{V - b} - \frac{a}{V^2} = \frac{RT}{V \left(1 - \frac{b}{V} \right)} - \frac{a}{V^2}$$

$$\Rightarrow PV = RT \left(1 - \frac{b}{V} \right)^{-1} - \frac{a}{V}$$

$$= RT \left(1 + \frac{b}{V} + \frac{b^2}{V^2} \dots \right) - \frac{a}{V}$$

(using binomial expansion)

$$\Rightarrow PV = RT \left(1 + \frac{b-a/RT}{V} + \frac{b^2}{V^2} + \frac{b^3}{V^3} + \dots \right) \dots (i)$$

Given equation :

$$PV = RT \left(1 + \frac{B}{V} + \dots \right) \dots (ii)$$

Comparing (1) and (2), we get, $B = \frac{b-a/RT}{V}$

8. According to Graham's law of diffusion for two gases undergoing diffusion at different pressures through same hole

$$\frac{r_A}{r_B} = \sqrt{\frac{M_B}{M_A}} \times \frac{P_A}{P_B}$$

$$\left(r \propto P \times \sqrt{\frac{1}{M}} \text{ At constant temperature} \right)$$

9. Weight of gas = 50.5 – 50

$$\text{using, } PV = nRT = \frac{W}{m}RT$$

$$\frac{760}{760} \times \frac{100}{1000} = \frac{0.5}{m} \times 0.082 \times 300 \quad \left[n = \frac{0.5}{m} \right]$$

\(\therefore\) Molecular weight of gas (m) = **123**

10. Van der Waals equation for n moles of gas is

$$\left[P + \frac{n^2 a}{V^2} \right] [V - nb] = nRT$$

Given V = 4 litre; P = 11.0 atm, T = 300 K;
b = 0.05 litre mol⁻¹, n = 2

$$\text{Thus, } \left[11 + \frac{2^2 a}{4^2} \right] [4 - 2 \times 0.05] = 2 \times 0.082 \times 300$$

\(\therefore\) a = 6.46 atm litre² mol⁻²

12. We know that

$$\frac{r_1}{r_2} = \sqrt{\frac{M_2}{M_1}} \times \frac{P_1}{P_2} \text{ or } \frac{n_1}{t_1} \times \frac{t_2}{n_2} = \sqrt{\frac{M_2}{M_1}} \times \frac{P_1}{P_2}$$

$$\text{or } \frac{1}{38} \times \frac{57}{1} = \sqrt{\frac{M}{28}} \times \frac{0.8}{1.6}$$

\(\therefore\) M = 252

$$\left[\text{Xe} + (\text{F})_x = 252 \right. \\ \left. 131 + 19x = 252; \therefore x = 6 \right]$$

Thus compound of xenon with fluorine is XeF₆.

13. For an ideal-gas behaviour, the molecules of a gas should be far apart. the factors favouring this condition are high temperature and low pressure.

14. **TIPS/Formulae :**

$$\text{Compressibility factor of ideal gas (Z)} = \frac{PV}{nRT}$$

For one mole of ideal gas at STP

$$Z = \frac{P \times 22.4}{RT}$$

For other gases Z < 1 and $Z = \frac{P \times V_m}{RT}$

\(\therefore\) V_m < 22.4 litres

Alternate solutions

$$(PV)_{\text{Observed}} / (PV)_{\text{ideal}} < 1$$

\(\Rightarrow\) V_{obs} < V_{ideal}, V_{obs} < 22.4 litre.

15. **TIPS/Formulae :**

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

$$\sqrt{\frac{3RT_{\text{H}_2}}{2}} = \sqrt{7} \sqrt{\frac{3RT_{\text{N}_2}}{28}};$$

\(\therefore\) T_{N₂} = 2T_{H₂} or T_{N₂} > T_{H₂}

17. Van der Waals equation for one mole of a gas is

$$\left[P + \frac{a}{V^2} \right] (V - b) = RT \quad \dots (1)$$

Given that volume occupied by CO₂ molecules, 'b' = 0

Hence, (1) becomes

$$\left[P + \frac{a}{V^2} \right] V = RT \text{ or } P = \frac{RT}{V} - \frac{a}{V^2}$$

Using R = 0.082, T = 273 K, V = 22.4 l for 1 mole of an ideal gas at 1 atm pressure

$$\therefore P = \frac{0.082 \times 273}{22.4} - \frac{3.592}{(22.4)^2} = 0.9922 \text{ atm}$$

19. We know that, Compressibility factor, $Z = \frac{PV}{RT}$

$$0.5 = \frac{100 \times V}{0.082 \times 273}$$

\(\therefore\) V = 0.1119 L

Note : Further when volume of a gas molecule is negligible, Van der Waal's equation becomes

$$\left(P + \frac{a}{V^2} \right) (V - 0) = RT$$

$$\text{or } PV = RT - \frac{a}{V} \text{ or } a = RTV - PV^2$$

Substituting the values

$$a = (0.082 \times 0.1119 \times 273) - (100 \times 0.1119 \times 0.1119) \\ = 1.253 \text{ and L}^2 \text{mol}^{-2}$$

21. (a) d = 0.36 kgm⁻³ = 0.36 g/L

(i) From Graham's Law of diffusion

$$\frac{r_v}{r_{\text{O}_2}} = \sqrt{\frac{M_{\text{O}_2}}{M_v}}; 1.33 = \sqrt{\frac{32}{M_v}}$$

$$\therefore M_v = \frac{32}{(1.33)^2} = 18.09$$

Where M_v = MW of the vapour

$$(ii) \text{ Thus, } 0.36 \text{ g} = \frac{0.36}{18.09} \text{ mol}$$

$\frac{0.36}{18.09}$ mol occupies 1 L volume, so 1 mole occupies

$$\frac{18.09}{0.36} \text{ L} = 50.25 \text{ L}$$

Thus, molar volume of vapour = 50.25 L
Assuming ideal behaviour the volume of the vapour can be calculated by

$$\frac{V_1}{T_1} = \frac{V_2}{T_2} \Rightarrow V_2 = 22.4 \times \frac{500}{273} = 41.025 \text{ L}$$

$$(iii) \text{ Compressibility factor (Z)}$$

$$= \frac{(PV)_{\text{obs}}}{(PV)_{\text{ideal}}} = \frac{1 \times 50.25}{1 \times 41.025} = 1.224$$

(iv) Z is greater than unity, hence it is the short range repulsive force that would dominate (\because actual density is less than given density)

$$(b) \quad E = \frac{3}{2}KT = \frac{3}{2} \times \frac{8.31}{6.02 \times 10^{23}} \times 100$$

$$= 2.07 \times 10^{-20} \text{ J per molecule}$$

(\because K, Boltzmann constant = R/N)

22. TIPS/Formulae :

$$C_{\text{rms}} = \sqrt{\frac{3RT}{M}}, \quad C_{\text{av}} = \sqrt{\frac{8RT}{\pi M}}$$

$$\frac{C_{\text{rms}}}{C_{\text{av}}} = \sqrt{\frac{3RT}{M}} \times \sqrt{\frac{\pi M}{8RT}} = \sqrt{\frac{3\pi}{8}} = 1.085$$

$$C_{\text{rms}} = 1.085 \times C_{\text{av}} = 1.085 \times 400 = 434 \text{ ms}^{-1}$$

24. For positive deviation : $PV = nRT + nPb$

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

Thus, the factor nPb is responsible for increasing the PV value, above ideal value, b is actually the effective volume of molecule. So, it is the finite size of molecules that leads to the origin of b and hence positive deviation at high pressure.

25. The Van de Waal equation (for one mole) of a real gas is

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

$$PV_m - Pb + \frac{a}{V_m} - \frac{ab}{V_m^2} = RT$$

$$PV_m = RT + Pb - \frac{a}{V_m} + \frac{ab}{V_m^2} \dots (i)$$

Note This step : To calculate the intercept $P \rightarrow 0$, hence $V_m \rightarrow \infty$ due to which the last two terms on the right side of the equation (i) can be neglected.

$$\therefore PV_m = RT + Pb$$

When $P = 0$, intercept = RT

26. TIPS/Formulae :

Use Graham's law of diffusion

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

27. For gas A, $a = 0$, $Z = 1 + \frac{Pb}{RT}$ implies Z varies linearly with pressure.

For gas B, $b = 0$, $Z = 1 - \frac{a}{VRT}$. Hence, Z does not vary linearly with pressure.