

HINTS & SOLUTIONS

EXERCISE - 1

Single Choice



$$\text{ratio} = \frac{4}{2} = \frac{2}{1}$$

4. Required % =  $\frac{4}{3} \times \frac{\pi \times (2 \times 10^{-8})^3 \times 6 \times 10^{23}}{22400} \times 100$ .

7.  $P = CRT$ ;  $T = \frac{1 \times 12}{1 \times 1} = 12 \text{ K}$ .

8.  $PV = nRT$

$$PV = \frac{1}{M} RT$$

9.  $P_A = \frac{3RT}{M_A}$ ;  $P_B = \frac{1.5RT}{M_B}$

$$\frac{P_A}{P_B} = \frac{2M_B}{M_A} = \frac{2 \times 2M_A}{M_A} = 4$$

10.  $\frac{15}{30} = \frac{75}{M_B}$

$$M_B = 150. \quad (\text{V.D.})_B = \frac{150}{2} = 75$$

13.

(D) Weight of  $H_2 = 20 \text{ g}$  in  $100 \text{ g}$  mixture; Weight of  $O_2 = 80 \text{ g}$

$$\therefore \text{Moles of } H_2 = \frac{20}{2} = 10; \quad \therefore \text{Moles of } O_2 = \frac{80}{32} = \frac{5}{2}$$

$$\therefore \text{Total moles} = 10 + \frac{5}{2} = \frac{25}{2}$$

$$\therefore P_{H_2} = P_T \times \text{mole fraction of } H_2 = 1 \times \frac{10}{25/2} = 0.8 \text{ bar}$$

14. Since A and  $A_2$  are two states in gaseous phase having their wt ratio 50% i.e. 1 : 1

$$\text{moles of } A = \frac{96}{2} \times \frac{1}{48} = 1 \quad \text{Moles of } A_2 = \frac{96}{2} \times \frac{1}{96} = \frac{1}{2}$$

$$\text{Total mole} = 3/2$$

$$P = nRT/V$$

15.  $\frac{20}{60} \times \frac{30}{V} = \sqrt{\frac{32}{64}}$

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

So  $NH_3$  diffuses with faster rate.

17.  $\frac{r_1}{r_2} = \frac{t_2}{t_1} = \sqrt{\frac{M_2}{M_1}}$

20.  $K.E_{O_2} = \frac{\frac{3}{2} \times \frac{N}{32} \times R \times 150}{\frac{3}{2} \times \frac{N'}{32} \times R \times 300} = \frac{x}{2x} \Rightarrow K.E_{O_2} = \frac{N \times 1}{N' \times 2} = \frac{1}{2}$

$N = N'$  Therefore, (A) option is correct.

21. Average KE =  $\frac{3}{2} \times \frac{8.314 \times 300}{6.023 \times 10^{23}} = 6.21 \times 10^{-21} \text{ J/molecule}$ .

23.  $\frac{u_1}{u_2} = \sqrt{\frac{T_1 \times M_2}{T_2 \times M_1}}$

25.  $m_A = 2 m_B$

$$u_A = 2 u_B$$

$$n_A = n_B$$

$$v_A = v_B$$

$$\frac{P_A V_A}{P_B V_B} = \frac{\frac{1}{3} m_A n_A u_A^2}{\frac{1}{3} m_B n_B u_B^2}$$

29.  $\frac{(V_{rms})_1}{(V_{rms})_2} = \sqrt{\frac{T_1 M_2}{M_1 T_2}}$

30.  $PV = Pb + RT$

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

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

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

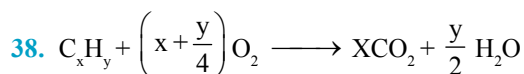
$$\frac{PV}{RT} = 1 - \frac{a}{VRT}$$

32.  $4 \times \frac{4}{3} \pi r^3 \times N_A = 24$

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

34.  $(P)(V - nb) = nRT$

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



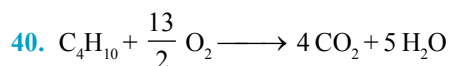
7.5 ml    36 ml

$$36 - 7.5 \left(x + \frac{y}{4}\right) + 7.5x = 28.5$$

$$\Rightarrow 36 - 7.5 \left(15 + \frac{y}{4}\right) + 7.5x = 28.5$$

$y = 4$  ;  $x = 2$

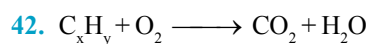
So formula =  $C_2H_4$



x ml    n-butane

y ml    isobutane

$$\text{Volume of } O_2 = x \times \frac{13}{2} + y \times \frac{13}{2}$$



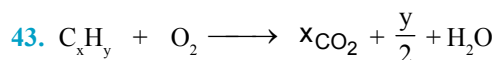
$$x \times n_{C_xH_y} = n_{CO_2} \quad (\text{POAC on C})$$

$$x \times 500 = 2500 \quad (x = 5)$$

$$y \times n_{C_xH_y} = 2 \times n_{H_2O} \quad (\text{POAC on H})$$

$$y \times 500 = 2 \times 3000 \quad y = 12$$

Formula =  $C_5H_{12}$



$$15 \text{ ml} \quad \frac{357 \times 21}{100} \text{ ml}$$

75 ml

$$\left(x + \frac{y}{4}\right) \times 15 = 75 \quad x + \frac{y}{4} = \frac{75}{15}$$

$$x + \frac{y}{4} = 5$$

$$x + \frac{y}{4} = 5$$

$$3 + \frac{y}{4} = 5$$

$$15x + 15x + 282 = 327$$

$$y = 8$$

$$x = 3$$

Formula =  $C_3H_8$

44. Two flask initially at  $27^\circ$  and 0.5 atm, have same volume and 0.7 mole thus each flask has 0.35 mole

Let n mole of gas are diffuse from II to I on heating the flask at  $127^\circ C$

Mole in I flask =  $0.35 + n$ , Mole in II flask =  $0.35 - n$

If new pressure of flask is P then

$$\text{for I flask } P \times V = (0.35 + n) \times R \times 300; \quad \text{for II flask } P \times V = (0.35 - n) \times R \times 400$$

$$n = 0.5$$

mole in I flask = 0.40

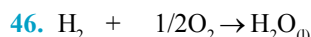
mole in II flask = 0.30

$$0.5 \times 2V = 0.7 \times 0.0821 \times 300 \quad (\text{initially})$$

$$V = 17.24 \text{ Lt.}$$

$$P \times 17.24 = 0.30 \times 0.0821 \times 400 \quad (\text{finally})$$

$$P = 0.57 \text{ atm}$$



$$a \quad b \quad 0$$

$$a - 2b \quad 0 \quad b$$

Reaction is studied at constant P & T.

$$a + b = 40 \quad a - 2b = 10$$

$$a = 30 \text{ ml} \quad b = 10 \text{ ml}$$

mole fraction of  $H_2$  = volume fraction of  $H_2 = 30/40 = 0.75$ .



$$\text{at } t = 0 \quad \frac{1.4}{28} = \frac{1}{20} \quad 0$$

$$\text{at } t = t_f \quad \frac{1}{20} - x \quad 2x$$

$$\text{but, } x = 30\% \text{ of } \frac{1}{20} = \frac{3}{200}$$

$$\text{Final number of mole} = \frac{1}{20} - x + 2x = \frac{1}{20} + x = \frac{1}{20} + \frac{3}{200}$$

$$= \frac{13}{200}$$

$$\therefore P = \frac{13}{200} \times \frac{0.0821 \times 1800}{5} = 1.92 \text{ atm.}$$

50.  $\frac{t_{\text{mix}}}{t_{O_2}} = \frac{r_{O_2}}{r_{\text{mix}}} = \sqrt{\frac{M_{\text{mix}}}{32}}$

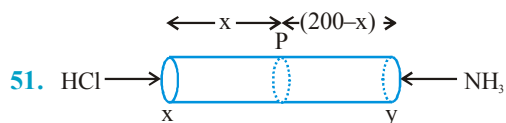
$$\frac{234}{224} = \sqrt{\frac{M_{\text{mix}}}{32}}$$

$$M_{\text{mix}} = 34.92$$

$$\Rightarrow \frac{1}{\sqrt{M_{\text{mix}}}} = \frac{X_{\text{gas}}}{\sqrt{M_{\text{gas}}}} + \frac{X_{O_2}}{\sqrt{M_{O_2}}}$$

$$\Rightarrow \frac{1}{\sqrt{34.92}} = \frac{0.2}{\sqrt{M_{\text{gas}}}} + \frac{0.8}{\sqrt{32}}$$

$$M_{\text{gas}} = 51.5$$



$$\frac{r_{\text{HCl}}}{r_{\text{NH}_3}} = \sqrt{\frac{17}{36.5}} \Rightarrow \frac{x}{200-x} = \sqrt{\frac{17}{36.5}}$$

$$\Rightarrow x = 81.13 \text{ cm}$$

52. Let vol. of each flask is 'V' L, Initially

$$0.5 \times 2V = 0.7 \times 0.0821 \times 300$$

$$V = 17.24 \text{ L}$$

Let T is final temperature of flask when pressure in each flask becomes equal, it happens. when

$$n_{\text{Total}} = n_1 + n_2$$

$$\frac{P \times (2V)}{R \times T} = \frac{PV}{R \times 400} + \frac{PV}{R \times 300}$$

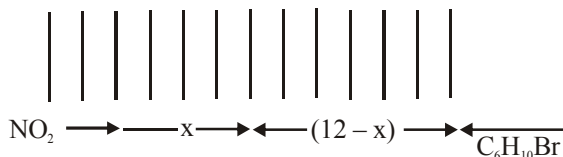
$$\Rightarrow \frac{2}{T} = \frac{1}{400} + \frac{1}{300} = \frac{3+4}{1200} = \frac{7}{1200}$$

$$T = \frac{2400}{7} = 342.85 \text{ K}$$

$$P \times 2 \times 17.24 = n_1 \times 0.0821 \times 400 \Rightarrow n_1 = 0.3$$

$$0.5714 \times 17.24 = n_2 \times 0.0821 \times 300 \Rightarrow n_2 = 0.4$$

53. Let both gases meet at n<sup>th</sup> row



$$\frac{r_{\text{NO}_2}}{r_{\text{C}_6\text{H}_{10}\text{Br}}} = \frac{x}{12-x} = \sqrt{\frac{179}{44}} = 2$$

$$x = 24 - 2x$$

$$3x = 24$$

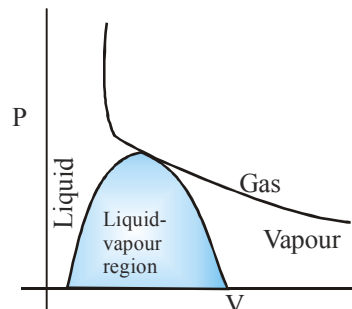
$$x = 8 = n - 1$$

$$n = 9^{\text{th}} \text{ Row}$$

56. I- Slope of isotherm below critical point < 0.

Slope of isotherm above critical point < 0.

Slope of isotherm at critical point = 0.



So slope of isotherm at critical point is maximum.

$$\text{II- } T_c = \frac{8a}{27Rb}$$

$$T_c \propto a$$

Larger value of  $T_c$  It means less decreases in temperature is required to liquify the gas. Gas will liquify at higher temperature. So, easier'll be liquifcatzion.

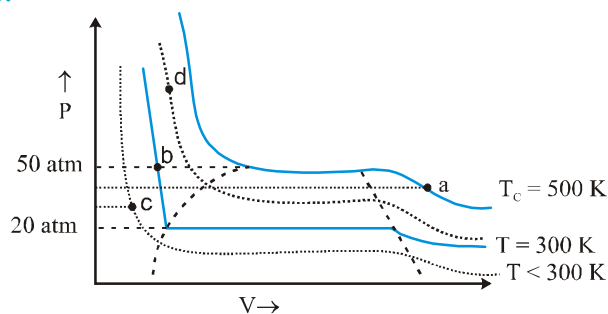
III- When gas is below critical temperature. It is 'liquid' so vander waal equation of state is not valid.

So, Answer (B).

59. If  $Z > 1$  positive deviation

$Z < 1$  negative deviation

60.



(a) at  $T = 500 \text{ K}$ ,  $P = 40 \text{ atm}$  corresponds to 'a' substance - gas

(b) at  $T = 300 \text{ K}$ ,  $P = 50 \text{ atm}$  corresponds to 'b' substance - liquid

(c) at  $T < 300 \text{ K}$ ,  $P > 20 \text{ atm}$  corresponds to 'c' substance - liquid

(d) at  $T < 500 \text{ K}$ ,  $P > 50 \text{ atm}$  corresponds to 'd' substance - liquid

So, Answer (D)

$$65. \sqrt{\frac{8RT}{\pi M}} = 2 \sqrt{\frac{8 \times R \times 300}{\pi M}} \Rightarrow T = 1200 \text{ K} = 927^\circ\text{C}$$

$$66. n_T = n_A + n_B$$

$$P_f V_f = P_A V_A + P_B V_B$$

$$P_f = \frac{2150P}{250}$$

$$\text{Decrease in } P \text{ of A} = 20P - \frac{215}{25}P$$

$$\% \text{ drop} = \frac{285}{25}P \times \frac{1}{20} \times 100 = 57\%$$

67.  $PV \propto T$

68. Using  $p_1V_1 = P_2V_2$   $1 \times 2.5 = 0.5 \times P_2 = 5 \text{ bar}$ .

$$\therefore \% \text{ increase in pressure} = \frac{(5-1)\text{bar}}{1\text{bar}} \times 100\% = 400\%$$

69.  $V_{\text{rms}} \propto \frac{1}{\sqrt{M}}$  'M' is Molecular wt.

$$\text{order of M.wt.} = \text{H}_2 < \text{N}_2 < \text{O}_2 < \text{HBr}$$

$$\therefore \text{order of } V_{\text{rms}} = \text{H}_2 > \text{N}_2 > \text{O}_2 > \text{HBr}$$

70. Net pressure of gas =  $P_{\text{gas}}$

$$P_{\text{gas}} = 650 \text{ mm}$$

$$\frac{P_1V_1}{T_1} = \left( \frac{P_2V_2}{T_2} \right)_{\text{STP}}$$

$$\frac{650 \times 50}{291} = \frac{760 \times V_2}{273}$$

$$V_2 = 40.11 \text{ ml}$$

$$P_1 = 9 \text{ atm} \quad P_2 = 6 \text{ atm}$$

$$V_1 = 5 \ell \quad V_2 = 10 \ell$$

71.  $n_{\text{N}_2} > n_{\text{O}_2}$  where 'n' is no of moles of gases.

$$\Rightarrow P_{\text{N}_2} > P_{\text{O}_2} \quad \text{because } P_{\text{gas}} \propto n$$

### EXERCISE - 2

#### Part # I : Multiple Choice

1. Suppose the cylinder will burst at  $T_2$ K

$$T_2 = \frac{P_2T_1}{P_1} \quad (V_1 = V_2) = \frac{14.9 \times 300}{12} = 372.5 \text{ K}$$

3. Given  $\frac{r_A}{r_B} = \frac{16}{3}$ ;  $\frac{w_A}{w_B} = \frac{2}{3}$

$$\text{we have } \frac{r_A}{r_B} = \frac{n_A}{n_B} \sqrt{\frac{M_B}{M_A}}$$

$$\frac{16}{3} = \frac{w_A}{M_A} \frac{M_B}{w_B} \sqrt{\frac{M_B}{M_A}}$$

$$\frac{16}{3} = \frac{2}{3} \left( \frac{M_B}{M_A} \right)^{3/2} \Rightarrow \left( \frac{M_B}{M_A} \right)^{3/2} = 8 \Rightarrow \frac{M_B}{M_A} = 4$$

$$\therefore \text{mole ratio} = \frac{8}{3}$$

$$4. \text{ Given } \sqrt{\frac{8RT}{\pi M_A}} = \sqrt{\frac{3RT}{M_B}} \Rightarrow 8M_B = 3\pi M_A$$

$$\& \sqrt{\frac{3RT_A}{M_A}} = \sqrt{\frac{3RT_B}{M_B}} \Rightarrow \frac{T_A}{M_A} = \frac{T_B}{M_B}$$

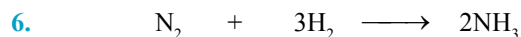
$$\Rightarrow M_B \cdot T_A = M_A \cdot T_B$$

$$\Rightarrow \frac{3\pi}{8} M_A \cdot T_A = M_A \cdot T_B \Rightarrow T_B > T_A \quad \text{Hence (B)}$$

$$5. U_{\text{rms}} = \sqrt{\frac{2RT}{M}}$$

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

$$U_{\text{av}} = \sqrt{\frac{8RT}{\pi M}}$$



$$t=0 \quad 1 \text{ mole} \quad 4 \text{ mole} \quad 0$$

$$t = t_{\text{final}} \quad 0 \quad 1 \text{ mole} \quad 2 \text{ mole}$$

$\text{NH}_3$  will absorb by water and volume will be  $15 - 5 = 10 \text{ L}$

$$P = \frac{nRT}{V} = \frac{1 \times 0.0821 \times 300}{10} \text{ atm}$$

$$7. \text{ (A) Total moles} = \frac{1 \times 0.2}{RT} \quad \text{(B) Total moles} = \frac{1 \times 0.2}{RT}$$

$$\text{(C) Total moles} = \frac{0.5 \times 100}{RT} \quad \text{(D) Total moles} = \frac{2 \times 0.1}{RT}$$

$$8. \left[ \frac{3}{2} nRT \right]_{\text{He}} = \frac{3}{2} nRT$$

$$0.3T = 0.4 \times 400$$

$$T = 533 \text{ K}$$

$$9. V = \frac{15}{56} \times \frac{1}{2} \times \frac{0.0821 \times 295}{1} = 3.24 \text{ L}$$

10.  $PV = nRT$

$$\frac{P}{3} \times 2V = nRT$$

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

$$11. \frac{V_1}{T_1} = \frac{V_2}{T_2}$$

$$\frac{V_0}{273} = \frac{V_2}{283} \Rightarrow V_2 = \frac{283}{273} V_0$$

12. (B) Frequency of collision will increase.

$$13. n_{\text{total}} = \frac{PV}{RT} = \frac{1 \times 2}{0.0821 \times 299} = 0.081 \text{ moles}$$

$$X_{\text{H}_2} = \frac{n_{\text{H}_2}}{n_{\text{total}}} = \frac{0.0788}{\frac{0.0821}{2} \times 299} = 0.967$$

14. K.E.  $\propto$  Temperature

$$16. P_c = \frac{a}{27b^2} \quad T_c^2 = \frac{64 a^2}{27 \times 27 R^2 b^2}$$

$$V_c = 3b \quad \frac{T_c^2}{P_c} = \frac{64 a^2}{27 \times 27 R^2 b^2} \times \frac{27 b^2}{a}$$

$$T_c = \frac{8a}{27Rb} \quad a = \frac{27 R^2 T_c^2}{64 P_c}$$

19.  $yM_x \longrightarrow xM_y$

$$\frac{y}{x} = \frac{12}{8} = \frac{3}{2}$$

$M_2$  &  $M_3$

20. No. of moles of  $N_2 = \frac{7}{28} = \frac{1}{4}$

No. of moles of  $H_2 = 1$  Mole      Total moles =  $\frac{1}{4} + 1 + \frac{1}{8}$

No. of moles of  $SO_2 = \frac{1}{8}$  moles      =  $\frac{1}{8} (2 + 8 + 1) = \frac{11}{8}$

$$P = \frac{nRT}{V} = \frac{11}{8} \times \frac{0.0821 \times 300}{6} = 5.64 \approx 5.7 \text{ atm.}$$

21. Let Temp (T) where  $V_{\text{rms}}$  of  $N_2 = V_{\text{rms}}$  of  $C_3H_8$  at STP

$$= \sqrt{\frac{3RT_1}{M_{N_2}}} = \sqrt{\frac{3RT_2}{M_{C_3H_8}}} = \sqrt{\frac{3 \times 8.314 \times 273}{44 \times 10^{-3}}}$$

$$= \sqrt{\frac{3RT_1}{M_{N_2}}} = 393.38$$

$$T_1 = 173.72 \text{ K}$$

22. Pressure of Total mixture = 10 atm

$$P_A + P_B + P_C = 10$$

$$3 + 1 + P_C = 10 \Rightarrow P_C = 6 \text{ atm}$$

Total moles of mixture = 10

$$n_A + n_B + n_C = 10$$

$$\frac{P_A}{P_B} = \frac{n_A}{n_B} = \frac{3}{1} \Rightarrow \frac{P_B}{P_C} = \frac{n_B}{n_C} = \frac{1}{6}$$

$$\text{Let } n_A = K \Rightarrow n_B = \frac{K}{3} \quad n_C = \frac{1}{6}$$

$$n_B = 2K$$

$$\Rightarrow K + \frac{K}{3} + 2K = 10 \Rightarrow \frac{K}{3} = \frac{n_C}{6} \Rightarrow n_C = 2K$$

$$\Rightarrow K \left( \frac{10}{3} \right) = 10 \quad K = 3, \quad \Rightarrow n_A = 3$$

$$n_B = 1$$

$$n_C = 6$$

$\therefore$  weight of 'C' in mixture =  $2 \times 6 = 12$ .

23.  $C_n H_{3n} O_m + yO_2 \longrightarrow nCO_2(g) + \frac{3n}{2} H_2O(l)$

Contraction in volume = Contraction in moles of gas =

$$1 + \frac{3n}{4} - \frac{m}{2}$$

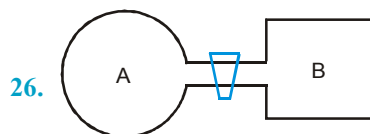
$$\Rightarrow \left( 2n + \frac{3n}{2} - m \right) \times \frac{1}{2} = y \Rightarrow n + \frac{3n}{4} - \frac{m}{2} = y$$

$$24. \frac{P_{N_2}}{P_{CO}} = \frac{X_{N_2}}{X_{CO}} = \frac{n_{N_2}}{n_{CO}} = \frac{x \times 28}{28 \times x} = 1 \quad P_{N_2} = P_{CO} \text{ (A)}$$

Where  $x_{N_2}, x_{CO}$  is mole fraction of  $N_2$  &  $CO$  and  $x$  is wt. of  $N_2$  &  $CO$  taken.

25. Average K.E. =  $\frac{3}{2} RT$  and  $T$  is constant 298 K

$\therefore$  K.E. is same for all gases at same Temperature.



$$V_A = 100 \text{ ml}$$

$$V_B = V \text{ ml}$$

$$P_A V_A = P_A' V'$$

$$\text{Where } V' = V_A + V_B = (V_A + V) \text{ ml}$$

$$P_A 100 = \frac{2}{5} P_A \times V' \quad P_A = \frac{P_A \times 40}{100} = \frac{2}{5} P_A$$

$$250 = V' \quad \Rightarrow V_A + V = 250 \text{ ml}$$

$$V = 150 \text{ ml}$$

27. No. of molecules in 22.4 L at STP

is  $6.02 \times 10^{23} = 1$  mole of gas.

$$28. P = \frac{nRT}{V} = \frac{2 \times 0.0821 \times 546}{44.8} = 2 \text{ atm}$$

$$31. 3P_C V_C^2 = 3 \times \frac{a}{27b^2} \times (3b)^2 = a$$

### Part # II : Assertion & Reason

1. New gas may have pressure equal to sum of both reacting gases or less or more depending on the reacting gases and product formed.
5. From Charle's law, volume is theoretically zero at 0 K and kinetic energy is directly proportional to absolute temperature. So, it is zero at 0 K.
6. Pressure increases due to increase in number of moles in fixed volume. This is because number of collision per unit volume increases.
8. Rate of diffusion  $\propto \frac{1}{\sqrt{\text{Molar mass}}}$
9. On collision, K.E. redistributes, one molecule acquires and other loses the K.E. so, average K.E. remains the same at the same temperature.

### EXERCISE - 3

#### Part # I : Matrix Match Type

2. (A)  $PV = K$  (Boyle's law)

$$P_1 V_1 = P_2 V_2 = P_3 V_3$$

(B) From charle's law

$$V \propto T \quad \Rightarrow \frac{V}{T} = K \quad \Rightarrow \frac{V_1}{T_1} = \frac{V_2}{T_2}$$

(C) From Graham's law

$$r \propto \frac{1}{\sqrt{M}} \quad \text{and } d = \frac{PM}{RT} \quad \Rightarrow d \propto M.$$

$$\text{So, } r \propto \frac{1}{\sqrt{d}}.$$

(D) From Dalton's law of partial pressure at constant temperature.

$$P = P_1 + P_2 + \dots$$

(E) Vander Waal's equation (real gas equation)

$$\left( P + \frac{a}{V^2} \right) (V - b) = RT \quad (\text{For 1 mole})$$

(F)  $\frac{R}{N} = K$  (Boltzmann constant)

(G) Molar volume = 22.4 L at STP

(I) Constant temperature  $P - V$  curve is called isotherm.

(J) Graph between  $V$  and  $T$  at constant pressure called isobar.

3. (A) At low pressure,  $b$  is negligible in comparison to  $V_m$ .

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

$$\Rightarrow \frac{PV_m}{RT} = Z = 1 - \frac{a}{V_m RT} < 1$$

So, gas is more compressible than ideal gas.

(B) At high pressure,  $\frac{a}{V_m^2}$  is negligible in comparison to  $P$ .

$$\therefore P(V_m - b) = RT$$

$$\Rightarrow \frac{PV_m}{RT} = Z = 1 + \frac{Rb}{RT} > 1.$$

So, gas is less compressible than ideal gas.

(C) Low density of gas means pressure is low so, at

low pressure  $Z = 1 - \frac{a}{V_m RT} < 1$  and gas is more compressible than ideal gas.

(D) At  $0^\circ\text{C}$   $\text{H}_2$  and  $\text{He}$  have  $a \approx 0$ .

So,  $Z = 1 + \frac{Pb}{RT}$  and gas is less compressible than ideal gas.

### Part # II : Comprehension

#### Comprehension # 1 :

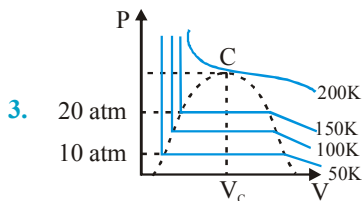
1. At critical point

$$\frac{\partial p}{\partial V_m} = 0 \Rightarrow -\frac{RT_c}{V_m^2} + \frac{2B}{V_m^3} - \frac{3C}{V_m^4} = 0$$

$$\Rightarrow -RT_c + \frac{2B}{V_m} - \frac{3C}{V_m^2} = 0 \Rightarrow RT_c V_m^2 - 2BV_m + 3C = 0$$

as equation will have repeated root then  $D = 0$

$$\Rightarrow T_c = \frac{B^2}{3RC}$$



3. At 100 K and pressure below 20 atm it may have liquid or gaseous state depending on the pressure.

**Comprehension # 2 :**

2.  $P_1 = 75 \text{ cm of Hg}, V_1 = 24 \times A$   
 $P_2 = 75 + 10 + \frac{20.4 \times 10}{13.6} = 100 \text{ cm of Hg}$   
 $\Rightarrow 75 \times 24 = 100 \times x$   
 $x = 18 \text{ cm}$



3. **Case I**  $P_1 = (P_0 + h)$       **Case II**  $P_2 = (P_0 - h)$   
 $P_1 V_1 = P_2 V_2$

Now in both the cases, the gas is the same and temperature is also constant, hence boyles law can be applied.

$\ell_1 A (P_0 + h) = \ell_2 A (P_0 - h)$   
 $P_0 = \frac{h(\ell_1 + \ell_2)}{(\ell_2 - \ell_1)} \text{ cm of Hg column.}$

**Comprehension # 3 :**

2.  $Z = \frac{PV_m}{RT} > 1$

$\frac{PV_m}{RT} = \frac{1 \times 22.4}{R \times T}$

At same pressure = 1 atm.

$\frac{1 \times V_m}{RT} > \frac{1 \times 22.4}{R \times T}$

$\Rightarrow V_m > 22.4 \text{ L at STP for real gas.}$   
 For,  $V_m = 22.4 \text{ L of real gas, we have to increase the pressure.}$

**EXERCISE - 4**  
**Subjective Type**

1. The number of moles of the gas =  $\frac{750-100}{750} \times \frac{50}{1000}$   
 $= \frac{1}{12} \times (20 + 273)$   
 $= 0.0018 \text{ mol.}$   
 Hence volume at STP =  $22400 \times 0.0018 = 40.3 \text{ mL}$

3. Since the vessel is open, the gas can escape out on heating. In this case we can imagine a imaginary boundary to trace the final volume of the gas.

(a) Now in the given situation, 3/5th of the gas (by amount) has escaped which means only 2/5th of the amount is occupying the complete volume of the open container.

And the Pressure is constant,

$\frac{n_2}{n_1} = \frac{T_1}{T_2} \Rightarrow \frac{2n/5}{n} = \frac{300}{T_2} \Rightarrow T_2 = 750 \text{ K.}$

(b) Similarly,  $\frac{n_2}{n_1} = \frac{300}{900} \Rightarrow 1/3\text{rd of the gas remained in the container. Hence, } 2/3\text{rd of the gas escaped.}$

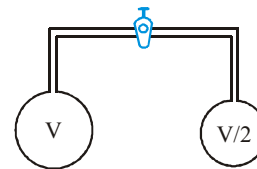
(c) Half of the gas will escape out by doubling the temperature. Hence, the final temperature = 600 K.

5. Let the total number of molecules of the gas be  $n$ , of which  $n_1$  are in the larger sphere and  $n_2$  in the smaller sphere after the stopcock is opened

$n = n_1 + n_2$  and  $pV = nRT$

$\frac{pV}{RT_1} = \frac{p_1 V}{RT_1} + \frac{p_1' V}{2T_2 R}$

$p' = \frac{2pT_2}{2T_2 + T_1}$



6. Since P is constant, From Charles law,  $\frac{100}{50} = \frac{50+273}{t+273}$   
 $\Rightarrow t = -111.5^\circ\text{C.}$

9. Let total moles of gas mixture be 100.

$P_{N_2} = \left(\frac{n_{N_2}}{n_T}\right) \times P_T = \frac{55}{100} \times 760 = 418 \text{ torr.}$

$P_{O_2} = \left(\frac{n_{O_2}}{n_T}\right) \times P_T = \frac{25}{100} \times 760 = 190 \text{ torr.}$

$P_{CO_2} = (760 - 418 - 190) = 152 \text{ torr.}$

10. Molar mass of methane ( $\text{CH}_4$ ) =  $12 + 4 \times 1 = 16 \text{ g mol}^{-1}$   
 Mass of carbon dioxide ( $\text{CO}_2$ ) =  $12 + 2 \times 16 = 44 \text{ g mol}^{-1}$

Moles of  $\text{CH}_4 = \frac{3.2}{16} = 0.2$

Moles of  $\text{CO}_2 = \frac{4.4}{44} = 0.1$

$p\text{CH}_4 = \frac{nRT}{V} = \frac{0.2 \times R \times T}{V} = \frac{0.2 \times 8.314 \times 300}{9 \times 10^{-3}}$

$$= 0.554 \times 10^5 \text{ Nm}^{-2} = 5.54 \times 10^4 \text{ Pa}$$

$$p_{\text{CO}_2} = \frac{nRT}{V} = \frac{0.1 \text{ mol} \times 8.314 \text{ Jmol}^{-1}\text{K}^{-1} \times 300\text{K}}{9 \times 10^{-3} \text{ m}^3}$$

$$= 2.77 \times 10^4 \text{ Pa}$$

$$\text{Total pressure of mixture} = p_{\text{CH}_4} + p_{\text{CO}_2}$$

$$= (5.54 + 2.77)10^4 + \text{Pa}$$

$$= 8.218 \times 10^4 \text{ Pa.}$$

13. Based on Dalton law of partial pressure, partial pressure of  $\text{H}_2$  is determined hence, its number of moles. Partial pressure of  $\text{H}_2$  and water vapour are known, hence, mole fraction can be determined. Since number of moles of dry  $\text{H}_2$  is known, mass of dry  $\text{H}_2$  can be determined.

$$(a) n_{\text{H}_2\text{O}} (\text{vapour}) = \frac{P_{\text{H}_2\text{O}} V}{RT} = \frac{19}{760} \times \frac{0.300}{0.0821 \times 294} = 0.31 \text{ m mole}$$

$$(b) X_{\text{H}_2} = \frac{n_{\text{H}_2}}{n_{\text{Total}}} = \frac{P_{\text{H}_2}}{P_{\text{Total}}} = \frac{729}{748} = 0.975$$

$$(c) P_{\text{Total}} = P_{\text{H}_2} + P_{\text{H}_2\text{O}} \Rightarrow 748 = P_{\text{H}_2} + 19$$

$$\therefore P_{\text{H}_2} = 748 - 19 = 729 \text{ Torr} = \frac{729}{760} \text{ atm}$$

$$n_{\text{H}_2} = \frac{P_{\text{H}_2} V}{RT} = \frac{729}{760} \times \frac{0.300}{0.0821 \times 294} = 0.0119 \text{ mol H}_2$$

$$\text{mass of gas (H}_2) = n_{\text{H}_2} \times M_{\text{gas}} = 0.0119 \times 2 = 0.24 \text{ g}$$

14.  $P_{\text{H}_2\text{O}} (\text{g}) + P_{\text{O}_2} = 1.1$

$$0.1 + P_{\text{O}_2} = 1.1 \Rightarrow P_{\text{O}_2} = 1 \text{ atm}$$

Vol is made  $\frac{1}{3}$  rd so  $P_{\text{O}_2}$  becomes 3 times but  $P_{\text{H}_2\text{O}} (\ell)$

will be same

$$\text{So } P_{\text{O}_2} = 3 \text{ atm}$$

$$\text{Total Pressure} = P_{\text{O}_2} + P_{\text{H}_2\text{O}} (\ell) = 3 + 0.1 = 3.1 \text{ atm}$$

$$15. \frac{n_{\text{N}_2}}{n_x} = \sqrt{\frac{m_x}{M_{\text{N}_2}}} \quad \dots\dots(i)$$

$$P_T V_T = n_T RT \quad \dots\dots(ii)$$

$$\text{Here } n_T = \frac{2.8 \times 4}{0.0821 \times 273} = 0.5 \quad \text{and} \quad n_x + n_{\text{N}_2} = 0.5$$

$$\Rightarrow n_x = 0.1$$

From (1)

$$\frac{0.4}{0.1} = \sqrt{\frac{M_x}{28}} \Rightarrow M_x = 448.$$

16. Change in pressure = 2000-1500 = 500 torr; time-taken = 40 min

$$\text{rate}_1 = \frac{500}{40} \text{ torr/min; similarly rate}_2 = \frac{500}{80} \text{ torr/min}$$

$$\frac{\text{rate}_1}{\text{rate}_2} = \sqrt{\frac{M}{32}}$$

$$18. \frac{r_{\text{mix}}}{r_{\text{O}_2}} = \frac{V}{V} \times \frac{220}{245} = \sqrt{\frac{M_{\text{O}_2}}{M_{\text{mix}}}} \quad \therefore M_{\text{mix}} = 39.6$$

$$\Rightarrow \frac{1}{\sqrt{M_{\text{mix}}}} = \frac{X_{\text{gas}}}{\sqrt{M_{\text{gas}}}} + \frac{X_{\text{O}_2}}{\sqrt{M_{\text{O}_2}}}$$

$$\Rightarrow \frac{1}{\sqrt{39.6}} = \frac{1/5}{\sqrt{M_{\text{gas}}}} + \frac{4/5}{\sqrt{32}}$$

$$M_{\text{gas}} = 133$$

$$20. U_{\text{MPS}} \propto \sqrt{T} \Rightarrow \frac{(U_{\text{MPS}})_2}{(U_{\text{MPS}})_1} = \sqrt{\frac{T_2}{T_1}}$$

$$\Rightarrow \frac{2}{1} = \sqrt{\frac{T_2}{400}}$$

$$T_2 = 1600 \text{ K} = 1327^\circ\text{C.}$$

$$21. u_{\text{rms}} = \sqrt{\frac{\sum n_i u_i^2}{\sum n}} = \sqrt{\frac{u_1^2 \times n_1 + u_2^2 \times n_2 + u_3^2 \times n_3}{n_1 + n_2 + n_3}}$$

$$\therefore u_{\text{rms}} = \sqrt{\frac{10^{23} \times (10^4)^2 [2 + 2 \times 4 + 2 \times 9]}{6 \times 10^{23}}}$$

$$= 2.16 \times 10^4 \text{ cm/sec}$$

23. Volume of one mole of given vapour =  $\frac{18}{0.36} \text{ L} = 50 \text{ L}$

$$\text{volume of one mole of an ideal gas} = \frac{RT}{P} = \frac{0.082 \times 500}{1}$$

$$= 41 \text{ L}$$

$$\text{so value of } Z = \frac{V_{\text{m, real}}}{V_{\text{m, ideal}}} = \frac{50}{41}$$



$$24. Z_1 = \frac{P_1 V_1}{RT_1} \quad \text{and} \quad Z_2 = \frac{P_2 V_2}{RT_2}$$

$$\frac{Z_1}{Z_2} = \frac{P_1}{P_2} \times \frac{T_2}{T_1} \times \frac{V_1}{V_2} \Rightarrow V_2 = \frac{1}{3} \text{ litre}$$

$$26. T_c = 273 + 31 = 304 \text{ K}, P_c = 728 \text{ atm}$$

$$T_c = \frac{8a}{27Rb} \quad \text{and} \quad P_c = \frac{a}{27b^2}$$

$$\therefore \frac{T_c}{P_c} = \frac{8a}{27Rb} \times \frac{27b^2}{a} = \frac{8b}{R}$$

$$\text{On substitution } \frac{304}{728} = \frac{8b}{0.082}$$

$$\therefore b = \frac{304 \times 0.082}{728 \times 8} = 4.28 \times 10^{-3} \text{ litre/mole}$$

$$\text{Now } T_c = \frac{8a}{27Rb}$$

$$\therefore a = \frac{27RbT_c}{8} = \frac{27 \times 0.082 \times 4.28 \times 10^{-3} \times 304}{8}$$

$$= 0.36 \text{ atm litre}^2 \text{ mole}^{-2} \text{ Ans.}$$

$$27. \frac{P_r V_r}{T_r} = \frac{P}{P_c} \cdot \frac{V_m}{V_c} \cdot \frac{T_c}{T} = \frac{PV_m}{RT} \cdot \frac{RT_c}{P_c V_c}$$

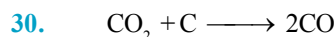
$$Z = \frac{PV_m}{RT} = 2.4 \times \left(\frac{3}{8}\right)$$

$$\text{so } V_{m,\text{real}} = \frac{0.0821 \times 200}{8.21} \times 0.9 = 1.8 \text{ L}$$

so volume of two moles = 3.6L.

28. **Significance of constant 'b'.** The constant 'b' is called co-volume or excluded volume per mole of a gas. Its units are litre mol<sup>-1</sup>. The volume of 'b' is four times the actual volume of the molecules.

**Significance of constant 'a'.** The value of constant 'a' gives the idea of magnitude of attractive forces between the molecules of the gas. Its units are atm L<sup>2</sup> mol<sup>-2</sup>. Larger the value of a, larger will be the intermolecular attraction among the gas molecules.



$$\text{At } t = 0 \quad x \text{ L} \quad (1-x) \text{ L}$$

$$\text{At } t \quad 0 \quad 2x \text{ L}$$

$$1-x+2x=1.6$$

$$1+x=1.6$$

$$x=0.6 \text{ L}$$

$$1-x=0.4 \text{ L}$$

31. In the mix., volume of O<sub>3</sub> = 20 ml

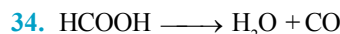
Volume of O<sub>2</sub> = 80 ml

on heating 2O<sub>3</sub> → 3O<sub>2</sub>

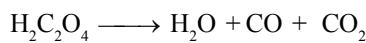
20 ml O<sub>3</sub> will give  $\frac{3}{2} \times 20 = 30 \text{ ml O}_2$

total volume = 80 + 30 = 110 ml

increase in volume = 110 - 100 = 10 ml.



a mole                    0        0  
                                  a        a



b mole                    0        0        0  
                                  b        b        b

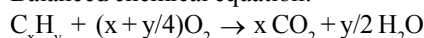
H<sub>2</sub>O absorb by H<sub>2</sub>SO<sub>4</sub> and CO<sub>2</sub> absorbed by KOH

volume of CO<sub>2</sub> / total volume = b/a + 2b = 1/6

a/b = 4/1

the molar ratio of HCOOH and H<sub>2</sub>C<sub>2</sub>O<sub>4</sub> is 4 : 1.

35. **Balanced chemical equation:**



22.4 Lt of C<sub>x</sub>H<sub>y</sub> gives = 44 a gram CO<sub>2</sub>

1.12 Lt of C<sub>x</sub>H<sub>y</sub> gives = 44 a × 1.12 / 22.4 gram CO<sub>2</sub>

44 a × 1.12 / 22.4 = 2.2

a = 1

22.4 Lt of C<sub>x</sub>H<sub>y</sub> gives = 18 × b/2 gram H<sub>2</sub>O

1.8 Lt of C<sub>x</sub>H<sub>y</sub> gives = 18 × b/2 × 1.12 / 22.4 gram H<sub>2</sub>O

18 b/2 × 1.12 / 22.4 = 1.8

b = 4

∴ Hydrocarbon is CH<sub>4</sub>

wt of 1.12 Lt CH<sub>4</sub> at NTP = 16 × 1.12 / 22.4 = 0.8 gram

mole of O<sub>2</sub> used in the 22.4 Lt. hydrocarbon combustion

= a + b/4 = 2 mole

mole of O<sub>2</sub> used in the 1.12 Lt. hydrocarbon combustion

= 2 × 1.12 / 22.4 = 0.1

volume of O<sub>2</sub> used in the 1.12 Lt. hydrocarbon combustion

= 0.1 × 22.4 = 2.24 Lt.

$$36. \text{Initially at } 300 \text{ K, length of Hg column} = \frac{152}{2} = 76 \text{ cm}$$

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

Let the volume of the cylinder be V litres

$$\text{Applying ideal gas equation : } (1 + 1) \cdot \frac{V}{2}$$

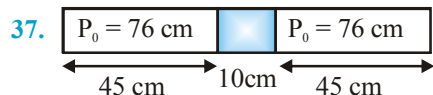
$$= nR \cdot 300. \quad \dots (1)$$

$$\text{Finally, say at a temp. } T : \text{length of Hg column} = \frac{76}{2} \text{ cm}$$

$$= 0.5 \text{ atm.}$$

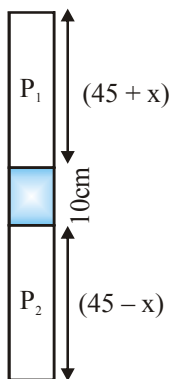
$$\therefore (1 + 0.5) \frac{3V}{4} = nRT. \quad \dots (2)$$

From equation (1) and (2), T = 337.5 K.



**Initially :** (A)  $76 \times 45 \times A = 76 \times 45 \times A$  (B)  
 $A =$  Area of cross section.

When tube is made vertical, let Hg column gets displaced by  $x$  cm towards A.



**For A side :**  $P_1 \times (45 - x) \times A = 76 \times 45 \times A$

**For B side :**  $P_2 \times (45 + x) \times A = 76 \times 45 \times A$

also  $P_1 = P_2 + 10$

$$\frac{76 \times 45}{(45 - x)} = \frac{76 \times 45}{(45 + x)} + 10$$

$$\Rightarrow 76 \times 45 \left[ \frac{1}{(45 - x)} - \frac{1}{(45 + x)} \right] = 10$$

$$76 \times 45 \left[ \frac{45 + x - 45 + x}{(45 - x)(45 + x)} \right] = 10$$

39. (a) By Dalton's partial pressure

$$P_{N_2} + P_{H_2O} = 760 \text{ mm}$$

From given data  $P_{N_2} = 745 \text{ mm}$

$$\text{So } P_{H_2O} = 760 - 745 = 15 \text{ mm}$$

$$\% \text{ Mole of } N_2 = \% \text{ of pressure of } N_2 = \frac{745}{760} \times 100 = 98.02$$

$$\therefore \text{ Mole \% of } H_2O = 100 - 98.02 = \mathbf{1.98\% \text{ Ans.}}$$

(b) Increase weight of drying agent due to absorption of water ( $H_2O$ ).

$$\text{Hence, Wt. of } H_2O = 0.15 \text{ g}$$

$$\therefore \text{ Mole of } H_2O = \frac{0.15}{18}$$

$$\text{Pressure of } H_2O (P_{N_2}) = 15 \text{ mm} = \frac{15}{760} \text{ atm}$$

From gas equation  $PV = nRT$

$$\frac{15}{760} \times V = \frac{0.15}{18} \times 0.0821 \times (273 + 20)$$

$$V = \mathbf{10.156 \text{ litres Ans.}}$$

$$41. \left( \frac{P_1 V_1}{T_1} \right)_{\text{Inside cylinder}} = \left( \frac{P_2 V_2}{T_2} \right)_{\text{Outside cylinder}}$$

$$\frac{20 \times 2.82}{300} = \frac{1 \times V_2}{273}$$

$$V_2 = 51.324 \text{ L}$$

Volume of gas at STP in cylinder = 51.324 L

Volume of gas left inside cylinder = 2.82 L

Volume of gas available to be filled in balloon = 48.504 L

Let  $n$  balloons are filled

$$\therefore \frac{4}{3} \pi \times \left( \frac{21}{2} \right)^3 \times \frac{n}{1000} = 48.504$$

$$\Rightarrow n = 10$$

$$44. u_{AV} = \sqrt{\frac{8RT}{\pi M}}$$

$$\text{For He: } 4 \times 10^2 = \sqrt{\frac{8RT}{\pi \times 4 \times 10^{-3}}}$$

$$\text{so } RT = \frac{16 \times 10^4 \times \pi \times 1 \times 10^{-3}}{8} = 80\pi$$

$$\text{for Ne: } 4 \times 10^2 = \sqrt{\frac{8RT}{\pi \times 20 \times 10^{-3}}}$$

$$\text{so } RT = \frac{16 \times 10^4 \times \pi \times 20 \times 10^{-3}}{8} = 400\pi$$

$$\therefore KE = \frac{3}{2} nRT$$

$$\therefore \text{ Total KE of He} = \frac{3}{2} \times \frac{6}{4} \times 80\pi = 565.71 \text{ J/mol}$$

$$\therefore \text{ Total KE of Ne} = \frac{3}{2} \times \frac{12}{20} \times 400\pi = 1131.42 \text{ J/mol}$$

$$\text{Total K.E. of mixture} = 565.71 + 1131.42 \text{ J} = 1697.13 \text{ J/mol}$$

$$\text{Total mole in mixture} = \frac{6}{4} + \frac{12}{20} = 1.5 + 0.6 = 2.1.$$

$$KE / \text{mole of mixture} = \frac{1697.13}{2.1} = 808.16 \text{ J/mol}$$

45. (a) Under low pressure region, V is high

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

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

$$\Rightarrow \frac{PV}{RT} + \frac{a}{RTV} = 1$$

$$\therefore Z = \frac{PV}{RT} = \left(1 - \frac{a}{RTV}\right)$$

$$Z = 1 - \frac{20.39}{0.0821 \times 350 \times 35} = 0.98$$

(b) Under high pressure region, P is high,

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

$$\Rightarrow PV - Pb = RT \quad \Rightarrow \quad \frac{PV}{RT} - \frac{Pb}{RT} = 1$$

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

$$Z = 1 + \frac{b}{V} \quad \text{by approximation} \left( \because \frac{PV}{RT} = 1, \frac{P}{RT} = \frac{1}{V} \right)$$

$$= 1 + \frac{0.1383}{35} = 1 + 0.004 = 1.004$$

46. Mole of H<sub>2</sub> diffused = 0.7 in 20 min

Mole of gas diffused = n<sub>1</sub> in 20 min

for gaseous mixture after diffusion PV = nRT

$$n = 6 \times 3 / 0.0821 \times 300 = 0.731$$

Mole of mixture (n) = mole of H<sub>2</sub> + mole of gas

$$0.731 = 0.7 + n_1 \quad \Rightarrow \quad n_1 = 0.0308$$

$$r_{H_2} / r_g = \sqrt{\frac{Mg}{M_{H_2}}} \quad \Rightarrow \quad 0.7 / 0.0308 = \sqrt{\frac{Mg}{2}}$$

47. At constant volume and temperature P ∝ W (here, volume of balloon is assumed to be constant)

Thus, for N<sub>2</sub> : P<sub>1</sub> = 2 atm      P<sub>2</sub> = 1/2 atm    at t = 1 hr

$$\frac{P_1}{P_2} = \frac{w_1}{w_2} \quad \text{or} \quad w_2 = \frac{P_2}{P_1} \times w_1 \quad \text{or} \quad w_2 = \frac{1/2}{2} \times 14 = \frac{14}{4}$$

$$\therefore \text{wt of N}_2 \text{ diffused} = 14 - \frac{14}{4} = \frac{21}{4} \text{ kg}$$

$$\text{For H}_2 : P_1 = 2 \text{ atm } P_2 = 1/2 \text{ atm} \quad \text{at } t = t \text{ hr}$$

$$w_1 = 1 \text{ kg} \quad w_2 = ?$$

$$w_2 = \frac{P_2}{P_1} \times w_1 = 1/4 \text{ kg}$$

Hence wt of H<sub>2</sub> diffused = 1 - 1/4 = 3/4 kg

Now, we are to conclude one point as

$$\frac{r_A}{r_B} = \sqrt{\frac{\rho_B}{\rho_A}}, \text{ as per Graham law}$$

$$\frac{V_A}{V_B} \times \frac{t_B}{t_A} = \sqrt{\frac{\rho_B}{\rho_A}} \quad \text{or} \quad \frac{V_A}{V_B} \times \frac{t_B}{t_A} = \sqrt{\frac{\rho_B}{\rho_A}} \quad \text{or}$$

$$\frac{V_A}{V_B} \times \frac{t_B}{t_A} = \frac{\rho_B}{\rho_A} \sqrt{\frac{\rho_A}{\rho_B}}$$

$$\text{or} \quad \frac{V_A \rho_B t_B}{V_B \rho_B t_A} = \sqrt{\frac{\rho_A}{\rho_B}} \quad \text{or} \quad \frac{w_A}{w_B} \times \frac{t_B}{t_A} = \sqrt{\frac{\rho_A}{\rho_B}}$$

For our problem we can write,

$$\frac{w_{H_2} \times t_{N_2}}{w_{N_2} \times t_{H_2}} = \sqrt{\frac{M_{H_2}}{M_{N_2}}} \quad \text{or} \quad \frac{3/4 \times 1}{21/2 \times t} = \sqrt{\frac{2}{28}} = \sqrt{\frac{1}{14}}$$

$$\text{or} \quad \frac{6}{21 \times 4} \times \frac{1}{t} = \sqrt{\frac{1}{14}} \quad \text{or} \quad \frac{1}{14t} = \frac{1}{\sqrt{14}} \quad \text{or}$$

$$t = \frac{\sqrt{14}}{14} = \frac{1}{\sqrt{14}} \text{ hr} = \frac{60}{\sqrt{14}} \text{ mins} = \frac{60}{3.741} \text{ mins} = 16 \text{ mins}$$

∴ for H<sub>2</sub>, 16 mins are required      **Ans.**

48. For the gaseous mixture

$$PV = nRT \quad 1 \times 40 = n \times 0.0821 \times 400 \quad n = 1.219$$

Total mole of mix. = 1.219

Suppose moles of C<sub>2</sub>H<sub>6</sub> and C<sub>2</sub>H<sub>4</sub> are a and b respectively  
a + b = 1.219      ..... (1)



a    7a/2

b    3b

moles of O<sub>2</sub> required for the combustion of mix. = 7a/2 + 3b

$$\frac{7a}{2} + 3b = \frac{130}{32} \quad \text{..... (2)}$$

by solving eq. (1) and (2) we get

$$a = 0.808 \quad b = 0.4115$$

$$\text{mole fraction of } C_2H_6 = \frac{0.808}{1.219} = 0.66$$

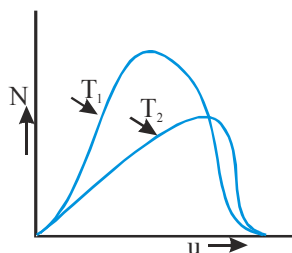
$$\text{mole fraction of } C_2H_4 = \frac{0.4115}{1.219} = 0.34$$

49. Volume of H<sub>2</sub>O produced = 17 mL; Volume of CO<sub>2</sub> produced = 14 mL  
 Total volume of CO<sub>2</sub> = volume of CO<sub>2</sub> initially + volume of CO<sub>2</sub> produced = 14 ml  
 suppose volume of CH<sub>4</sub> and C<sub>2</sub>H<sub>4</sub> in the mixture x and y ml respectively  
 volume of CO<sub>2</sub> produced on explosion = 14 - (10 - x - y) = (4 + x + y) ml  
 POAC for C, H and O  
 for C, 1 × mole of CH<sub>4</sub> + 2 × mole of C<sub>2</sub>H<sub>4</sub> = 1 × mole of CO<sub>2</sub>  
 x + 2y = 4 + x + y      y = 4  
 for H, 4x + 4y = 2 × mole of H<sub>2</sub>O ..... (i)  
 for O, 2 × mole of O<sub>2</sub> = 2 × (4 + x + y) + mole of H<sub>2</sub>O ..... (ii)
- for equation (i) and (ii)  
 mole of O<sub>2</sub> = (4 + 2x + 2y) (use in explosion)  
 in explosion reaction  
 volume of reactant - volume of product = 17 ml  
 (x + y) + (4 + 2x + 2y) - (4 + x + y) = 17  
 2x + 2y = 17 ..... (iii)  
 from equation (i) and (iii)  
 (volume of CH<sub>4</sub>) = 4.5  
 (volume of C<sub>2</sub>H<sub>4</sub>) = 4 ml  
 (volume of CO<sub>2</sub>) = 4 ml

EXERCISE - 5

Part # I : AIEEE/JEE-MAIN

- K.E. =  $\frac{3}{2} RT$   
 $E_1 = \frac{3}{2} R 293$  and  $E_2 = \frac{3}{2} R 313 \Rightarrow E_2 = \frac{313}{293} \times E_1$
- b = 4N × v i.e., total volume occupied by molecules of one mole of gas in motion.
- Helium is not used to produced and sustain powerful superconducting magnets. All others are the uses of helium.
- Distribution of molecules (N) with velocity (μ) at two temperature T<sub>1</sub> and T<sub>2</sub> (T<sub>2</sub> > T<sub>1</sub>) is show below:



At both temperatures, distribution of molecules with

increase in velocity first increases, reaches a maximum value and then decreases.

5. Let the mass of methane and oxygen be m gm. Mole fraction of oxygen x<sub>O<sub>2</sub></sub>

$$= \frac{\frac{m}{32}}{\frac{m}{32} + \frac{m}{16}} = \frac{m}{32} \times \frac{32}{3m} = \frac{1}{3}$$

Let the total pressure be P.

$$\therefore \text{Partial pressure of O}_2, P_{O_2} = P \times x_{O_2} \quad P \times \frac{1}{3} = \frac{1}{3} P.$$

- |                               |  |                             |
|-------------------------------|--|-----------------------------|
| 6.                            | a  | b                           |
| Cl <sub>2</sub>               | 6.579 L <sup>2</sup> bar mol <sup>-2</sup> | 0.05622 L mol <sup>-1</sup> |
| C <sub>2</sub> H <sub>5</sub> | 5.562 L <sup>2</sup> bar mol <sup>-2</sup> | 0.06380 L mol <sup>-1</sup> |

7.  $r \propto \frac{p}{\sqrt{M}}$

$$\frac{r_A}{r_B} = \frac{p_A}{p_B} \sqrt{\frac{M_B}{M_A}}$$

8.  $v = \sqrt{\frac{8RT}{\pi M}}$

$$v \propto \sqrt{T}$$

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

at high pressure  $\frac{a}{V^2}$  can be neglected.

$$PV - Pb = RT$$

$$PV = RT + Pb$$

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

$$Z = 1 + \frac{Pb}{RT} \quad ;$$

Z > 1 at high pressure

10. C\* = most probable speed =  $\sqrt{\frac{2RT}{M}}$

$$\bar{C} = \text{average speed} = \sqrt{\frac{8RT}{\pi M}}$$

$$C = \text{Mean square speed corrected as rms} = \sqrt{\frac{3RT}{M}}$$

$$C^* < \bar{C} < C$$

$$C^* : \bar{C} : C = 1 : \sqrt{\frac{4}{\pi}} : \sqrt{\frac{3}{2}} = 1 : 1.128 : 1.225$$

11. 18g H<sub>2</sub>O contains 2g H  
 ∴ 0.72 g H<sub>2</sub>O contains 0.08 gH.  
 44 g CO<sub>2</sub> contains 12g C  
 ∴ 3.08 g CO<sub>2</sub> contains 0.84 g C  
 ∴ C : H =  $\frac{0.84}{12} : \frac{0.08}{1} = 0.07 : 0.08$   
 = 7 : 8  
 ∴ Empirical formula = C<sub>7</sub>H<sub>8</sub>

12.  $\left(P + \frac{n^2 a}{V^2}\right)(V - b) = nRT$

For 1 mole,  $\left(P + \frac{a}{V^2}\right)(V - b) = RT$

$$PV = RT + Pb - \frac{a}{V} + \frac{ab}{V^2}$$

at low pressure, terms Pb &  $\frac{ab}{V^2}$  will be negligible as compared to RT.

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

$$Z = 1 - \frac{a}{RTV}$$

13. Moles of O<sub>2</sub> =  $\frac{w}{32}$

Moles of N<sub>2</sub> =  $\frac{4w}{28}$

$$\frac{n_{O_2}}{n_{N_2}} = \frac{w}{32} \times \frac{28}{4w} = \frac{7}{32}$$

14. Applying Mole conservation

$$\frac{p_1^0 V}{RT_1} + \frac{P_i V}{RT_1} = \frac{P_f V}{RT_1} + \frac{P_f V}{RT_2}$$

$$\frac{2P_i}{T_1} = P_f \left\{ \frac{1}{T_1} + \frac{1}{T_2} \right\}$$

$$P_f = \frac{2P_i}{T_1} \left\{ \frac{T_1 T_2}{T_1 + T_2} \right\} = \frac{2P_i^0 T_2}{T_1 + T_2}$$

Part # II : IIT-JEE ADVANCED

1.  $\frac{\text{rate of diffusion}_2}{\text{rate of diffusion}_1} = \sqrt{\frac{M_1}{M_2}} \quad \frac{r_{He}}{r_{CH_4}} = \sqrt{\frac{16}{4}} = 2$

2. The vander waals equation of state is -  
 (for 1 mole of gas)

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

When a is negligible, then

$$Z = \frac{pV_m}{RT} = 1 + \frac{b}{RT} p$$

that is Z increases with increaser in p.

When b is negligible, then

$$Z = \frac{pV_m}{RT} = 1 - \frac{a}{VRT}$$

increasing p implies decrease in V, which is turn, implies increase in the value of a/VRT and hence decrease in the value of Z.

The curve IV is applicable provided temperature of the gas is near but larger than it's critical temperature Hence, the choice (a), (b) and (c) are correct.

3. (A) For H<sub>2</sub> gas at high pressure Z > 1.  
 (B) For any gas at P ~ 0, Z ~ 1 i.e. ideal behaviour.  
 (C) For CO<sub>2</sub> gas at normal pressure and temperature Z < 1.  
 (D) For any gas at very large molar volume i.e. P ~ 0, Z ~ 1 i.e. ideal behaviour of gas.

4. (A) At very large molar volume

$$P + \frac{a}{V_m^2} \approx P \quad \text{and} \quad V_m - b = V_m$$

(C) According to van der Waals equation 'a' and 'b' are independent of tempt.

5. Correction factor for attractive force in to the real gas is given by  $\frac{an^2}{V^2}$ .

6.  $V_{rms} = V_{mp}$   
 $\sqrt{\frac{3RT}{M_X}} = \sqrt{\frac{2RT}{M_Y}} \Rightarrow \sqrt{\frac{3R \times 400}{40}} = \sqrt{\frac{2R \times 60}{M_Y}}$   
 $M_Y = 4.$

7. (A) Fact

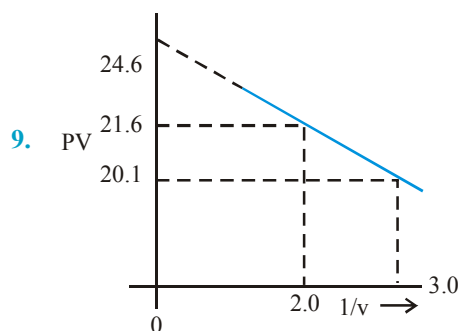
(B)  $P = MV = M \sqrt{\frac{3RT}{M}} = \sqrt{3MRT}$

(C) Max well distribution

(D) Fact

8.  $P_{\text{He}} = 1 - 0.68 = 0.32 \text{ atm}$   
 $V = ?$   
 $n = 0.1$

$$V = \frac{nRT}{P} = \frac{0.1 \times 0.0821 \times 273}{0.32} = 7$$



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

$$PV + a/V = RT$$

$$PV = RT - a(v)$$

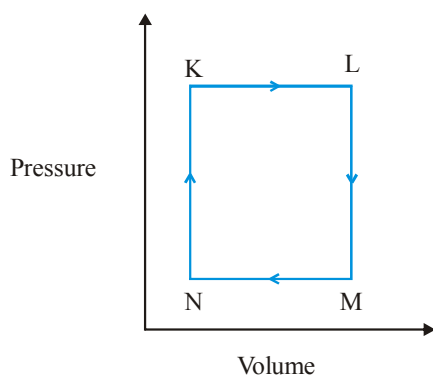
$$y = RT - a(x)$$

$$\text{So, slope} = a = \frac{21.6 - 20.1}{3 - 2} = \frac{1.5}{1} = 1.5$$

10.  $\lambda = \frac{h}{\sqrt{2m(\text{KE})}}$        $\text{KE} \propto T$

$$\frac{\lambda_{\text{He}}}{\lambda_{\text{Ne}}} = \sqrt{\frac{m_{\text{Ne}} \text{KE}_{\text{Ne}}}{m_{\text{He}} \text{KE}_{\text{He}}}} = \sqrt{\frac{20 \times 1000}{4 \times 200}} = 5.$$

11.



$K \rightarrow L \Rightarrow V \uparrow$  at constant P

Hence T  $\uparrow$  (Heating)

$L \rightarrow M \Rightarrow P \downarrow$  at constant V

Hence T  $\downarrow$  (Cooling)

$M \rightarrow N \Rightarrow V \downarrow$  at constant P

Hence T  $\downarrow$  (Cooling)

$N \rightarrow K \Rightarrow P \uparrow$  at constant V

Hence T  $\uparrow$  (Heating)

13.  $L \rightarrow M$

$M \rightarrow K$

Both are having constant volume therefore these processes are isochoric.

16.

$1 \text{ m}^3, 5 \text{ bar},$ $400 \text{ K}$ A	$3 \text{ m}^3, 1 \text{ bar}, 300 \text{ K}$ B
---	--

Finally,  $P_A = P_B$       also  $T_A = T_B$

$$\text{So } \frac{n_A}{n_B} = \frac{V_A}{V_B}$$

$$\frac{\frac{5}{400R}}{\frac{3}{300R}} = \frac{V_A}{V_B} \Rightarrow \frac{V_A}{V_B} = \frac{5}{4}$$

$$\Rightarrow V_A = \frac{5}{9} \times 4 = \frac{20}{9} = 2.22$$

MOCK TEST

1.  $V_{\text{real}} = \frac{\text{Molar mass}}{\text{density}} = \frac{18}{0.36}$

$$V_{\text{ideal}} = \frac{nRT}{P} = \frac{1 \times 0.082 \times 500}{1}$$

$$\text{So, } Z = \frac{V_{\text{real}}}{V_{\text{ideal}}} = \frac{1 \times 0.082 \times 500}{1} = \frac{50}{0.082 \times 500} = \frac{50}{41}$$

2.  $PM = dRT$

$$\text{So, } M = \frac{dRT}{P} = 75 \text{ (approx.)}$$

Normal molecular wt. of HF = 18

i.e. HF is tetramer  $(HF)_4$  in gaseous state due to H-bonding.

3.  $E_1 = \frac{3}{2} \times \frac{M}{16} RT_1$

$E_2 = \frac{3}{2} \times \frac{M}{30} RT_2 \Rightarrow \frac{E_1}{E_2} = \frac{30 T_1}{16 T_2}$

$\frac{3}{1} = \frac{30 T_1}{16 T_2} \Rightarrow \frac{T_1}{T_2} = \frac{8}{5}$

4. At constant pressure  
 $PV = nRT$

$V = \left(\frac{nR}{P}\right)T$  So,  $\log V = \log\left(\frac{nR}{P}\right) + \log T$

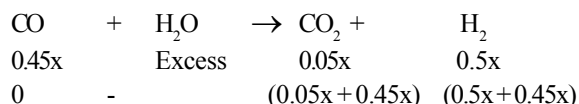
$y = C + mx$ .

So answer is (B).

5. For constant pressure  $V \propto T$ , hence linear dependence with the slope.

6. Let suppose we use x-litre water gas at S.T.P.  
So it contain 0.5x litre  $H_2$ .

Now according to the given equation



So total volume of  $H_2$  gas = 0.95x

But according to question

It is 5 litre

So  $0.95x = 5$

$x = 5.263$  litre

7.  $\frac{r_{O_3}}{r_{O_2}} = \sqrt{\frac{M_2}{M_1}}$

$0.98 = \sqrt{\frac{M_{O_2}}{M_{O_3}}}$

$0.9604 = \frac{32}{M_{O_3}}$

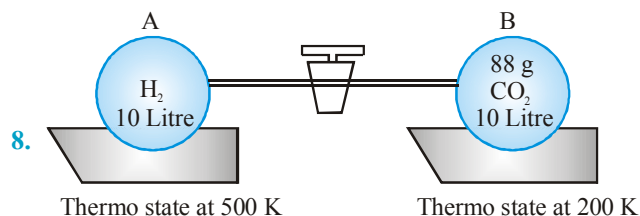
$M_{O_3} = 33.32$

Now ozonised gas	pure oxygen
x%	100-x

Avg. molar mass =  $\left(\frac{M_1x_1 + M_2x_2}{x_1 + x_2}\right)$

$33.32 = \frac{48x + 32(100-x)}{100}$

$x = 8.25$ .



No. of mole of  $H_2$  in flask A =  $20/2 = 10$  mole

No. of mole of  $CO_2$  in flask B =  $88/44 = 2$  mole

Now pressure of gas in flask A

$PV = nRT$

$P_A \times 10 = 2 \times R \times 200$

$P_A = 500R$

Now pressure of gas in flask B

$P_B \times 10 = 2 \times R \times 200$

$P_B = 40R$

Because flask A is on higher pressure that's why  $H_2$  flows from flask A to B.

Let suppose x mole of  $H_2$  move from flask A to B.

So mole of  $H_2$  remain in A =  $(10 - x)$  and total mole in B =  $(2 + x)$

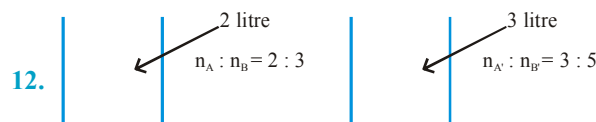
Now after opening stop cock pressure of both flask become equal.

$n_A T_A = n_B T_B$

$(10 - x) \times 500 = (2 + x) \times 200$

$x = 6.57$

Composition of  $H_2$  in B =  $\frac{6.57 \times 2}{101.14} \times 100 = 13\%$



So  $n_A = 2/3 n_B$

and  $n_A = 3/5 n_B$ .

Put the values of  $n_A, n_B, n_{A'}, n_{B'}$  and get

mean molar mass =  $\frac{(n_A + n_{A'})m_A + (n_B + n_{B'})m_B}{(n_A + n_B + n_{A'} + n_{B'})}$

13. Applying Boyle's law.

$P_1 V_1 = P_2 V_2$

$10P_w \cdot g = (10 + n) \times (2 - h) P_w \cdot$  & [A = Area of cross

section ]  $\times 2$ . A  $h = 1.71\text{m}$

14.  $PV = nRT$

$$V = \frac{nR}{P} \cdot T \Rightarrow V = KT$$

$$\therefore \log P = \log T + \log K$$

Linear dependence with positive slope

At the y-intercept  $P/t \rightarrow 0$  implying  $P \rightarrow 0$ , under such conditions all gases show ideal behaviour.

15.  $P_{\text{mix}} = \frac{PM_{\text{mix}}}{RT} \Rightarrow M_{\text{mix}} = \frac{1.7 \times 0.0821 \times 273}{1}$   
 $= 1.7 \times 22.4 \text{ gms}$

$$M_{\text{mix}} = X_{\text{CO}} \times M_{\text{CO}} + (1 - X_{\text{CO}}) \cdot M_{\text{CO}_2}$$

$$= X_{\text{CO}} \times 18 + (1 - X_{\text{CO}}) \times 44$$

$$\Rightarrow X_{\text{CO}} = 0.37$$

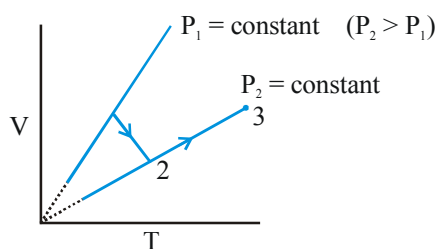
16.  $b = \frac{16}{3} \pi r^3 N_a$

18.  $b = \frac{16}{3} \pi r^3 N_a$

$$0.072 \times 1000 = \frac{16}{3} \times 6.023 \times 10^{23} \times \pi r^3$$

then calculate r.

21. V – T curve for a given mass of the gas is given



34. 24.

$$P = P_0 e^{-kt}$$

$$P_0 = \frac{228}{3} + 76 = 152 \text{ cm Hg.}$$

At  $t = 7 \text{ min.}$

$$P = \frac{114}{3} + 76 = 114 \text{ cm Hg.}$$

$$\Rightarrow 152 e^{-kt} = 114$$

$$\Rightarrow kt = \frac{1}{t} \ln \frac{152}{114} = \frac{1}{7} \times 0.28 = 0.04 \text{ min}^{-1}$$

$$= 0.04 \times 60 \text{ hr}^{-1} = 2.4 \text{ hr}^{-1}$$