UNIT # 03

STATE OF MATTER EXERCISE # 1

1. Let initial temperature and pressure are T_1 & P_1 (माना प्रारम्भिक ताप व दाब T_1 व P_1 है)

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

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

2.
$$\begin{array}{lllll} N_2 & + & 3H_2 & \longrightarrow & 2NH_3 \\ 1 & & 3 & & \\ 0 & & 0 & & 2 \end{array}$$

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

3. SO_2 replaced by O_2 (SO_2, O_2 से प्रतिस्थापित होती है)

P, V, T ⇒ same

n ⇒ constant $\qquad n_{O_2} = n_{SO_2}$

$$\frac{w_{O_2}}{32} = \frac{w_{SO_2}}{64} \qquad w_{O_2} = \frac{1}{2}w_{SO_2}$$

4. At const pressure (नियत दाब पर) $V \propto T$

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

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

6. $P_{n_2} \propto n_{H_2}$ $\qquad P_{total} \propto (n_{H_2} + n_{CH_4})$

$$\frac{P_{H_2}}{P_{total}} = \frac{w/2}{w/2 + w/16} \Rightarrow \frac{8}{9}$$

7. PV = nRT $\qquad n = \frac{10^{-10}}{760} \times \frac{10^{-3}}{0.082 \times 293}$

number of molecules (अणुओं की संख्या) =

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

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

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

$M_w = 91.84 = 92 \quad C_7H_8$

9. $V_A = 0.5\ dm^3$, $\quad V_B = 1\ dm^3$

$d_A = 3\ g/dm^3$, $\quad d_B = 1.5\ g/dm^3$

$$M_A = \frac{1}{2}M_B \qquad P_A = \frac{d_ART}{M_A},\ P_B = \frac{d_BRT}{M_B}$$

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

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

11. $PV = \frac{w}{M_w}RT$ $\qquad \frac{P}{wT} = \text{const.}$

$$\frac{P_1}{w_1T_1} = \frac{P_2}{w_2T_2} \qquad \frac{4.05}{w \times 300} = \frac{P_2}{\frac{w}{2} \times 285}$$

$P_2 = 1.92$ MPa

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

$$M_w = \frac{wRT}{PV} \Rightarrow \frac{1 \times 0.082 \times 273}{2 \times 0.350} \qquad M_w = 32$$

The mass of one atom (एक परमाणु का द्रव्यमान) = 16 amu ⇒ $2.64 \quad 10^{-23}$ g

13. PV = nRT

$$n = \frac{PV}{RT} \Rightarrow \frac{7.6 \times 10^{-10}}{760} \quad \frac{1}{0.082 \times 273}$$

$n \Rightarrow 0.0446 \quad 10^{-12}$

The no. of oxygen molecule (ऑक्सीजन अणु की संख्या) = $0.0446 \quad 10^{-12}\ N_A \Rightarrow 2.7 \quad 10^{-10}$

14. $$\frac{\text{vol. of } O_2 \text{ molecule } (O_2 \text{ अणु का आयतन})}{\text{vol. of } O_2 \text{ molecule at STP } (\text{STP पर } O_2 \text{ अणु का आयतन})}$$

$$\Rightarrow \frac{\frac{4}{3}\pi \times 8 \times 10^{-30} \times 10^3}{22.4/N_A} = 0.09\ \%$$

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

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

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

$$\frac{T_{Ne}}{T_{O_2}} = \frac{20}{32} \qquad T_{O_2} = 480\ K$$

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

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

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

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

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

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

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

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

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

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

$\Rightarrow$ 0.352 cm/sec.

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

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

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

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

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

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

= 6235.5 J

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

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

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

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

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

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

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

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

V_2 = 14.14 lit.

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

$r_{N_2} : r_{H_2} : r_{He} :: \frac{1}{\sqrt{28}} : \frac{1}{\sqrt{2}} : \frac{1}{\sqrt{4}} :: \frac{1}{\sqrt{14}} : \frac{1}{\sqrt{1}} : \frac{1}{\sqrt{2}}$

$r_{N_2} : r_{H_2} : r_{He} :: 1 : \sqrt{14} : \sqrt{7}$

30. Rate of diffusion (विसरण की दर) $\propto$

$\frac{1}{\sqrt{\text{molecular mass (आण्विक द्रव्यमान)}}}$

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

Z = 0.65

36. $C_xH_y + (x + y/4)O_2 \longrightarrow xCO_2 + y/2\ H_2O$

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

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

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

C_4H_{10}

37. $CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$

38. $C_4H_{10} + \frac{13}{2}O_2 \longrightarrow 4CO_2 + 5H_2O$

58 gm $\qquad \frac{13}{2} \times 32$

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

(NTP पर 58 g CH_4 के लिए O_2 का आवश्यक आयतन)

1000 g CH_4 required vol. of O_2 at NTP=

$\frac{13}{2} \times \frac{22.4}{58} \times 1000$

(NTP पर 1000 g CH_4 के लिए O_2 का आवश्यक आयतन)

= 2510 litre

47. Extent of intermolecular hydrogen bonding increasing the viscosity.

(श्यानता बढ़ने पर अन्तराण्विक हाइड्रोजन बन्धन की मात्रा)

STATE OF MATTER EXERCISE # 2

7. $P_{total} = \frac{3W}{32}\frac{RT}{V}$ $\quad P_{O_2} = \frac{W}{32}\frac{RT}{V}$ $\quad \frac{P_{O_2}}{P_{total}} \Rightarrow \frac{1}{3}$

9. K.E. α T

11. $Z = \frac{PV_m}{PV}$ $\quad \frac{V_m}{22.4} < 1$ $\quad V_m < 22.4L$

12. $PV = nRT$ $\quad P = \frac{2 \times 0.82 \times 546}{44.8}$

$P = 2$ atm

13. $U_{rms} = \sqrt{\frac{3RT}{M_w}}$

14. $P = \frac{dRT}{M_w}$

$dT = \text{const}$ $\qquad d_1T_1 = d_2T_2$

$d \quad 300 = 0.75\ d \quad T_2$

$T_2 = 100 \quad 4 \Rightarrow 400$ K

15. $U_{rms} = \sqrt{\frac{3RT}{M_w}}$ $\quad \frac{(U_{rms})_{O_3}}{(U_{rms})_{O_2}} = \sqrt{\frac{32}{48}} \Rightarrow \sqrt{\frac{2}{3}}$

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 ⇒ 0.2 lit

20. Rates of diffusion $\propto \frac{1}{\sqrt{\text{Molar Mass}}}$

22. $PV = nRT$ $\quad P'V = \frac{n}{2}RT$ $\quad P' = \frac{P}{2}$

26. $r \propto \frac{1}{\sqrt{M}}$ $\quad r_{CH_4} = 2\ r_x$

$\frac{r_{CH_4}}{r_x} = \sqrt{\frac{M_x}{M_{CH_4}}}$ $\quad 4 = \frac{M_x}{16}$

$M_x \Rightarrow 64$

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. $r \propto \frac{1}{\sqrt{M}}$ $\quad \frac{t_2}{t_1} = \sqrt{\frac{M_2}{M_1}}$

$\frac{60}{45} = \sqrt{\frac{X}{40}} \Rightarrow \sqrt{\frac{X}{40}} = \frac{4}{3} \Rightarrow \sqrt{\frac{X}{40}} = \frac{16}{9}$

$X = 71.11$

30. $P_1V_1 = P_2V_2$ $\quad 1 \quad 550 = P_2 \quad 600$

$P_2 = \frac{5}{6}$atm $\quad P_2 = \frac{5}{6} \times 760 \Rightarrow P_2 = 633.33$ mm

Pressure decrease ⇒ 760 – 633.33 ⇒ 126.67 mm

31. $P = \frac{dRT}{M_w}$ $\quad M_w = \frac{7.71 \times 0.082 \times 309}{2.88}$

$M_w = 67.83$ $\quad$ Molecular formula = ClO_2

36. rate of diffusion $\alpha \frac{1}{\sqrt{\text{Molar mass}}}$

$\frac{r_{He}}{r_{CO}} = \sqrt{\frac{M_{CO}}{M_{Hr}}} = \sqrt{\frac{28}{4}} = 2.65$

$\frac{r_{He}}{r_{CO}} = \sqrt{\frac{M_{SO_2}}{M_{He}}} = \sqrt{\frac{64}{4}} = 4$

39. K.E. $= \frac{3}{2}nRT$ $\qquad nT = \text{const}$

$0.3 \quad T = 0.4 \quad 400$ $\qquad T = 533.33$ K

40. $V = \frac{4}{3}\pi r^3$

$V_m = \frac{4}{3} \times \pi \quad (10^{-10})^3 \quad 6.023 \quad 10^{23}$

$V_m = 2.52 \quad 10^{-6}\ m^3$

$V_m\ 2.52$ mL

41. Rate of diffusion $\alpha \frac{1}{\sqrt{\text{molar mass}}}$

42. $Cv = \frac{11}{2}R$; $Cp = \frac{13}{2}R$

43. $N_2 \quad + \quad 3H_2 \longrightarrow 2NH_3$

11 12

9 6 4

Volume remaining after injected water

= 20 – 3.58 = 16.42

All NH_3 dissolve in water $PV = nRT$

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

$P = 22.5$ atm

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

$\therefore \quad P_AV = (n - -x)\ RT_1$ ...(1)

and $\quad P_AV = (n + x)\ RT_2$ ...(2)

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

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

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

$P_A = \frac{2P_1T_2}{T_1 + T_2}$

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

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

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

46. % relative humidity

$= \dfrac{\text{Partial pressure of } H_2O}{\text{Vapour pressure of } H_2O} \times 100$

$75 = \dfrac{P_{H_2O}}{30} \times 100 \Rightarrow P_{H_2O} = 22.5$ torr ;

% of H_2O vapour in air $= \dfrac{(22.5)}{760} \times 100 = 2.96$

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

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

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

47. Density of air at sea level,

$d_0 = \dfrac{29 \times 1}{0.0821 \times 290} = \dfrac{1}{0.821}\,g/L$

density at 831 m = d

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

$\Rightarrow \quad \dfrac{1}{0.821} \times e^{-0.1} = \dfrac{.9}{0.821}\,g/L$

Let x be number of balloons

$\therefore \quad 10^3 \quad g + x \quad 40\ g$

$= \dfrac{0.9}{0.821} \quad 8.21 \quad g \quad x \Rightarrow x = 20$ balloons

STATE OF MATTER EXERCISE # 3

Comprehension # 2

1. $200 < T_B < 1000$

$\Rightarrow \quad 200 < \dfrac{a}{Rb} < 1000$

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

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

2. उच्चदाब क्षेत्र में $Z = 1 + \dfrac{Pb}{RT}$

दोनों बिन्दुओं के लिए हल कर लेते हैं। $= 10^{-3}\ \text{atm}^{-1}$

3. Use $z = \dfrac{P_{Vm}}{RT} \Rightarrow Um = \dfrac{zRT}{P}$

= 0.065 L

4. बोयल ताप पर, वास्तविक गैस कम दाब क्षेत्र में आदर्श व्यवहार दर्शाती है।

5. $Z = \dfrac{1 + Pb}{RT}$, ढाल $z\,\dfrac{b}{RT}$ ताप के व्युत्क्रमानुपाती है।

STATE OF MATTER EXERCISE # 4[A]

1. $P \quad 8 = \left(\dfrac{3.6}{M}\right) \quad R \quad T$ ... (i)

from eq.(i)/(ii)

$P \quad 8 = \left(\dfrac{3.0}{M}\right) \quad R\ (T + 15)$ ... (ii)

$3.6 \quad T = 3\ (T + 15)$

$= 3T + 45 \Rightarrow T = \dfrac{45}{0.6} = 75\ K$

$\Rightarrow \quad P = \dfrac{3.6}{44} \times \dfrac{0.0821 \times 75}{8} = 0.062\,\text{atm}$

2. $P \quad \dfrac{4}{3}\pi(10)^3 = \left(\dfrac{1}{4}\right) R \times T$ ... (i)

from eq. (i)/(ii)

$P \quad \dfrac{4}{3}\pi r^3 = \dfrac{0.75}{4} \times RT$ ....(ii)

$\dfrac{(10)^3}{r^3} = \dfrac{1}{0.75} = \dfrac{4}{3} \Rightarrow r = 3\sqrt{\dfrac{3}{4}} \times 10$

r = 9.0856 cm

3. $P \quad 30 = 0.5 \quad 38 \quad 60 \quad 1 \quad P = 38$ atm

4. $C_6H_{12}O_6 \quad + \quad 6O_2 \longrightarrow 6CO_2 + 6H_2O$

0.08928 mole $\quad \left(\dfrac{0.2}{22.4}\right) \times 60$ mole $\quad$ 0.53568 mole

= 16.071 gm $\quad$ = 11.999 lit

5. $P \quad 1 = \left(\dfrac{12}{28} + \dfrac{4}{2} + \dfrac{9}{32}\right) \quad 0.0821 \quad 300 = 66.74$ atm

P = 66.74 atm

6. $P \quad 10 = \left(\frac{10}{2}+\frac{64}{32}\right) \quad 0.0821 \quad 473$

$\Rightarrow P = 27.1833$ atm

$= 27.54 \quad 10^5$ N/m^2

$H_2 \quad + \frac{1}{2}O_2 \longrightarrow H_2O(\ell)$

5 $\qquad$ 2

(5–4) – $\qquad\qquad$ 4

$P \quad 10 = 5 \quad 0.0821 \quad 473$

$P \quad 19.4166$ atm $= 19.66 \quad 10^5$ N/m^2

7. $\frac{60}{40}=\frac{P}{1}\sqrt{\frac{17}{36.5}} \Rightarrow P = 2.1979$ atm

8. $\frac{x}{100}=\sqrt{\frac{(32+6\times19)}{28}} \Rightarrow x \simeq 228$ **Ans.**

9. $\frac{d_{NO}}{100-d_{NO}}=\sqrt{\frac{32}{30}} \Rightarrow d_{NO} = 50.8$ cm

10. $\frac{t_2}{t_1}=\sqrt{\frac{M_2}{M_1}}=\sqrt{\frac{2}{28}} \Rightarrow t_2 = 0.2672$ hr $\simeq$ 16 min

11. $\frac{234}{224}=\sqrt{\frac{M_{mix}}{32}} \Rightarrow M_{mix} = 34.92 = \frac{100}{\frac{80}{32}+\frac{20}{M}}$

M = 46.6 **Ans.**

12. **(a)** $\frac{0.3}{(dP/dt)} = \sqrt{\frac{17}{20}} \Rightarrow \frac{dP}{dt}=0.325$ torr/sec

(b) $M_{avg} = 0.30 \quad 4 + 0.2 \quad 32 + 0.5 \quad 28 = 21.6$

$\frac{dP}{dt}=0.3\sqrt{\frac{21.6}{17}} \Rightarrow \frac{dP}{dt} = 0.3387$ torr/sec

13. Hint :

$P = P_0e^{-Mgh/RT}$

14. $P = (101.325)\ e^{-\frac{28.8\times10^{-3}\times9.8\times10\times10^3}{8.314\times243}} = 25.027$ kPa

15. If it melts then (यदि यह पिघलता है तो) T > 1800 K

$n = \frac{250\times V}{R\times300} = \frac{P\times V}{R\times1800} \Rightarrow P = 1800 \quad \frac{250}{300}$

P = 1500 kPa

1500 kPa > 10^6 Pa (or 10^3 kPa)

so it will blow up before melt. (अत: यह पिघलने से पहले फटेगा।)

16. $\frac{P_0}{2}=P_0e^{-\frac{M\times9.8\times1}{8.314\times298}}$

M = 175.133 kg mole^{-1}

17.(i) $\frac{75}{70}=\sqrt{\frac{M}{28}} \Rightarrow M = 32.1428$ gm/mole

(ii) $v = \sqrt{\frac{3RT}{M}} = \sqrt{\frac{3\times8.314\times273}{32.1428\times10^{-3}}} = 460.28$ m/s

18. $\sqrt{\frac{3RT}{64\times10^{-3}}}=\sqrt{\frac{8R\times300}{\pi\times32\times10^{-3}}}$

$T = \frac{8\times300\times64}{3\times32\times\pi} = 509.29$ K $= 236.29$ C

19.(a) $u_{rms}=\sqrt{\frac{3P}{d}}=\sqrt{\frac{3\times1.01325\times10^5}{1.2504}} = 493.03$ m/s

(b) $u_{avg} = \sqrt{\frac{8}{\pi}\times\frac{1.01325\times10^5}{1.2504}} = 454.259356$

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

20. Use the results :

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

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

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

putting $\begin{cases} u = 0.995\,u_{mp} \\ du = 0.01\,u_{mp} \end{cases}$

$\frac{1}{N}dN = 8.303\times10^{-3}$

23. Similar as Q.22

25.(a) $P=\left(\frac{22}{44}\right)\times\frac{0.0821\times298.15}{0.5}$ atm $=2.479 \quad 10^3$kPa

(b) $\left(\frac{P+\left(\frac{1}{2}\right)^2\times363.76}{(0.5)^2}\right)\left(0.5-\frac{1}{2}\times\frac{42.67}{1000}\right)$

$= \frac{1}{2}\times8.3187\times298.15\,kPa$

P = 2225.55 kPa

26. $1.95 = \dfrac{800\times1}{nR\times223}$ ....(i)

$1.10 = \dfrac{200\times V}{nR\times373}$ ....(ii)

$\Rightarrow \dfrac{1.95}{1.10} = \dfrac{800}{200}\times\dfrac{1}{V}\times\dfrac{373}{223}$ $\qquad V = 3.77$ lit

27. $0.927 = \dfrac{10.1325\times10^5\times100\times10^{-3}}{n\times8.314\times273.15}$

$w = n \quad 32 = 15.40 \quad 10^3$ gm = 15.40 kgm

28. Hint : At critical temp (T_C) and critical pressure (P_C) O_2 will behave ideally.
(क्रान्तिक ताप (T_C) व क्रान्तिक दाब (P_C) पर O_2 आदर्श व्यवहार करेगी ।)

29.(i) find T_C (T_C ज्ञात कीजिए)

(ii) large value of b α largest molecular vol. (b का अधिकतम मान α अधिकतम आण्विक आयतन)

(iii) least value of a and b (a व b का न्यूनतम मान)

30. Reduced pressure. (समानित दाब) $P_r = \dfrac{P}{P_C} = 2.99$

Reduced temperature (समानित ताप) $T_r = \dfrac{T}{T_C} = 1.90$

31. Hint : low density (कम घनत्व) ⇒ high molar volume (अधिक मोलर आयतन) (V_m)

$\overset{\lim}{V_m} \to \infty$

32. $\left(15+\dfrac{9\times6.7}{(10)^2}\right)(10 - 3 \quad 0.0564) = 3 \quad 0.0821$

T

$\Rightarrow T = 623.5$ K $\qquad \Rightarrow T = 350.5$ C

33.(i) $P \quad 12 = 15 \quad 0.0821 \quad (273 + 30)n$

$P = 31.1$ atm

(ii) $\left(P+\dfrac{(15)^2\times0.2107}{(12)^2}\right)(12 - 15 \quad 0.0171)$

$= 15 \quad 0.0821 \quad (273 + 30) \quad P = 31.4$ atm

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

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

35. $Q = C_{V_1}(1000 - 500) + C_{V_2}(1500 - 1000)$

$= \left(\dfrac{3R}{2}+\dfrac{3R}{2}\right) \quad 500 + \left(\dfrac{3R}{2}+\dfrac{3R}{2}+3R\right)(500)$

$= 1500\,R + 3000\,R = 4500\,R$

STATE OF MATTER EXERCISE # 4[B]

1 $\rho_1h_1 = \rho_2h_2$,

In one hour (एक घण्टे में), $h_1 = 37 \quad 2 = 74$ mm

$1.034 \quad 74 = 13.6 \quad h_2$

$h_2 = 5.626$ mm of Hg

$P = \dfrac{5.626}{760}$ atm / hr. $\qquad PV = nRT$

$\dfrac{5.626}{760}\times0.016 = n \quad 0.821 \quad 310$

$n = 4.653 \quad 10^{-3}$ mole/hr.

rate of O_2 consumption = n $\quad 22400\ cm^3$

$= 0.104\ cm^3/m$

(O_2 के प्रयुक्त होने की दर) = $104\ mm^3/hr.$

2. P = 750 – 17.5 = 732.5 torr

T = 20 C = 293 K

Inhaled (ग्रहण की गई) $O_2 = 52.5 \quad 0.2032$

Exhaled(निष्कासित) $O_2 = 52.5 \quad 0.1675$

so at STP $\dfrac{P_1V_1}{T_1} = \dfrac{P_2V_2}{T_2}$

$\dfrac{732.5\times52.5(0.2032-0.1675)}{293} = \dfrac{760\times V}{273}$

⇒ V = 1.683 L for 6 min.

oxygen consumption per min (प्रति मिनट प्रयुक्त ऑक्सीजन) $= \dfrac{1.683}{6} = \dfrac{0.28L}{min}$ = 280 mL/min

3. Let moles of water vapour initially (माना प्रारम्भ में जल वाष्प के मोल) = n_1

Let moles of water vapour Finally (माना अन्त में जल वाष्प के मोल) = n_2

$n_1 = \dfrac{17.5\times0.8\times V}{R\times293} \Rightarrow n_2 = \dfrac{6.5\times V}{R\times277}$

$\dfrac{n_1}{n_2} = 2.036$

$\dfrac{n_2}{n_1} = 0.491$

so fraction of water vapour condensed

$= 1 - \dfrac{n_2}{n_1} = 0.509$

(अतः संघनित जल वाष्प की भिन्न)

4. Average velocity (औसत वेग) $= \sqrt{\frac{8RT}{\pi M}} = 4 \quad 10^{2}$

$\Rightarrow \frac{RT}{\pi M} = 2 \quad 10^{4} \Rightarrow RT = 2\pi M \quad 10^{4}$

Total K.E. of He

$= \frac{6}{4}\times\frac{3}{2}RT = \frac{9}{4}RT = \frac{9}{4}.2\pi \quad 4 \quad 10^{-3} \quad 10^{4} = 180\pi J$

Total K.E. of Ne

$= \frac{12}{20}\times\frac{3}{2}RT = \frac{9}{10}RT = \frac{9}{10} \quad 2\pi \quad 20 \quad 10^{-3} \quad 10^{4}$

$= 360\ \pi J$

Average K.E. per mol (प्रति मोल औसत K.E.) =

$\frac{(360+180)\pi}{1.5+0.5}$ = **807.84 J**

5. $V - b = RT = 100\ (0.011075\ V - b) = 1.1075$

$V - 100b \quad \Rightarrow \quad V = \frac{99b}{0.0175} = 921b$

$\Rightarrow 920\ b = RT$

$\Rightarrow b = 24.33\ cm^{3}\ mol^{-1} = 4 \quad \frac{4}{3}\pi r^{3} \quad 6.023 \quad 10^{23}$

$\Rightarrow r = 13.4 \quad 10^{-9}$ cm = **134 pm**

6. $V = \frac{RT}{P} + B = 2.058$ L. Also, for the given equation (और, दी गयी समीकरण के लिए) :

$Z = 1 + \frac{PB}{RT} = 1 + \frac{10(-0.1814)}{0.082\times273}$ = **0.918**

From vander Waal's equation, for Z < 1, Z

वाण्डर वॉल समीकरण से, Z < 1 के लिए, $Z = 1 - \frac{a}{VRT}$

$\Rightarrow \frac{a}{VRT} = 0.082 \Rightarrow$ **a = 3.77 bar L² mol⁻²**

7. $\frac{-dP}{dt} = \frac{KP}{\sqrt{M}} \quad \Rightarrow \int_{P_0}^{P} \frac{-dP}{P} = \frac{K}{\sqrt{M}}\int_{0}^{t} dt$

$\Rightarrow \ln\left(\frac{P_0}{P}\right) = \frac{Kt}{\sqrt{M}} \quad \Rightarrow \quad \ln 4 = \frac{4K}{\sqrt{4}} = 2K$

$\ln\frac{10}{P} = \frac{K}{2} \quad \Rightarrow$ $\mathbf{P_{He} = 7.07\ atm}$

Also, $\ln\left(\frac{P_0}{P}\right)_{He} = \frac{Kt}{2}$ and $\ln\left(\frac{P_0}{P}\right)_{CH_4} = \frac{Kt}{4}$

$\Rightarrow \left(\frac{P_0}{P}\right)_{He} = \left(\frac{P_0}{P}\right)^{2}_{CH_4} \Rightarrow \frac{10}{7.07} = \frac{100}{P^{2}_{CH_4}}$

$\Rightarrow P_{CH_4} = 8.4\,atm$

8.

	$NH_3(g)\ +$	$HCl(g)$	$\longrightarrow NH_4Cl(s)$
Moles	0.08	0.26	0
	0	0.18	0.08

$\Rightarrow \quad Q = 0.08 \quad 4300 = 3440\ J$

Also, $Q = nC_v\Delta T \quad \Rightarrow \quad \Delta T = \frac{3440}{0.18\times20} = 955.55$

T_{final} ($T_{\text{अन्तिम}}$) = 1255.55 K

P_{final} ($P_{\text{अन्तिम}}$) $= \frac{0.18\times0.082\times1255.55}{1.8}$

= **10.3 atmosphere (वायुमण्डल)**

9. $b = 39.1 cm^{3} mole^{-1} = 39.1 \quad 10^{-6} m^{3}\ mole^{-1} = 4V \quad N_A$

$39.1 \quad 10^{-6} = 4 \quad \frac{4}{3}\pi r^{3} \quad 6.023 \quad 10^{23}$

$r = 1.57 \quad 10^{-10}$ m

$\sigma = 2r = 3.14 \quad 10^{-10}$ m = 314 pm

$\mu_{avg.} = \sqrt{\frac{8RT}{\pi M}} = \sqrt{\frac{8\times8.314\times298}{3.14\times28\times10^{-3}}}$ = 474.8 m/sec.

$N^* = \frac{P}{kT} = \frac{10^{-3}\times101325}{760\times1.38\times10^{-23}\times298} = 3.24 \quad 10^{19}$

$\lambda_1 = \frac{1}{\sqrt{2}\pi\sigma^{2}N^*} = \frac{1}{\sqrt{2}\times3.14\times(3.14\times10^{-10})^{2}\times3.24\times10^{19}}$

= 0.0705 m = 7.05 cm

$Z_1 = \sqrt{2}\ \pi\sigma^{2}UN^*\ \sqrt{2} \quad 3.14 \quad (3.14 \quad 10^{-10})^{2}$

$474.8 \quad 3.24 \quad 10^{19} = 6739.4\ sec^{-1}$

$Z_{11} = \frac{1}{\sqrt{2}}\pi\sigma^{2}\ UN^* = \frac{Z_1 N^*}{2} = \frac{6739.4\times3.24\times10^{19}}{2}$

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

10. $\lambda = 2.6 \quad 10^{-5}$ m, $\sigma = 0.26$ nm $= 2.6 \quad 10^{-10}$m

T = 300 K

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

$2.6 \quad 10^{-5} = \frac{1}{\sqrt{2}\times3.14\times(2.6\times10^{-10})^{2}\times N^*}$

$N^* = 1.281 \quad 10^{23}\ m^{-3}$

$N^* = \frac{P}{KT}$

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

P = 530.3 Pa

11. V, n, T → same (समान) so P → also same (अतः P भी समान)

$\sigma \to$ same (समान)

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

& $\quad v_{rms} = \sqrt{\frac{3\pi}{8}}(v_{avg.})$ 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 (के लिए) : $\quad Z_1 = \sqrt{2}\pi\sigma^2 (v_{avg.})_x N^*$

For CH_4 (के लिए) : $Z_1 = \pi\sigma^2 (v_{avg.})_{CH_4} N^*$

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

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

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

12. $\quad CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$

Initially(प्रारम्भ में) $\quad \frac{n_{CH_4}}{n_{O_2}} = \frac{1}{192}$

Finally (अंत में) $\quad \frac{n_{CH_4}}{n_{O_2}} = \frac{1}{6}$

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

$$32 = 2^{n/2}$$

$$5 = n/2 \Rightarrow n = 10 \text{ steps}$$

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

(CH_4 के प्रारम्भिक मोल → x अतः 10 पदों पश्चात्)

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

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

moles of O_2 initially (प्रारम्भ में O_2 के मोल)

$= 192 \quad 27.78 = 5333.3$ moles

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

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

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

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

(b) $\quad nA \rightleftharpoons A_n$ $\quad$ with 50% yield (लब्धि के साथ)

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

(तापमान के साथ दाब में वृद्धि सैद्धान्तिक रूप से 1.66 atm होनी चाहिए लेकिन वास्तविक रूप से यह केवल 1.0375 है।)

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

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

14. Each time Sabu sucks air, volume of CO become Half so

(प्रत्येक बार जब साबू वायु को खिंचता है तो CO का आयतन आधा हो जाता है अतः)

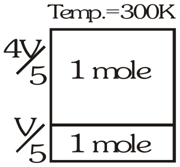
$5\left(\frac{1}{2}\right)^n < 0.001 \qquad 5(0.5)^n < 0.001$

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

$\log 5 - 0.3\,n < -3 \qquad 0.3n > 3 + \log 5$

$n > 12.3 \qquad n = 13$

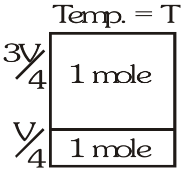
15. $P_{lower} = P_{upper} + P_{piston}$



Initial

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

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



Final

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

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

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

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

(मानाकि मिश्रण का प्रारम्भिक आयतन V L है तो)

$H_2 \to 0.5$ V, CO → 0.45 V, $CO_2 \to 0.05$ V

On reaction with excess steam (भाप के आधिक्य के साथ क्रिया पर)

CO +	$H_2O \to$	CO_2 +	H_2
0.045V	–	0.05V	0.95V
–	–	0.5V	0.95V

0.95 V = 5

V = 5.263 L

(ii) Molecular mass of initial mixture (प्रारम्भिक मिश्रण का आण्विक द्रव्यमान)

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

$PM = \rho RT$

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

$\rho = 0.7$ g/L

(iii) Volume of $CO_2 = 0.5\ V = 0.5 \quad 5.263 = 2.6315L$

moles of $CO_2 = \frac{2.6315}{22.4} = 0.1174$

moles of KOH required = $0.1174 \quad 2 = 0.2349$

moles of $Ca(OH)_2$ required = 0.1174

moles of $OH - CH_2 - CH_2 - NH_2$ required

(आवश्यक $OH - CH_2 - CH_2 - NH_2$ के मोल)

$= 0.1174 \quad 2 = 0.2349$

17.(i) Let (माना) $n = mT + C$

$2 = 300\ T + C \ \& \ 3 = 200\ T + C$

On solving (हल करने पर) $m = -\frac{1}{100}$, $C = 5$

So (अतः) $n = \frac{-T}{100} + 5$

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

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

(iii) For max. volume (अधिकतम आयतन के लिए)

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

$V = \frac{-R(250)^2}{100} + 5 \quad 250\ R = -\ 625\ R + 1250$

$R = 625\ R = 625 \quad 0.0821\ L = 51.3125\ L$

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 [क्रॉन्तिक बिन्दु पर] $(V - Vc)^3 = 0$

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

so on comparision (अतः तुलना पर)

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

$3V_c = RT/P$ ....(ii)

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

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

$= V_c = 6B/A$

from equation (i)

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

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

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

19. 14 g N_2 → 0.5 mole

T = 200 k, P=8.21 atm

$\frac{P_cV_c}{RT_c} = \frac{3}{8}$, $\frac{P_rV_r}{T_r} = 2.2$

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

$\frac{(P_cP_r)(V_cV_r)}{R(T_cT_r)} = \frac{3}{8} \times 2.2 \Rightarrow \frac{PV}{RT} = \frac{3}{2} \times 2.2$

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

so volume of 0.5 mole N_2 (अतः 0.5 मोल N_2 का आयतन) = $1.65 \quad 0.5 = 0.825$ L

STATE OF MATTER EXERCISE # 5[A]

1. PV = nRT (number of moles = nV)

$\therefore$ n/V = P/RT

2. Value of gas constant

(R) = 0.0821 L atm $K^{-1}mol^{-1}$

= 8.314 10^7 ergs $K^{-1}mol^{-1}$

= 8.314 $JK^{-1}mol^{-1}$ = 1.987 cal $K^{-1}mol^{-1}$

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

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

STATE OF MATTER EXERCISE # 5[B]

2. The expression of root mean square speed is

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

Hence,

$$\frac{U_{rms}(H_2)}{U_{rms}(O_2)} = \left[\frac{3R(50K)/(2\,g\,mol^{-1})}{3R(800K)/(32\,g\,mol^{-1})}\right]^{1/2} = 1$$

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, $t_2 = \sqrt{\frac{4}{2}}$ (5s) = $5\sqrt{2}$ s ≠ 10s

(b) For O_2, $t_2 = \sqrt{\frac{32}{2}}(5s)$ = 20s

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

(d) For CO_2, $t_2 = \sqrt{\frac{44}{2}}(5s)$ ≠ 55s

4. $N_2O_4(g) \rightleftharpoons 2NO_2(g)$

	$N_2O_4(g)$	$2NO_2(g)$
At start	100/92 mol = 1.08 mol	0
At equilibrium	80/92 mol = 0.86 mol	20/46 mol = 0.43 mol

According to ideal gas equation, at two conditions

At 300 K;

$P_0V = n_0RT_0$

1 V = 1.08 R 300 ..... (i)

At 600 K;

$P_1V = n_1RT_1$

P_1 V = (0.86 + 0.43) R 600 ..... (ii)

Divide (ii) by (i),

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

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

6. TIPS/formulae :

Use vander Waal's equation

Real gas equation for on mole is given as

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

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

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

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

(using binomial expansion)

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

Given equation :

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

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 throught same hole

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

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

9. Weight of gas = 50.5 – 50

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

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

∴ Molecular weight of gas (m) = **123**

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

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

Given V = 4 litre; P = 11.0 atm, T = 300 K; b = 0.05 litre mol^{-1}, n = 2

Thus, $\left[11+\frac{2^2a}{4^2}\right][4 - 2\quad 0.5] = 2\quad 0.082\quad 300$

∴ a = 6.46 atm $litre^2\ mol^{-2}$

12. We know that

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

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

∴ M = 252

$$\left[\begin{array}{l} Xe+(F)_x = 252 \\ 131+19x=252;\ \therefore x=6 \end{array}\right.$$

Thus compound of xenon with fluorine is XeF_6

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 :**

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 = $\frac{P\times V_m}{RT}$

∴ V_m < 22.4 litres

Alternate solutions

$(PV)_{Observed}/(PV)_{Ideal} < 1$

⇒ $V_{obs} < V_{ideal}$, V_{obs} < 22.4 litre.

15. **TIPS/Formulae :**

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

$$\sqrt{\frac{3RT_{H_2}}{2}} = \sqrt{7}\sqrt{\frac{3RT_{N_2}}{28}}\ ;$$

$$\therefore\ T_{N_2} = 2T_{H_2}\quad \text{or}\quad T_{N_2} > T_{H_2}$$

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

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

Given that volume occupied by CO_2 molecules, 'b' = 0

Hence, (1) becomes

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

Using R = 0.082, T = 273 K, V = 22.4ℓ 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 = $\frac{PV}{RT}$

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

∴ V = 0.1119 L

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

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

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

Substituting the values

a= (0.082 0.1119 273)–(100 0.1119 0.1119)

= 1.253 and L^2mol^{-2}

21. (a) d = 0.36 kgm^{-3} = 0.36 g/L

(i) From Graham's Law of diffusion

$$\frac{r_v}{r_{O_2}} = \sqrt{\frac{M_{O_2}}{M_v}}\ ;\ 1.33 = \sqrt{\frac{32}{M_v}}$$

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

Where M_v = MW of the vapour

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

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

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

Thus, molar volume of vapour = 50.25 L

Assuming ideal behaviour the volume of the vapour can be calculated by

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

(iii) Compressibility factor (Z)

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

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

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

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

22. **TIPS/Formulae :**

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

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

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

24. For positive deviation : PV = nRT + nPb

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

Thus, the factor nPb is responsible for increaseing 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

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

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

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

Note This step : To calculate the intercept P → 0, hence $V_m \to \infty$ due to which the last two terms on the right side of the equation (I0 can be neglected.

$\therefore \quad PV_m = RT + Pb$

When P = 0, intercept = RT

26. **TIPS/Formulae :**

Use Grahms' law of diffusion

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

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.