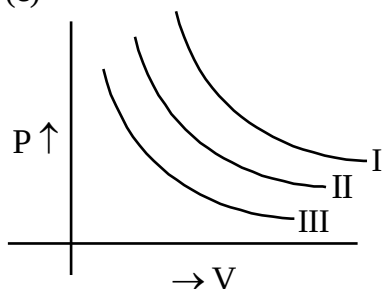


EXERCISE - 1 [A]

1. (c)

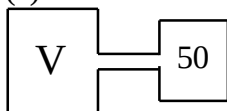


Boyle's law

$$PV = \text{constant} \\ = nRT$$

As $T \uparrow$ constant also increases. And graph shifted upward i.e. $T_1 > T_2 > T_3$

2. (a)



$$P_1 = 21 \text{ atm}$$

$$V_1 = 50 \text{ L}$$

$$P_2 = 7 \text{ atm}$$

$$V_2 = V + 50 \text{ L}$$

Boyle's law

$$P_1 V_1 = P_2 V_2$$

$$21 \times 50 = 7 \times (V + 50)$$

$$V = 100 \text{ L}$$

3. (c)

At constant temperature $P_1 V_1 = P_2 V_2$

$$P_1 = P, V_1 = V$$

$$P_2 = ?, V_2 = 0.95V$$

$$P_2 = \frac{P_1 V_1}{V_2} = \frac{V}{0.95} P$$

$$P_2 = 1.0526P$$

% increases in $P = 5.26\%$

4. (a)

At constant pressure

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

$$V_1 = V$$

$$T_1 = T$$

$$V_2 = 1.1V$$

$$T_2 = ?$$

$$T_2 = \frac{V_2 T_1}{V_1} = \frac{1.1V}{V} T$$

$$T_2 = 1.1T$$

% increases in $T = 10\%$

5. (a)
Charles's law
at constant $\frac{V}{T} = K(\text{constant}) \Rightarrow V = KT$
 $\left(\frac{dV}{dT}\right)_p = K$

6. (b)
 $V_1 = 100\text{mL}$ $T_1 = 100^\circ\text{C} = 373\text{K}$
 $V_2 = 200\text{mL}$ $T_2 = ?$
Constant P $\frac{V_1}{T_1} = \frac{V_2}{T_2}$
 $T_2 = \frac{V_2 T_1}{V_1} = \frac{200 \times 373}{100} = 746\text{K}$
 $T_2 = 746 - 273 = 473^\circ\text{C}$

7. (c)
 $T_1 = 27^\circ\text{C} = 300\text{K}$ $P_1 = 12\text{atm}$
 $T_2 = ?$ $P_2 = 14.9\text{atm}$
At constant V $\frac{P_1}{T_1} = \frac{P_2}{T_2}$
 $T_2 = \frac{P_2 T_1}{P_1} = \frac{14.9 \times 300}{12} = 372.5\text{K}$
 $T_2 = 372.5 - 273 = 99.5^\circ\text{C}$

8. (c)
Ideal Gas Law
Both flasks have equal size
No. of moles of $\text{H}_2 = \frac{2}{2} = 1$
No of molecules of $\text{H}_2 = N_A$
No. of moles of $\text{N}_2 = \frac{2}{28} = \frac{1}{14}$
No of molecules of $\text{N}_2 = \frac{1}{14} N_A$
No. of molecules in flask A > No. of molecules in flask B

9. (d)
No. of molecule of $\text{S}_x = \frac{PV}{RT}$
 $P = \frac{723}{760} \text{atm}$, $V = 0.780\text{L}$, $T = 450 + 273$

$$= 723\text{K}$$

$$n = \frac{723 \times 0.780}{760 \times 0.0821 \times 723} = 0.0125$$

$$\text{No. of moles} = \frac{3.2}{\text{Molecular weight}} = 0.0125$$

$$\text{Molecular weight} = \frac{3.2}{0.0125} = 256$$

If x atom in one molecule of S_x then molecular weight = $32x = 256$

$$x = 8$$



10. (a)

$$V = \frac{nRT}{P} = \frac{4 \times 0.0821 \times 295 \times 760}{4 \times 720} = 25.565\text{L}$$

11. (d)

$$P_A = 2P_B, V_A = 2V_B, T_A = 2T_B$$

$$M_A = M_B$$

$$m_B = X, m_A = ?$$

$$\frac{P_A V_A}{n_A T_A} = \frac{P_B V_B}{n_B T_B} \Rightarrow \frac{P_A V_A M_A}{m_A T_A} = \frac{P_B V_B M_B}{m_B T_B}$$

$$\frac{2P_B (2V_B) M_B}{m_A (2T_B)} = \frac{P_B V_B M_B}{X(T_B)} \Rightarrow m_A = 2 \times g$$

12. (a)

$$P_1 = 3\text{atm}$$

$$T_1 = 500\text{K}$$

$$V_1 = 275\text{L}$$

$$V_2 = 200\text{L}$$

$$P_2 = 2.50\text{atm}$$

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2} \Rightarrow T_2 = \frac{P_2 V_2 T_1}{P_1 V_1}$$

$$T_2 = \frac{2.50 \times 200 \times 500}{3 \times 275}$$

$$= 303\text{K}$$

13. (a)

$$\frac{P_A V_A}{n_A T_A} = \frac{P_{H_2} V_{H_2}}{n_{H_2} T_{H_2}}$$

$$P_A = P_{H_2}$$

$$V_A = V_{H_2}$$

$$n_A T_A = n_{H_2} T_{H_2}$$

$$\frac{m_A}{M_A} T_A = \frac{m_{H_2}}{M_{H_2}} T_{H_2} \Rightarrow M_A = \frac{m_A T_A M_{H_2}}{m_{H_2} T_{H_2}}$$

$$M_A = \frac{5.40 \times 300 \times 2}{0.14 \times 290} = 79.8$$

14. (d)
 $PV = nRT$
 $PV = \frac{m}{M}RT \Rightarrow PM = \frac{m}{V}RT \Rightarrow PM = dRT$
 $x = \frac{PM}{RT}$
 Value of M is large, density large (at constant P & T)
 $M_{CH_4} = 16, M_{C_2H_2} = 26, M_{C_2H_4} = 28, M_{C_3H_8} = 44$
15. (d)
 $n_2 = \frac{n_1}{2} \Rightarrow n_1 = 2n_2$
 $n_1T_1 = n_2T_2 \Rightarrow T_2 = \frac{n_1T_1}{n_2} = \frac{2n_2(300)}{n_2} = 600K$
 $T_2 = 600 - 273 = 327^\circ C$
16. (b)
 $n_1T_1 = n_2T_2$
 $n_2 = \frac{n_1T_1}{T_2} = \frac{n_1 300}{400} = \frac{3}{4}n_1$
 Fraction of molecule of air goes out $\frac{n_1 - \frac{3}{4}n_1}{n_1} = \frac{1}{4}$
17. (a)

$$C_xH_y + \left(X + \frac{Y}{4}\right)O_2 \longrightarrow XCO_2 + \frac{Y}{2}H_2O$$

$$\begin{array}{ccccccc} 0.2 & & 0.8 & & 1 & & \\ \frac{X}{1} = \frac{0.8}{0.2} = 4 \Rightarrow X = 4 & & & & & & \\ \frac{Y}{2} = \frac{1}{0.2} = 5 \Rightarrow Y = 10 & & & & & & \\ & & C_4H_{10} & & & & \end{array}$$
18. (d)
 $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} \Rightarrow \frac{P_1V_1}{T_1} = \frac{P_1V_2}{2(T_1)} \Rightarrow V_2 = 4V_1$ i.e. four times of initial volume
19. (b)
 $\frac{P_1V_1}{n_1T_1} = \frac{P_2V_2}{n_2T_2}$
 $\frac{300V_1}{1(T_1)} = \frac{300V_2}{2(T_1)} \quad [T_1 = T_2]$
 $V_2 = 2V_1$
 Now separation removed volume $V_3 = V_1 + V_2 = 3V_1$
 $n_3 = 1 + 2 = 3$

$$\frac{P_1 V_1}{n_1 T_1} = \frac{P_3 V_3}{n_3 T_3}$$

$$\frac{300 V_1}{1(T_1)} = \frac{P_3 (3V_1)}{3(T_1)} \quad [T_1 = T_3]$$

$$P_3 = 300 \text{ mm of Hg}$$

20. (c)

$$PV = nRT \Rightarrow PM = dRT \Rightarrow T = \frac{PM}{dR}$$

$$T = \frac{1.12 \times 10^9 \times 2}{1.3 \times 0.0821 \times 10^3} \quad (d = 1.3 \text{ g/cc} = 1.3 \times 10^3 \text{ g/L})$$

$$T = 2 \times 10^7 \text{ K}$$

21. (d)

$$PV = nRT \Rightarrow PV = \frac{m}{M} RT \Rightarrow V = \frac{mRT}{PM}$$

The gas which has highest value of M , have the least volume i.e. HI

22. (b)

$$PM = dRT$$

for same gas $m = \text{constant}$

$T = \text{constant}$

$$\frac{P_1}{d_1} = \frac{P_2}{d_2} \Rightarrow \frac{P_1}{d_1} = \frac{P_2}{2d_1} \quad [d_2 = 2d_1]$$

$$p_2 = 2P_1 = 2 \text{ atm}$$

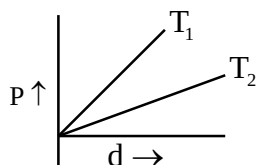
23. (b)

$$PM = dRT$$

$$d = \frac{PM}{RT}$$

For same gas $\frac{P}{T}$ higher, density higher. i.e. $0^\circ \text{C} (273\text{K}), 2 \text{ atm}$

24. (a)



$$P = \frac{RT}{M} d$$

For same gas T higher, $\frac{RT}{M}$ higher, slope increases

$$T_1 > T_2$$

25. (c)

Partial pressure will depend upon no. of moles of each gas. As mass of each gas is equal, partial pressure will depend upon relative molecular mass.

26. (c)
 Delton's Law of partial pressure
 $P_A = 1 \text{ atm}, P_T = 1.5 \text{ atm}, m_A = 2 \text{ gm}, m_B = 3 \text{ gm}$
 $P_B = P_T - P_A = 1.5 - 1 = 0.5 \text{ atm}$
 $P_A = X_A P_T, P_B = X_B P_T$
 $\frac{P_A}{P_B} = \frac{X_A}{X_B} = \frac{n_A}{n_B} = \frac{m_A m_B}{m_A m_B} = \frac{1}{0.5} = 2$
 $\frac{M_A}{M_B} = \frac{2}{2(3)} = \frac{1}{3}$
27. (a)
 $P_{O_2} = X_{O_2} P_T = 0.21 \times 750$
 $P_{O_2} = 157.5 \text{ mm of Hg}$
28. (c)
 $n_{H_2} = \frac{1}{2}, n_{He} = \frac{4}{4} = 1, n_{H_2} = \frac{7}{28} = \frac{1}{4}, n_{O_2} = \frac{8}{32} = \frac{1}{4}$
 The gas having highest mole fraction i.e, highest no. of moles, will have highest partial pressure, i.e. He
29. (a)
 $n_{\text{total}} = 0.10 + 0.05 + 0.20 + n_{CO_2}$
 $n_{\text{total}} = 0.35 + n_{CO_2}$
 $PV = n_{\text{total}} RT \Rightarrow n_{\text{total}} = \frac{PV}{RT}$
 $0.35 + n_{CO_2} = \frac{1 \times 9.6}{0.0821 \times 300} = 0.389$
 $n_{CO_2} = 0.389 - 0.35 = 0.039 \approx 0.04$
30. (b)
 Graham's Law
 $\text{rate} = \frac{V}{t} = \frac{K}{\sqrt{M}}$
 $\frac{t_1}{t_2} = \sqrt{\frac{M_1}{M_2}} \Rightarrow t_{He} = \sqrt{2} \times 5 = 7 \text{ sec}, t_{CO} = \sqrt{14} \times 5 = 18.7 \text{ sec}$
 $\frac{t_{H_2}}{t_{O_2}} = \sqrt{\frac{M_{H_2}}{M_{O_2}}} = \sqrt{\frac{2}{32}} = \sqrt{\frac{1}{16}} = \frac{1}{4}$
 $t_{O_2} = 4t_{H_2} = 4 \times 5 = 20 \text{ sec}$
 $t_{CO_2} = \sqrt{22} \times 5$
 $= 23.45 \text{ sec}$
31. (a)
 The gases having the same molecular mass diffuse at the same rate
 i.e. CO_2 & N_2O

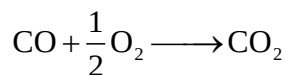
32. (c)
- $$\frac{r_1}{r_2} = \frac{n_1}{n_2} \sqrt{\frac{m_2}{m_1}} = \frac{2}{1} \sqrt{\frac{32}{2}} = \frac{2}{1} \times \frac{4}{1} = 8$$
33. (c)
The gas having less molecular mass will travel more distance than other
 $M_{\text{NH}_3} = 17$ $M_{\text{HCl}} = 36.5$
 i.e white fumes of NH_4Cl will formed towards HCl and (Point C)
34. (a)
Ratio of molecular mass is large gas can be easily separated
- $$\sqrt{\frac{M_{\text{D}_2}}{M_{\text{H}_2}}} = \sqrt{\frac{4}{2}} = \sqrt{2}, \sqrt{\frac{M_{\text{CD}_4}}{M_{\text{CH}_4}}} = \sqrt{\frac{20}{16}}, \sqrt{\frac{M_{\text{C}^{14}\text{H}_4}}{M_{\text{C}^{12}\text{H}_4}}} = \sqrt{\frac{18}{16}}$$
- $$\sqrt{\frac{M_{\text{U}^{238}\text{F}_6}}{M_{\text{U}^{235}\text{F}_6}}} = \sqrt{\frac{352}{349}}$$
35. (a)
- $$\frac{r_{\text{CH}_4}}{r_x} = \sqrt{\frac{M_x}{M_{\text{CH}_4}}} = 2 \Rightarrow \frac{M_x}{M_{\text{CH}_4}} = 4$$
- $$\Rightarrow M_x = 4 \times 16 = 64$$
36. (a)
Gases having same molecular mass cannot be separated by diffusion.
37. (a)
- $$\frac{M_{\text{Br}}}{M_{\text{O}_2}} = 5$$
- $$\frac{r_{\text{O}_2}}{r_{\text{Br}}} = \sqrt{\frac{M_{\text{Br}}}{M_{\text{O}_2}}} = \sqrt{5} = 2.23$$
38. (a)
Moist air diffuse outside and balloon will colapse
39. (c)
- $$\frac{r_{\text{SO}_2}}{r_x} = \frac{n / 20}{n / 60} = \sqrt{\frac{m_x}{64}}$$
- $$\Rightarrow m_x = \left(\frac{60}{20}\right)^2 \times 64$$
- $$\Rightarrow \text{(c)}$$
40. (d)
Conceptually inside pressure decreases on steaming hot and when it cool, a vacuum will be created which will help to seal the jars.

41. (c)
 $V_{\text{CO}} + V_{\text{CO}_2} + V_{\text{N}_2} = 200\text{m}\ell$

Volume of $\text{CO}_2 = x$

Volume of $\text{CO} = y$

Volume of $\text{N}_2 = 200 - x - y$



Initial	y	$\frac{y}{2}$	
Final	0	0	y

$$\text{Contraction} = \left(y + \frac{y}{2}\right) - y = \frac{y}{2} = 40\text{m}\ell$$

$$y = 80\text{m}\ell$$

$$\begin{aligned}\text{Remaining volume} &= x + y + 200 - x - y \\ &= 200\text{m}\ell\end{aligned}$$

On passing KOH all CO_2 will be absorbed.

$$\text{Contraction in volume} = x + y$$

$$x + y = 100$$

$$x = 20\text{m}\ell$$

$$V_{\text{CO}_2} = 20\text{m}\ell, V_{\text{CO}} = 80\text{m}\ell, V_{\text{N}_2} = 100\text{m}\ell$$

42. (c)
 $\text{N}_x\text{O}_y(\text{g}) + y\text{H}_2(\text{g}) \longrightarrow y\text{H}_2\text{O}(\ell) + \frac{x}{2}\text{N}_2(\text{g})$

Initial	10	30	–	0
---------	----	----	---	---

$$\frac{y}{1} = \frac{30}{10} = 3 \quad \Rightarrow y = 3$$

$$\frac{x}{2} = \frac{10}{10} = 1 \quad \Rightarrow x = 2$$



43. (a)
 $V_{\text{O}_2} = x, V_{\text{N}_2} = y, V_{\text{CH}_4} = z$
 $\text{CH}_4(\text{g}) + 2\text{O}_2(\text{g}) \longrightarrow \text{CO}_2(\text{g}) + 2\text{H}_2\text{O}(\ell)$

For the maximum heat volume of O_2 should be two times of volume of CH_4 . And as per given condition volume of N_2 should be four times of volume of O_2 .

$$\frac{V_{\text{O}_2}}{V_{\text{CH}_4}} = \frac{n_{\text{O}_2}}{n_{\text{CH}_4}} = \frac{x_{\text{O}_2}}{x_{\text{CH}_4}} = 2$$

$$\frac{V_{\text{N}_2}}{V_{\text{O}_2}} = \frac{n_{\text{N}_2}}{n_{\text{O}_2}} = \frac{x_{\text{N}_2}}{x_{\text{O}_2}} = 4$$

$$V_{\text{CH}_4} = Z, V_{\text{O}_2} = 2Z, V_{\text{N}_2} = 8Z$$

$$V_{\text{CH}_4} = \frac{Z}{11Z} = \frac{1}{11}, x_{\text{O}_2} = \frac{2Z}{11Z} = \frac{2}{11}$$

$$x_{\text{N}_2} = \frac{8Z}{11Z} = \frac{8}{11}$$

44. (a)
 Constant volume & temperature $P_{C_2H_2} = x, P_{C_3H_8} = y$
 $P \propto n$

$$C_2H_2(g) + \frac{5}{2}O_2(g) \longrightarrow 2CO_2(g) + H_2O(l)$$

Initial	x	$\frac{5}{2}x$	0	–
Final	0	0	2x	–

$$C_3H_8(g) + 5O_2(g) \longrightarrow 3CO_2(g) + 4H_2O(l)$$

Initial	y	5y	0	–
Final	0	0	3y	–

 $x + y = 80, 2x + 3y = 230$
 $x = 10 \text{ mm}, y = 70 \text{ mm}$

45. (c)
 By KTG
 $E_k = \frac{3}{2}RT = \frac{3}{2}PV$
 $\Rightarrow PV = \frac{2}{3}E_k$
 $\Rightarrow (c)$

46. (a)
 $KE = \frac{3}{2}RT$
 $= \frac{3}{2} \times 2 \times T = 3T$

47. (d)
 $T_1 = 273K, T_2 = ?$
 $\frac{V_{rms1}}{V_{rms2}} = \sqrt{\frac{T_1}{T_2}} = \frac{1}{2}$
 $T_2 = 4T_1 = 4 \times 273 = 1092K$
 $T_2 = 1092 - 273 = 819^\circ C$

48. (b)
 $V_{rms}(H_2) = V_{rms}(O_2)$
 $\sqrt{\frac{3RT_{H_2}}{M_{H_2}}} = \sqrt{\frac{3RT_{O_2}}{M_{O_2}}} \Rightarrow \frac{T_{H_2}}{M_{H_2}} = \frac{T_{O_2}}{M_{O_2}}$
 $T_{H_2} = T_{O_2} \times \frac{M_{H_2}}{M_{O_2}} = 273 \times \frac{2}{32} = 17K$

49. (b)
 $K.E. \propto T$
 As T doubled K.E. also doubled.

50. (d)

$$v_{\text{rms}} \propto \frac{1}{\sqrt{M}} \quad \text{at constant } T$$

The gas having lowest molecular mass has highest rms speed. i.e CO

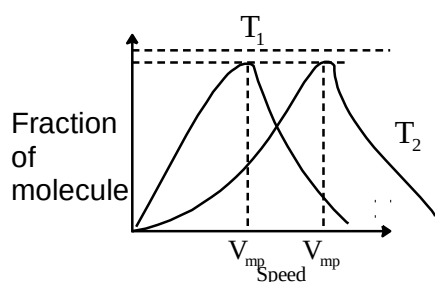
51. (a)

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

$$V_{\text{avg}} = \sqrt{\frac{8RT}{\pi M}}$$

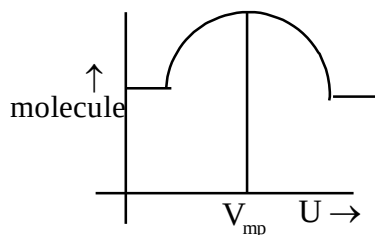
$$\frac{V_{\text{rms}}}{V_{\text{avg}}} = \sqrt{\frac{3\pi}{8}} = 1.086$$

52. (b)



$T_2 > T_1$ Fraction of molecule has acquired most probable velocity decreases.

53. (a)



As Temperature increases V_{mp} increases. i.e. curve shifts to higher velocity. Pressure & volume doesn't effect the curve.

54. (a)

$$\text{Total KE} = \frac{3}{2} nRT$$

$$x = \frac{3}{2} \frac{N}{N_A} R \times 150$$

$$2x = \frac{3}{2} \frac{N_1}{N_A} R \times 300$$

$$\Rightarrow N = N_1$$

55. (c)

$$\frac{V_{\text{rms}}(\text{H}_2)}{V_{\text{rms}}(\text{O}_2)} = \sqrt{\frac{M_{\text{H}_2} \times T_{\text{H}_2}}{M_{\text{O}_2} \times T_{\text{O}_2}}} = \sqrt{\frac{50}{2} \times \frac{32}{800}} = 1$$

56. (d)

$$V_{mp} = V_0 = \sqrt{\frac{2RT}{M}} = \sqrt{\frac{2R(t+273)}{M_{H_2}}}$$

$$V_{rms} = \sqrt{\frac{3RT}{M}} = \sqrt{\frac{3R(2t+273+273)}{\frac{M_{H_2}}{2}}}$$

$$= \sqrt{\frac{3R(t+273)2}{\frac{M_{H_2}}{2}}} = \sqrt{6}V_0$$

57. (a)

$$T_1 = 27^\circ \text{C} = 300\text{K}$$

$$V_{rms}, V_{mp}, V_{av} \propto \sqrt{T}$$

$$\frac{V_{rms_2}}{V_{rms_1}} = \sqrt{\frac{T_2}{T_1}}$$

$$2 = \sqrt{\frac{300+x}{300}}$$

$$4 = \frac{300+x}{300} \Rightarrow x = 900^\circ \text{C}$$

58. (b)

With increase in temperature most probable speed increases but fraction of molecules decreases.

59. (d)

I. molecules make elastic collisions with each other and with the walls of their container.

II. Average K.E. doesn't depend upon molecular mass.

III. Molecules of a gas are in constant random motion.

IV. Different molecules have different K.E, but average K.E. of molecules(gas) remains constant at given temperature.

60. (d)

$$\frac{V_{rms}(H_2)}{V_{rms}(CH_4)} = \sqrt{\frac{M_{CH_4}}{M_{H_2}}} \text{ at constant temperature}$$

$$\frac{V_{rms}(H_2)}{V_{rms}(CH_4)} = \sqrt{\frac{16}{2}} = 2.82$$

61. (b)

$$\frac{V_{avg}(SO_3)}{V_{avg}(Ne)} = \sqrt{\frac{M_{Ne}}{M_{SO_3}}} = \sqrt{\frac{20}{80}}$$

$$V_{avg}(SO_3) = \frac{1}{2} V_{avg}(Ne)$$

62. (c)
Temperature, pressure & volume of both vessel is same i.e same no. of moles and same number of molecule.
K.E. remains constant at constant temperature density is different as mass is different in both flask.
63. (d)

$$\frac{V_{\text{rms}}(\text{O}_2)}{V_{\text{rms}}(\text{CH}_4)} = \sqrt{\frac{M_{\text{CH}_4}}{M_{\text{O}_2}}} = \sqrt{\frac{16}{32}} = \frac{1}{1.41}$$
64. (b)
As kinetic molecular theory of gases pressure rises due to collision of molecule with the container walls, more frequently.
65. (b)
The number of molecular impacts per unit area increases at a higher temperature.
66. (b)
 $\text{KE} \propto T$
67. (c)
68. (d)

$$U \propto \frac{1}{\sqrt{m}}$$
69. (c)

$$K = \frac{3}{2}PV$$

$$\Rightarrow \frac{K}{V} = \frac{3}{2}P$$
70. (c)

$$U \propto \sqrt{T}$$
71. (b)
The speed distribution curve becomes sharper and is more peaked at lower temperature.
72. (b)
 $Z = 1$ for ideal gas
73. (c)
He has weak attraction forces. i.e. we can neglect a .

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

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

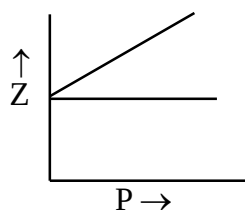
$$PV_m - Pb = RT$$

$$\frac{PV_m}{RT} = \frac{Pb}{RT} \Rightarrow Z = \frac{PV_m}{RT} = 1 + \frac{Pb}{RT}$$

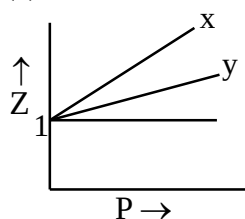
74. (b)

No force of attraction i.e. $a = 0$

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



75. (a)



For both He & H_2 no attraction force i.e. $a = 0$

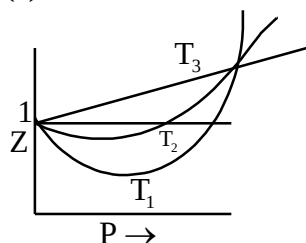
$$Z = 1 + \frac{Pb}{RT}$$

b for H_2 is greater than for He.

$x \rightarrow$ Hydrogen

$y \rightarrow$ Helium

76. (c)



As T increases, Z increases, so graph moves upwards.

$$T_3 > T_2 > T_1$$

77. (a)

For non-zero value of force of attraction

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

$$PV + \frac{an^2}{V} = nRT$$

$$PV = nRT - \frac{n^2a}{V}$$

78. (d)
There is low attraction force in H_2 means least value of 'a'.
79. (d)
The force of attraction is maximum in the case of NH_3 because of Hydrogen bonding i.e. maximum value of 'a'.
80. (a)
'a' depends on size & shape, but 'b' depends only upon size of molecule.
81. (b)
The value of 'a' higher, gas can be easily liquefied i.e. NH_3
82. (a)
Real gas shows maximum deviation at high pressure & low temperature.
83. (b)
 $\frac{a}{V^2}$ term is responsible for intermolecular attraction.
84. (a)
Pressure of real gas is less than the pressure calculated for an ideal gas.
85. (a)
Real gas equation

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

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

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

$$P = \frac{RT}{\bar{V} - b} - \frac{a}{\bar{V}^2}$$

$$Z = \frac{P\bar{V}}{RT} = \frac{\bar{V}}{\bar{V} - b} - \frac{a}{\bar{V}RT}$$
86. (b)

$$Z = \frac{PV}{RT} = A + \frac{B}{V} + \frac{C}{V^2} + \dots$$

$$A = 1, B = \left(b - \frac{a}{RT}\right)$$

 Temperature at which gas behave like an ideal gas is Boyle's temperature.
 i.e. $Z = 1$ (B, C.....are negligible)

87. (c)
At Boyle's Temperature real gas behaves like ideal gas for a range of pressure.
88. (c)
At temperature higher than Boyle temperature, $2 > 1$.
89. (b)
90. (c)
Due to polar nature HCl will have considerable intermolecular force.
91. (c)

$$Z = 1 + 0.34p - \frac{160p}{T} = 1$$

$$\Rightarrow T = 470K$$
92. (c)
93. (c)

EXERCISE - 1 [B]

1. (d)
Gaseous do not have fixed volume.
2. (c)
Vapour pressure of any liquid depends only on T.
3. (b)
Dalton's law does not holds for reaching gases.
4. (a)
At sea level pressure is max
So, volume minimum hence density maximum
5. (a)
 $PV = nRT = k$
 So slope = 0
6. (d)
Steam distillation is based on partial pressures
7. (d)
 $M_x = 16 M_{He} = 64$
8. (d)
 $K \propto T$

9. (b)
 $T \propto P$
 $T_r = 8 \times 300 = 2400 \text{ K} = 2127^\circ \text{C}$
10. (b)
 $\frac{n_f}{n_i} = \frac{1}{8}$
 $n \propto V$
 So, $\frac{V_f}{V_i} = \frac{1}{8}$
 $\Rightarrow \frac{r_f}{r_i} = \frac{1}{2}$
11. (b)
 $n_1 T_1 = n_2 T_2$
 $n_2 = n_1 \times \frac{300}{750} = 0.4 n_1$
12. (d)
 $d = \frac{PM}{RT}$
 $\Rightarrow \frac{d_1}{d_2} = \frac{800 \times 300}{750 \times 320} = 1$
13. (b)
 $\frac{16}{14} = \frac{T_2}{273} \Rightarrow T_2 = 312 \text{ K} = 39^\circ \text{C}$
14. (b)
 Gaseous state has highest kinetic energy due to least intermolecular forces.
15. (d)
 $\sqrt{\frac{8RT_A}{\pi M}} = 2 \sqrt{\frac{8RT_B}{\pi M}}$
 $\Rightarrow T_A = 4T_B$
 $\frac{P_A}{P_B} = \frac{T_A}{T_B} \frac{V_B}{V_A} = 4 \times \frac{2}{1} = 8$
16. (b)
 C_1 is most probable speed
 So, $C_1 = \sqrt{\frac{2RT}{M}}$
17. (c)
 Since, moles of N_2 & O_2 are equal, so on removing pressure will become half.
18. (a)
 $P \propto V_{rms}^2$

19. (d)
 $V_C = 3b$
20. (d)
 'a' depends on intermolecular attraction.
 'b' depends on volume of molecules.
21. (d)
 At high pressure repulsive forces dominate
22. (c)
 Real gas behaves like as an ideal gas at high T & low P.
23. (c)
 When repulse forces dominate $Z > 1$
24. (a)

$$V_{\text{ideal}} = \frac{1 \times 0.0821 \times 300}{24}$$

$$= 1.025$$

$$Z = \frac{0.9}{1.025} < 1$$

$$\Rightarrow \text{Negative deviation}$$
25. (a)
 Critical temperature is lesser than Boyle's temperature, so at low to moderate pressure $Z < 1$.
 Hence, attractive forces are dominating.
26. (b)
 For liquefaction of gases high pressure & low temperature is required.
27. (c)
 If $Z > 1$ repulsive forces dominate hence it is difficult to compress real gas.
28. (b)
 At critical point there is no difference between gaseous and liquid state, so meniscus vanishes.
29. (b)

$$T_C = \frac{8a}{27Rb}$$

$$P_C = \frac{a}{27b^2}$$

$$\frac{T_C}{P_C} = \frac{8b}{R} \Rightarrow b = \frac{RT_C}{8P_C}$$

$$V_C = 3b = \frac{3RT_C}{8P_C} = 5 \text{ L}$$
30. (b)
 At low P, b can be neglected

$$\left(P + \frac{4^2 a}{V^2} \right) (V) = 4RT$$

$$PV + \frac{16a}{V} = 4RT$$

$$PV = 4 \left(RT - \frac{4a}{V} \right)$$

$$\frac{PV}{RT - \frac{4a}{V}} = 4$$

31. (a)
According to KTG no forces act on gaseous molecule, hence they move in a straight line between successive collisions.

32. (b)
 $2\text{BCl}_3 + 3\text{H}_2 \rightarrow 2\text{B} + 6\text{HCl}$
 Moles of B = $\frac{21.6}{10.8} = 2$
 Moles of $\text{H}_2 = 3$
 $V = \frac{3 \times 0.0821 \times 273}{1} = 67.2 \text{ L}$

33. (c)
 $\text{KE} = \frac{3}{2} RT$
 $\frac{\text{KE}_{313\text{K}}}{\text{KE}_{293\text{K}}} = \frac{313}{293}$

34. (c)
As temperature is increased the peak of velocity distribution graph shifts to a lower height.

35. (d)
 $n_{\text{CH}_4} = \frac{x}{16}$
 $n_{\text{O}_2} = \frac{x}{32}$
 $X_{\text{O}_2} = \frac{\frac{x}{32}}{\frac{x}{16} + \frac{x}{32}} = \frac{1}{3}$
 So, $p_{\text{O}_2} = \frac{1}{3} P_{\text{total}}$

36. (d)
 $n_{\text{H}_2\text{O}} = \frac{3170 \times 10^{-3}}{8.314 \times 300} = 1.27 \times 10^{-3} \text{ mol}$

37. (a)
The mean free path, $\lambda = \frac{1}{\sqrt{2} \pi a^2 N}$

Or $\lambda \propto \frac{1}{a^2}$, where a = molecular diameter

$\therefore$ Smaller the molecular diameter, longer the mean free path, Hence, H_2 is the answer.

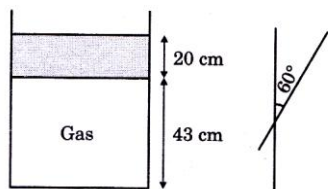
EXERCISE - 1 [C]

1. (48)

$$P_0 = 96 \text{ cm} \quad P_f = 76 + 20 \sin 30^\circ = 86$$

$$96 \times 43 = 86 \times l$$

$$\Rightarrow l = 48 \text{ cm}$$



2. (5)

$$15 = \frac{P \times 60}{\frac{1}{12} \times 300} \Rightarrow P = 6.25 \text{ atm (Same in both vessels)}$$

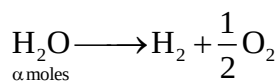
$$\frac{10}{n} = \frac{50}{(15 - n)} \Rightarrow n = \frac{15}{6} = 2.5 \text{ moles}$$

3. (9)

$$n_{N_2} = \frac{(1 - 0.04) \times 20}{0.08 \times 300} = 0.05 \text{ moles;}$$

$$P_{N_2} = 1 - 0.04 = 0.96 \text{ atm}$$

$$n_{(H_2 + O_2)} = \frac{0.90 \times 20}{0.08 \times 300} = 0.75$$



$$\Rightarrow \alpha + \frac{\alpha}{2} = 0.75$$

$$\Rightarrow \alpha = 0.5 \text{ or } 9 \text{ g } H_2O$$

4. (1327)

$$T = 4 \times 400 = 1600 \text{ K} = 1327^\circ \text{C}$$

5. (3)

$$0.2 \text{ L/mol, } Z = 0.75$$

6. (4)

$$3 \times \frac{400}{40} = 2 \times \frac{60}{M} \Rightarrow M = 4$$

7. (810)

$$P_A = 760 + 90 - 40 = 810$$

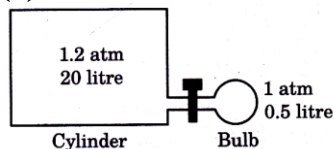
8. (3)

$$5^2 = \frac{4 \times 7^2 + 6x^2}{10} \Rightarrow x = 3$$

9. (2)

$$\begin{aligned} \text{Average KE} &= \frac{\frac{3}{2}kT}{1.6 \times 10^{-19}} \text{ eV} \\ &= \frac{1.5 \times 1.38 \times 10^{-23} \times 300}{1.6 \times 10^{-19}} \end{aligned}$$

10. (8)



$$\frac{1 \times 0.5}{RT} \times x + \frac{1 \times 20}{RT} = \frac{1.2 \times 20}{RT}$$

11. (800)

$$3b = 8.21; \frac{a}{27b^2} = 3$$

$$b = \frac{8.21}{3}$$

$$\frac{a}{27 \times b \times \frac{8.21}{3}} = 3$$

$$\begin{aligned} \frac{8a}{27Rb} &= \frac{3 \times 8}{0.0821} \times \frac{8.21}{3} \\ &= T_c \end{aligned}$$

12. (40)

$$h \times 3.4 = 10 \times 13.6 \Rightarrow h = 40$$

13. (7)

$$M = \frac{0.0013 \times 10^3 \times 0.0821 \times 273}{1} = 29.13$$

$$x \times 32 + (1-x) \times 28$$

$$\Rightarrow x = \frac{7}{25}$$

14. (8)

$$\frac{r_{H_2}}{r_{O_2}} = \frac{1}{8} \times \frac{32}{2} \sqrt{\frac{32}{2}} = 8$$

15. (3)

$$P_{N_2} = 90 - 63 = 27 \text{ cm of Hg}$$

$$X_{N_2} = \frac{27}{90} = 0.3$$

SECTION-I

1. (d)

$$\text{r.m.s. velocity } V_{\text{rms}} = \sqrt{\frac{3RT}{M}}$$

$$\text{i.e., } \frac{V_1}{V_2} = \sqrt{\frac{T_1}{T_2}}$$

$$\frac{5 \times 10^4}{10 \times 10^4} = \frac{1}{2} = \sqrt{\frac{T_1}{T_2}}$$

$$\therefore T_2 = 4T_1$$

2. (d)

Molecules move very fast in all directions in a straight line by colliding with each other but with different velocity.

3. (c)

$$C^* : \bar{C} : C = \sqrt{\frac{2RT}{M}} : \sqrt{\frac{8RT}{\pi M}} : \sqrt{\frac{3RT}{M}}$$

$$= 1 : 1.128 : 1.225$$

4. (b)

At low P, b can be neglected.

$$\text{So, } Z = 1 - \frac{a}{VRT}$$

5. (b)

$$\text{Number of moles of } O_2 = \frac{m}{32}$$

$$\text{Number of moles of } N_2 = \frac{4m}{28} = \frac{m}{7}$$

$$\therefore \text{Ratio of moles or molecules} = \frac{m}{32} : \frac{m}{7} = 7 : 32$$

6. (d)

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

$$V_{\text{rms}}(O_2) = V_{\text{rms}}(He)$$

$$\therefore T_{O_2} = \frac{300 \times 32}{4} = 2400K$$

7. (a)

According to Boyle's law

$$\frac{V_1}{V_2} = \frac{P_2}{P_1}, \frac{750}{V_2} = \frac{360}{840}$$

$$V_2 = 1750 \text{ mL} = 1.750 \text{ L}$$

8. (b)

According to Graham's laws of diffusion:

$$\frac{r_1}{r_2} = \sqrt{\frac{d_2}{d_1}} \text{ or } \frac{r_1}{r_2} = \sqrt{\frac{m_2}{m_1}} \quad \left[\because d = \frac{\text{Mol. wt}}{2} \right]$$

$$\text{Since rate of diffusion} = \frac{\text{Vol. of gas diffused (V)}}{\text{Time taken for diffusion (t)}}$$

$$\begin{aligned} \therefore \frac{r_1}{r_2} &= \frac{V_1/t_1}{V_2/t_2} \text{ or } \frac{r_1}{r_2} = \frac{V_1/t_1}{V_2/t_2} \Rightarrow \sqrt{\frac{m_2}{m_1}} \\ &= \frac{20/60}{V_2/30} \Rightarrow \sqrt{\frac{32}{64}} = \frac{20}{60} \times \frac{30}{V_2} \Rightarrow V_2 = 14.1 \end{aligned}$$

9. (a)

$$\text{Given } p = \frac{nRT}{V - nb} - a \left(\frac{n}{V} \right)^2$$

Which can also be written as,

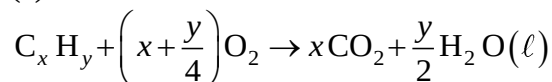
$$\left[p + \frac{n^2 a}{V^2} \right] (V - nb) = nRT$$

At low pressure and high temperature, the effect of $\frac{a}{V^2}$ and b is negligible, hence $PV = nRT$

10. (c)

According to KTG no intermolecular forces act between gas molecules.

11. (a)



$$15 \text{ ml} \quad 15 \left(x + \frac{y}{4} \right) \text{ ml} \quad 15x \text{ ml}$$

$$375 \times \frac{20}{100} = 15 \left(x + \frac{y}{4} \right)$$

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

$$15x + 300 = 345 \Rightarrow x = 3$$

$$\Rightarrow y = 8$$

12. (b)

$$\frac{p_i V}{RT_1} + \frac{p_i V}{RT_1} = \frac{p_f V}{RT_1} + \frac{p_f V}{RT_2}$$

$$p_f = \frac{\frac{2p_i}{\frac{1}{T_1} + \frac{1}{T_2}}}{T_1 + T_2} = \frac{p_i T_2}{T_1 + T_2}$$

13. (a)

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

$$\text{rms for } N_2, u = \sqrt{\frac{3RT}{28}}$$

$$\text{After dissociation, } u' = \sqrt{\frac{3R \times 2T}{14}}$$

$$\frac{u}{u'} = \sqrt{\frac{1}{4}} = \frac{1}{2}; u' = 2u$$

14. (a)
According to van der Waals equation for one mole of gas.

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

$$\text{At very high pressure, } P \gg \frac{a}{V^2}$$

$$\text{So, } \frac{a}{V^2} \text{ is negligible.}$$

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

$$PV - Pb = RT$$

On dividing RT on both sides

$$\therefore Z = 1 + \frac{Pb}{RT} \text{ compressibility factor.}$$

15. (b)
The real gases show deviation from ideality at low temperature, high pressure and low volume.

16. (c)

$$\frac{2 \times M}{R \times 300} = 2 \times \frac{4 \times 28}{R \times 300}$$

$$M = 112$$

17. (c)
From ideal gas equation-
 $PV = nRT$
So, $PV = mRT / M$; $P = mRT / MV$
 $P = dRT / M$
 $\therefore$ At constant temperature and pressure, $d \propto M$
 $\therefore d_1 / d_2 = 17 / 36.5$; $d_1 / d_2 = 0.46$

18. (b)
At 27°C or 300 K , number of moles of an ideal gas $= n_1$. At $T_2\text{K}$, number of moles of the ideal gas $= n_2$

$$\text{Number of moles escaped} = \frac{2n_1}{5}$$

$$n_2 = n_1 - \frac{2n_1}{5} = \frac{3n_1}{5}$$

$PV = nRT$ (Ideal gas equation)

$$n \propto \frac{1}{T}; n_1 T_1 = n_2 T_2$$

$$T_2 = \frac{n_1}{n_2} T_1 \Rightarrow T_2 = \frac{n_1}{\frac{3n_1}{5}} \times T_1 = \frac{5}{3} \times 300 = 500\text{K}$$

19. (a)

$$V_{\text{mp}} = \sqrt{\frac{2RT}{M}}$$

$$\therefore V_{\text{mp}} \propto \left(\frac{T}{M}\right)^{\frac{1}{2}}$$

From curve ,

$$(V_{\text{mp}})_I < (V_{\text{mp}})_{II} < (V_{\text{mp}})_{III}$$

$$(V_{\text{mp}})_{N_2} \propto \sqrt{\frac{300}{28}}; (V_{\text{mp}})_{O_2} \propto \sqrt{\frac{400}{32}}; (V_{\text{mp}})_{H_2} \propto \sqrt{\frac{300}{2}}$$

$$\therefore (V_{\text{mp}})_{N_2} < (V_{\text{mp}})_{O_2} < (V_{\text{mp}})_{H_2} \text{ (under given condition)}$$

20. (a)

If values of 'b' for two gases are same but values of 'a' are different, then the gas having a larger value of 'a' will occupy lesser volume. Since, it will have larger force of attraction, therefore, lesser distance between its molecules. If values of 'a' for two gases are same but values of 'b', are different then the smaller value of 'b' will occupy lesser volume, therefore, will be more compressible.

21. (a)

$$\text{Critical temperature} = \frac{8a}{27Rb}$$

$$\text{Ar} \Rightarrow \frac{a}{b} = 0.4; \text{Ne} \Rightarrow \frac{a}{b} = 0.12$$

$$\text{Kr} \Rightarrow \frac{a}{b} = 5.1; \text{Xe} \Rightarrow \frac{a}{b} = 0.82$$

Value of $\frac{a}{b}$ is highest for Kr. Therefore, Kr has highest value of critical temperature.

22. (b)

Compressibility factor is given by

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

$$\therefore \frac{Z_A}{Z_B} = \frac{P_A V_A}{P_B V_B}$$

$$\text{Given } Z_A = 3Z_B; V_A = 2V_B$$

$$\frac{3Z_B}{Z_B} = \frac{P_A \times 2V_B}{P_B \times V_B} \Rightarrow 3 = \frac{P_A}{P_B} \times 2$$

$$2P_A = 3P_B$$

23. (d)

Ideal gas equation: $PV = nRT$

After putting the values, we get

$$200 \times 10 = (0.5 + x) \times R \times 1000 \text{ (total no. of moles} = 0.5 + x)$$

$$\frac{2000}{1000} = 0.5R + xR \Rightarrow 2 = \left(\frac{1}{2} + x\right)R \Rightarrow \frac{2}{R} = \frac{1}{2} + x$$

$$\Rightarrow x = \frac{4 - R}{2R}$$

24. (a)
Noble gases such as Ne, Ar, Xe and Kr found to deviated from ideal gas behaviour.
Xe gas will exhibit steepest increase in plot of Z vs p .

Equation of state is given as:

$$p = \frac{RT}{(V-b)} \Rightarrow p(V-b) = RT$$

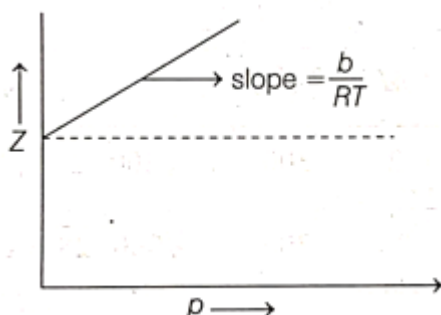
$$pV - pb = RT \Rightarrow pV = RT + pb$$

$$\frac{pV}{RT} = 1 + \frac{pb}{RT}$$

As, $Z = \frac{pV}{RT}$

So, $Z = 1 + \frac{pb}{RT} \Rightarrow y = c + mx$

The plot z vs p is found to be



The gas with high value of b will be steepest as slope is directly proportional to b , b is the van der Waals' constant and is equal to four times the actual volume of the gas molecules. Xe has the largest atomic volume among the given noble gases (Ne, Kr, Ar).

Hence, it gives the steepest increases in the plot of Z (compression factor) vs p .

25. (c)
In isothermal expansion, $pV_m = K$ (constant)

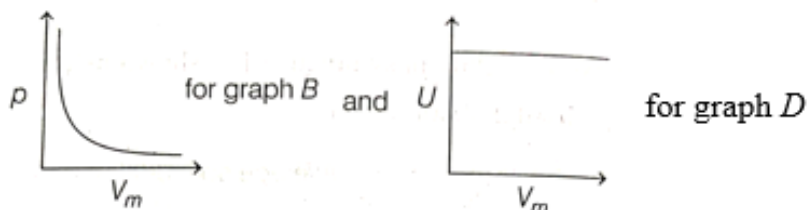
This relation is plotted in graph 'C'

Likewise, $p = \frac{K}{V_m}$

This relation is plotted in graph "A".

Thus graph B and D are incorrect.

For them the correct graphs are:



26. (a)

$$P_{\text{gas}} = \frac{n_{\text{gas}}RT}{V}$$
 As n , T and V are constant, so, $P_{\text{H}_2} = P_{\text{O}_2} = P_{\text{H}_2} = 2\text{atm}$
 So, $P_{\text{Total}} = P_{\text{H}_2} + P_{\text{O}_2} + P_{\text{He}} = 6\text{atm}$
27. (d)

$$V_{\text{rms}} > V_{\text{average}} > V_{\text{mp}}$$

$$\sqrt{\frac{3RT}{M}} > \sqrt{\frac{8RT}{\pi M}} > \sqrt{\frac{2RT}{M}}$$
28. (a)
 Critical temperature indicates the ease of liquefaction of gas more the critical temp. of gas more intermolecular attractive forces and greater is the ease of liquefaction hence greater is the adsorption.
29. (b)
 According to ideal gas equation

$$PV = nRT \Rightarrow PV = \frac{W}{M}RT$$

$$\Rightarrow P = \frac{RT}{M} \times d$$

$$\Rightarrow P \propto d \text{ and } P \propto T$$
30. (d)
 Mass liquid = $135 - 40 = 95\text{g}$
 Volume of liquid = $\frac{\text{mass}}{\text{density}} = \frac{95}{0.95}\text{mL} = 100\text{mL} = 0.1\text{L}$
 Mass of ideal gas = $40.5 - 40\text{g} = 0.5\text{g}$
 $PV = nRT$

$$0.82 \times 0.1 = \left(\frac{0.5}{M}\right) \times 0.082 \times 250 \Rightarrow M = 125$$
31. (a)
 For 1 mole of real gas
 $PV = ZRT$
 From graph PV for real gas is less than PV for ideal gas at point A
 $Z < 1$

$$Z = 1 - \frac{a}{V_m RT}$$
32. (a)
 Adsorption $\propto$ Vander Waal attraction forces
 $Z_c = \frac{3}{8}$ for all real gases
33. (a)
 Extent of adsorption decreases with decrease in critical temperature.
 Thus, the correct order is $D > C > B > A$.

34. (d)
Value of van der Waal's constant 'a' is measure of magnitude of intermolecular attractive within the gas and is independent of temperature and pressure.
The value of van der Waals' constant 'a' are as follows

Gases	van der Waal's constant 'a' (L ² atm mol ⁻²)
Ar	1.35
CH ₄	2.25
H ₂ O	5.536
C ₆ H ₆	18.57

SECTION-II

1. (750)
At constant temperature and number of moles

$$P_1 V_1 = P_2 V_2$$

$$P_1 = 48 \times 10^{-3} \text{ bar}; V_1 = \frac{4}{3} \pi (3)^3; V_2 = \frac{4}{3} \pi (12)^3$$

$$P_2 = \frac{P_1 V_1}{V_2} = \frac{48 \times 10^{-3} \times (3)^3}{(12)^3}$$

$$= \frac{48 \times 10^{-3}}{64} = 7.5 \times 10^{-4} = 750 \times 10^{-6} \text{ bar}$$

2. (1)
 $P(V_m - b) = RT \Rightarrow PV_m - Pb = RT$

$$\Rightarrow \frac{PV_m}{RT} = 1 + \frac{Pb}{RT} \Rightarrow Z = 1 + \frac{Pb}{RT}$$

$$\Rightarrow \left(\frac{\partial Z}{\partial P} \right)_T = \frac{b \times 1}{RT} \quad \therefore x = 1$$

3. (26)
 $PV = nRT$
 $\text{Mass} = \frac{PV}{RT} \times \text{molar mass}$
 $= \frac{1 \times 4 \times 10^6}{0.083 \times 300} \times 16 = 25.7 \times 10^5 \text{ g} \approx 26 \times 10^5 \text{ g}$

4. (70)
Using: $\frac{P}{T} = \text{Constant} \frac{P_1}{T_1} = \frac{P_2}{T_2}$
 $\Rightarrow T_2 = \frac{40 \times 300}{35} = 342.86 \text{ K}$
 $\therefore T_2 = 69.96^\circ \text{C} \approx 70^\circ \text{C}$

5. (150)

$$\text{Number of moles of } \text{CH}_4 = \frac{6.4}{16} = 0.4$$

$$\text{Number of moles of } \text{CO}_2 = \frac{8.8}{44} = 0.2$$

Total number of moles of the mixture = 0.6

$$\text{Now, } P = \frac{nRT}{V} = \frac{0.6 \text{ mol} \times 8.314 \text{ J mol}^{-1} \text{ K}^{-1} \times 300 \text{ K}}{10 \text{ L}}$$

$$= 149.65 \text{ J} \times \text{L} = \frac{149.65 \text{ N m}}{10^{-3} \text{ m}^3}$$

$$= 149.65 \times 10^3 \text{ Pa} \left[\because 1 \text{ Pascal} = \frac{\text{N}}{\text{m}^2}; 1 \text{ J} = \text{N.m} \right]$$

$$= \frac{149.65 \times 10^3}{1000} \text{ kPa} \approx 150 \text{ kPa}$$

6. (22)

At 27°C , moist gas pressure,

$$(p_g^\circ) + \text{v.p. of water} = 4$$

$$\text{Or, } (p_g^\circ)_1 = (4 - 0.4) \text{ atm} = 3.6 \text{ atm}$$

$$\text{After doubling the volume at constant } T, (p_g^\circ)_2 = 1.8 \text{ atm}$$

$$\therefore \text{The new pressure of the moist gas} = (1.8 + 0.4) \text{ atm}$$

$$= 2.2 = 22 \times 10^{-1} \text{ atm}$$

7. (1655)

$$\text{Moles of } \text{C}_3\text{H}_8 = \frac{\text{weight}}{\text{Molar mass}} = \frac{11}{44} = 0.25 \text{ moles}$$

Assuming ideal gas equation

$$PV = nRT$$

$$\Rightarrow 2 \times 10^6 \times 2 \times 10^{-3} = 0.25 \times 8.3 \times T$$

$$\Rightarrow T = 1927.710 \text{ K} = 1927.710 - 273.15 = 1654.56^\circ \text{C}$$

8. (152)

Assuming ideal behaviour $pV = nRT$

$$pV = \frac{m}{M} RT \Rightarrow M = \frac{m}{v} \frac{RT}{p} = \frac{dRT}{p}$$

$$760 \text{ mm Hg} \Rightarrow 1 \text{ atm}$$

$$p = \frac{100}{760} \text{ atm}, T = 257 + 273 = 530 \text{ K}, d = 0.46 \text{ gm / L}$$

$$\text{So, } M = \frac{0.46 \times 0.082 \times 530}{100} \times 760 = 151.93 \text{ g} \approx 152 \text{ g}$$

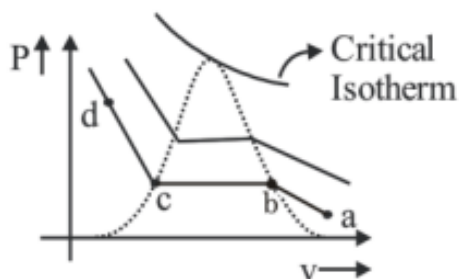
9. (4)

Using the ideal gas equation $pV = nRT$

$$1.5 \times 416 = \frac{100}{M} \times 0.083 \times 300; M = 3.99 \approx 4$$

10. (32)
- $$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$
- $$\frac{30}{300} = \frac{P_2}{318} \Rightarrow P_2 = \frac{30}{300} \times 318 = 32$$
11. (80)
- $$p_{\text{Total}} = 25 \text{ bar}; p_{\text{Ne}} = 20 \text{ bar}$$
- $$p_{\text{Ne}} = \chi_{\text{Ne}} \times p_{\text{Total}} \Rightarrow 20 = \chi_{\text{Ne}} \times 25$$
- $$\Rightarrow \chi_{\text{Ne}} = \frac{20}{25} = \frac{4}{5} \Rightarrow \frac{n_{\text{Ne}}}{n_{\text{Total}}} = \frac{4}{5}$$
- $$\Rightarrow \frac{200/20}{n_{\text{Total}}} = \frac{4}{5} \Rightarrow n_{\text{Total}} = 10 \times \frac{5}{4} = \frac{50}{4}$$
- $$\Rightarrow n_{\text{Total}} = \frac{50}{4} \Rightarrow \frac{x}{32} + \frac{200}{20} = \frac{50}{4} = 80 \text{ g}$$
12. (8)
- $$PV = n_{\text{mix}} RT$$
- $$n_{\text{mix}} = \frac{6 \times 12.5}{0.083 \times 300} \approx 3$$
- Let mole of $\text{He} = x$; Mole of $\text{H}_2 = 3 - x$
- $$4x + 2(3 - x) = 10; x = 2 \text{ mol}$$
13. (25)
- Real gas equation $= P(V - nb) = nRT$
- Or, $\frac{PV}{nRT} = 1 + \frac{Pb}{RT}$ or, $Z = 1 + \frac{Pb}{RT}$
- When $Z = 2$, $\frac{Pb}{RT} = 1$
- Or, $b = \frac{RT}{P} = \frac{0.083 \times 298}{99} \text{ L mol}^{-1} = 0.25 \text{ L mol}^{-1}$
- $$= 25 \times 10^{-2} \text{ L mol}^{-1}$$
14. (555)
- $$P_X = \chi P_T$$
- $$= \frac{\frac{0.6}{20}}{\frac{0.6}{20} + \frac{0.45}{45}} \times 740$$
- $$P_X = 555 \text{ mm Hg}$$

15. (2)
At



- (a) → CO₂ exist as gas
 (b) → liquefaction of CO₂ starts
 (c) → liquefaction ends
 (d) → CO₂ exist as liquid.

Between (b) & (c) → liquid and gaseous CO₂ co-exist.

As volume changes from (b) to (c) gas decrease and liquid increases.

16. (392)
 From compressibility factor :
 $[pV = Z \times n \times R \times T]$

$$\text{or, } n = \frac{pV}{ZRT}$$

For same gases, number of moles will be same

$$\therefore \frac{p_1 V_1}{Z_1 R T_1} = \frac{p_2 V_2}{Z_2 R T_2}$$

$$\text{or } \frac{100 \times 0.15}{1.07 \times R \times 500} = \frac{300 \times V_2}{1.4 \times R \times 300}$$

$$V_2 = \frac{100 \times 0.15 \times 1.4 \times 3}{1.07 \times 5 \times 300}$$

$$= 0.03925 \text{ dm}^3$$

$$\text{or } [392 \times 10^{-4} \text{ dm}^3]$$

17. (3)
 From ideal gas equation,
 $pV = nRT$

$$\text{For CH}_4, p_{\text{CH}_4} V_{\text{CH}_4} = n_{\text{CH}_4} RT$$

$$2 \times 2 = n_{\text{CH}_4} RT$$

$$n_{\text{CH}_4} = \frac{4}{RT}$$

$$\text{For CO}_2, p_{\text{CO}_2} V_{\text{CO}_2} = n_{\text{CO}_2} RT$$

$$4 \times 3 = n_{\text{CO}_2} RT$$

$$n_{\text{CO}_2} = \frac{12}{RT}$$

$$\text{For Ne, } p_{\text{Ne}} V_{\text{Ne}} = n_{\text{Ne}} RT$$

$$3 \times 4 = n_{\text{Ne}} RT$$

$$n_{\text{Ne}} = \frac{12}{RT}$$

⇒ Total moles (n_T)

$$\begin{aligned}
 &= n_{\text{CH}_2} + n_{\text{CO}_2} + n_{\text{Ne}} = \frac{28}{RT} \\
 \Rightarrow \text{Total pressure } (p_T) &= \frac{n_T RT}{V_T} \\
 &= \frac{28}{RT} \times \frac{RT}{V_T} = \frac{28}{V_T} \\
 &= \frac{28}{(2+3+4)} \approx 3
 \end{aligned}$$

EXERCISE - 2 [A]

1. (c)

$$\frac{r_{\text{He}}}{r_{\text{CH}_4}} = \frac{0.4}{0.6} \sqrt{\frac{16}{4}} = \frac{4}{3}$$

$$\% \text{CH}_4 = \frac{3}{7} \times 100 = 43\%$$

2. (a)

Charle's law : $V \propto T(\text{K})$

(B) is the correct graph.

(a) is wrong graph.

3. (d)

Since Piston is conducting $T_A = T_B$ & frictionless moving piston so $P_A = P_B$

$$n_A = \frac{P_A V_A}{RT_A} \quad n_B = \frac{P_B \times 3V_A}{RT_B}$$

$$\text{So, } n_B = 3n_A$$

$$\text{TKE}_A = \frac{3}{2} n_A RT_A$$

$$\text{TKE}_B = \frac{3}{2} n_B RT_B$$

$$\text{So, } \text{TKE}_B = 3\text{TKE}_A$$

4. (b)

$$n_1 = \frac{P_1 V_1}{RT_1} \quad \text{and} \quad n_2 = \frac{P_2 V_2}{RT_2}$$

$$\frac{n_2}{n_1} \times 100 = \frac{P_2 V_2 T_1}{P_1 V_1 T_2} \times 100 = 16.66\%$$

$$\therefore \text{Change} = 83.33\%$$

5. (a)

$$P_{\text{gas}} = 75 - 10 - 10 = 55 \text{ cm of Hg}$$

6. (a)
- $$P_{N_2} = 860 - 24 = 836 \text{ mm of Hg}$$
- $$W_{N_2} = \frac{836}{760} \times \frac{100}{11 \times 1000} \times \frac{28}{0.08 \times 250}$$
- $$= 0.014$$
- $$\% = \frac{0.014}{0.42} \times 100 = 3.33\%$$
7. (b)
- 20% mass $\Rightarrow$ 20% by moles too.
- $$\begin{array}{ccc} N_2O_4 & \longrightarrow & 2NO_2 \\ t=0 & 1 & - \\ t=1 & 1-0.2 & 0.4 \end{array} \quad \left. \vphantom{\begin{array}{ccc} N_2O_4 & \longrightarrow & 2NO_2 \\ t=0 & 1 & - \\ t=1 & 1-0.2 & 0.4 \end{array}} \right\} n_{\text{total}} = 1.2$$
- $$P = \frac{nRT}{V} = \frac{1.2 \times R \times 600}{\left(\frac{n_1 R T_1}{P_1} \right)}$$
- $$= 2.4 \text{ atm}$$

8. (a)
- $$C_xH_y + \left(x + \frac{y}{4} \right) O_2 \longrightarrow x CO_2 + \frac{y}{2} H_2O(g)$$
- $$a \quad ax + \frac{ay}{4} \quad ax \quad \frac{ay}{2}$$
- $$a + ax + \frac{ay}{4} = 600 \quad \& \quad ax + \frac{ay}{2} = 700$$
- Solving, $x = 3$; $y = 2$
- C_3H_8

9. (a)
- $$\frac{V_2}{V_1} = \frac{\frac{4}{3} \pi r_2^3}{4 \pi r_1^3} = \frac{P_1 T_2}{P_2 T_1} = \frac{P \times 2T}{\frac{P}{4} \times T} = 8$$
- $$\Rightarrow \frac{r_2}{r_1} = (8)^{1/3} = 2 \Rightarrow 100\% \text{ increase.}$$

10. (c)
- POAC on Br
- $${}^n\text{Br}_2 \times 2 = {}^n\text{BrF}_n \times 1$$
- $$\text{i.e. } \frac{423 \times 2}{\left(\frac{22400}{273} \times 423 \right)} = \frac{4.2}{(80 + 19n)} \times 1$$
- $$\therefore n = 5$$

11. (b)

$$V_{\text{gas mix}} = 150 \text{ mL} - V_{\text{H}_2\text{O}}$$

$$P_{\text{gas}} = 161 \text{ mm} = \text{Vapour pressure} + P_{\text{O}_2}$$

$$\therefore P_{\text{O}_2} = 161 - 28 = 133 \text{ mm Hg.}$$

$$\therefore V_{\text{O}_2} = \frac{(150 - V_{\text{H}_2\text{O}})}{1000} L = \frac{n_{\text{O}_2} RT}{P_{\text{O}_2}} = \frac{0.001 \times \frac{1}{12} \times 300}{\left(\frac{133}{760}\right)}$$

$$\therefore V_{\text{H}_2\text{O}} \approx 10 \text{ mL}$$

12. (a)

$$n_{\text{total}} = n_1 + n_2 + n_3$$

$$\text{or } \frac{P_{\text{total}} V_{\text{total}}}{RT} = \frac{P_1 V_1}{RT} + \frac{P_2 V_2}{RT} + \frac{P_3 V_3}{RT}$$

$$\therefore P_{\text{total}} = \frac{P_1 V_1 + P_2 V_2 + P_3 V_3}{V_{\text{total}}} = 1.412 \text{ atm}$$

13. (a)

$$n = \frac{PV}{RT} = \frac{W}{\text{mol. wt.}}$$

$$\text{i.e. mol. wt.} = \frac{W \times RT}{PV}$$

$$\begin{aligned} &= \frac{0.4429 \times \frac{1}{12} \times 373}{\left(\frac{743}{760}\right) \times (0.1153)} \\ &= 120.32 \text{ g} \end{aligned}$$

14. (b)

$$\sqrt{\frac{8RT}{\pi M_A}} = \sqrt{\frac{3RT}{M_B}}$$

$$\Rightarrow 8M_B = \frac{3\pi}{8} M_A$$

$$\Rightarrow M_B > M_A$$

So to equate their mean speed

$$T_B > T_A$$

15. (d)

At low P attractive force dominate

At high P repulsive force dominate

So, (D)

16. (a)

$$P_2 - P_1 = \ell$$

$$\frac{P_b}{b'} - \frac{P_a}{a} = \ell$$

$$P = \frac{\ell}{\frac{b}{b'} - \frac{a}{a'}}$$

17. (b)

$$n_{\text{tot}} = \frac{5.6 \times 3}{0.082 \times 273} = 0.75$$

$$n_{\text{N}_2} = 0.5$$

So, $n_x = 0.25$

$$\Rightarrow m_x = 4m_{\text{N}_2} = 112$$

EXERCISE - 2 [B]

1. (a, b, c)

$$P_2 > P_1$$

Since T is increasing & V is decreasing

$$P_3 = P_2$$

Since V – T graphs is straight line through origin.

2. (b, d)

(b), (d) are wrong.

$$Z_{\text{critical}} = \frac{\frac{\cancel{8}a}{\cancel{27}b^2} \times 3\cancel{b}}{\cancel{R} \times \frac{\cancel{8}a}{\cancel{27}\cancel{R}\cancel{b}}} = \frac{3}{8}$$

At zero K, $\text{KE}_{\text{avg}} = \frac{3}{2}RT$ per mole = Zero.

3. (b)

Here, $Z < 1$.

Attractive tendency is shown.

4. (a, b, c)

$$\text{Rate} \propto \frac{PA}{\sqrt{TM}}$$

Hence, (a), (b), (c).

5. (c, d)

$$\text{Time} = \frac{V}{\text{rate}}, \quad \text{rate} \propto \frac{PA}{\sqrt{TM}} \text{ or } \frac{1}{\sqrt{M}}$$

$$\therefore \text{time} \propto V\sqrt{M}$$

Time is same. That is, $V_1\sqrt{M_1} = V_2\sqrt{M_2}$

$$\therefore (C), (D) \quad \left[32\sqrt{32} = 27.3\sqrt{44} = 22.62\sqrt{64} \right]$$

6. (a, c)

(a) When 'a' is negligible, $Z = 1 + \frac{Pb}{RT}$

(c) When 'a' and 'b' are negligible, $Z = 1$

7. (a, b, d)

$$V_{mp} = \sqrt{\frac{2RT}{M}} \text{ i.e. } V_{mp} \propto \sqrt{T} \text{ and } \propto \frac{1}{\sqrt{M}}$$

$\therefore$ (a), (b) and (d) are right.

8. (b, c)

(c) is wrong.

$$P_c = \frac{a}{27b^2} \text{ or } P_c \propto \frac{1}{b^2}$$

9. (b, c, d)

For liquefaction

$$T \leq T_C, P \geq P_C$$

10. (a, c, d)

(a) $Z_{ideal} = 1$

(c) Z for real gas depend of attractive & repulsive forces.

(d) $Z < 1 \Rightarrow V_{real} < V_{ideal} \Rightarrow$ attractive tendency.

11. (b, c)

$$(b) U_{mps} = \sqrt{\frac{2RT}{M}} \Rightarrow T \uparrow; U_{mps} \uparrow$$

(c) Maxwellian distribution.

12. (a, c, d)

(a) 'a' = 0 and $Z = 1 + \frac{Pb}{RT}$

(c) 'a' and 'b' can be found out.

(d) At high D, $Z = 1 + \frac{Pb}{RT}$

$$\text{Slope} = \frac{b}{RT} > 0 \text{ for all gases.}$$

13. (a, b)

(a) T is constant

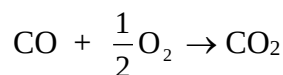
$$\therefore V \uparrow \Rightarrow P \downarrow$$

(b) $KE_{\text{avg}} = \frac{3}{2}KT$

Since 'T' is constant.

14. (a, b)

(a) $V_{\text{CO}} = x \quad V_{\text{O}_2} = y \quad V_{\text{CO}_2} = 100 - x - y$



initial $x \quad y$

If CO limiting reagent $x < 2y$

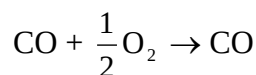
Final $0 \quad y - \frac{x}{2} \quad x$

On passing KOH all CO_2 absorbed.

$$100 - x - y + x = 80$$

$$100 - y = 80 \Rightarrow y = 20\text{m}$$

(b) if O_2 limiting reagent $x > 2y$



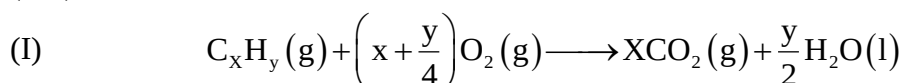
initial $x \quad y$

final $x - 2y \quad 0 \quad 2y$

$$100 - x - y + 2y = 80$$

$$100 - x + y = 80$$

15. (a, c)



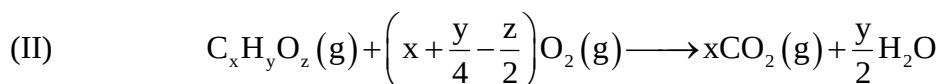
Initial $V_{\text{HC}} \quad V_{\text{O}_2} \quad 0 \quad -$

Final $0 \quad V_{\text{O}_2} - \left(x + \frac{y}{4}\right)V_{\text{HC}} \quad xV_{\text{HC}}$

$$\text{Contraction} = V_{\text{HC}} \left(1 + \frac{y}{4}\right)$$

$$\% \text{ contraction} = \frac{V_{\text{HC}} \left(1 + \frac{y}{4}\right)}{V_{\text{HC}} + V_{\text{O}_2}} \times 100 = 25\%$$

From option answer (a).



Initial $V_{\text{HC}} \quad V_{\text{O}_2} \quad 0 \quad -$

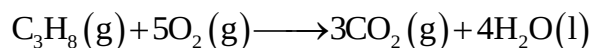
Final $0 \quad V_{\text{O}_2} - \left(x + \frac{y}{4} - \frac{z}{2}\right)V_{\text{HC}} \quad xV_{\text{HC}} \quad -$

$$\text{Contraction} = V_{\text{HC}} \left(1 + \frac{y}{4} - \frac{z}{2} \right)$$

$$\text{Contraction \%} = \frac{V_{\text{HC}} \left(1 + \frac{y}{4} - \frac{z}{2} \right)}{V_{\text{HC}} + V_{\text{O}_2}} \times 100 = 25\%$$

Answer (c)

16. (a, b)



Initial	x	y	0	—
Final	0	y - 5x	3x	—

If C_3H_8 limiting

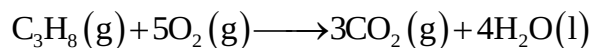
$$\text{Contraction} = (x + y) - (y - 5x) = 3x = 45$$

$$x = 15 \text{ ml}$$

$$x + y = 100 \text{ ml} \Rightarrow y = 85 \text{ ml}$$

Answer (a)

If O_2 limiting



Initial	x	y	0	—
Final	$x - \frac{y}{5}$	0	$\frac{3y}{5}$	—

$$\text{Contraction} = (x + y) - \left(x + \frac{2y}{5} \right) = 4.5$$

$$\Rightarrow \frac{3y}{5} = 45$$

$$y = 75 \text{ ml}, x = 25 \text{ ml}$$

Answer (b)

Comprehension Type :

PASSAGE-1

1. (a)

$$PV = nRT$$

$$\therefore \left(\frac{\partial P}{\partial T} \right)_V = \frac{nR}{V} \left(\frac{\partial P}{\partial T} \right)_T = \frac{-nRT}{P^2}; \left(\frac{\partial P}{\partial T} \right)_P = \frac{nR}{P}$$

$$\therefore \text{Product} = \frac{nR}{V} \times \frac{nRT}{P^2} \times \frac{nR}{P} = -\frac{n^2 R^2}{P^2} = \frac{-R^2}{P^2} \text{ (for one mole)}$$

2. (c)

$$V = \left(\frac{nR}{P} \right) T$$

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

$$\text{y-intercept} = \log\left(\frac{nR}{P}\right) = \log\left(\frac{R}{P}\right) \text{ for 1 mole.}$$

3. (a)

$$V_{\text{STP}} = n \times 22.4 \text{ L} = \frac{1.8}{18} \times 22.4 \text{ L} = 2.24 \text{ L}$$

4. (a)

$$U_{\text{rms}} = \sqrt{\frac{3RT}{M}} = \sqrt{\frac{3 \times 8.314 \times 300}{64 \times 10^{-3}}} = 3.42 \times 10^2$$

5. (c)

$$U_{\text{rms}} = 3\sqrt{R} = \sqrt{\frac{3R \times 300}{M}} = 3\sqrt{\frac{100R}{M}}$$

$$\Rightarrow M = 100$$

PASSAGE-2

6. (b)

When $V = 0$, $P = 1$

$$\Rightarrow Pe = 1 = 2 \times C \times 500 \Rightarrow C = \frac{1}{1000}$$

7. (d)

$$P = \left(\frac{nC}{e^{V/2}}\right)T \Rightarrow \text{Slope} = \frac{2C}{e} = \frac{2}{1000e}$$

8. (a)

$$P = \left(\frac{nC}{e^{V/2}}\right)T \Rightarrow P = \left(\frac{\left(\frac{PV}{RT}\right)C}{e^{V/2}}\right)T$$

PASSAGE-3

9. (c)

$$\frac{n-3}{3-2} = \frac{T-200}{200-300} \text{ (straight line)}$$

$$\text{or } n-3 = \frac{-T}{100} + 2$$

$$\text{or } n = 5 - \frac{T}{100}$$

10. (b)

$$V = \frac{nRT}{P} \quad \therefore V = \left(5 - \frac{T}{100}\right) \frac{RT}{P}$$

$$\text{But, } P = 1 \quad \therefore V = 5RT - \frac{RT^2}{100}$$

11. (b)

$$\frac{dV}{dT} = 0 \Rightarrow \frac{-2RT}{100} + 5R = 0$$

$$\Rightarrow T = 250 = -23^\circ\text{C}$$

12. (d)

Putting $T = 250$,

$$V = 5R \times 250 - \frac{R \times 250^2}{100}$$

$$= 1250R - 625R = 625R$$

PASSAGE-3

13. (b)

At critical temperature point of inflection occurs.

14. (d)

$$T_C = \frac{8a}{27Rb} . \text{ Greater is } T_C, \text{ greater is deviation from ideal behavior.}$$

15. (b)

$$Z_{\text{critical}} = \frac{3}{8} = 0.375$$

PASSAGE-5

16. (a)

Obvious. All H_2O freezes in B at -70°C .

17. (b)

$$^n\text{H}_2\text{O} + ^n\text{CO}_2 + ^n\text{N}_2 = \frac{PV}{RT} = \frac{(564/760) \times 1}{R \times 298} = 0.0303$$

$$^n\text{N}_2 + ^n\text{CO}_2 = \frac{(219/760) \times 1}{R} \left(\frac{1}{298} + \frac{1}{203} \right)$$

$$= 0.02906$$

$$\therefore ^n\text{H}_2\text{O} = 0.0013$$

18. (d)

All CO_2 freezes over at 'C'. Only N_2 remain as gas.
Hence (D).

19. (b)

$$^n\text{N}_2 = \frac{(33.5/760) \times 1}{R} \left(\frac{1}{298} + \frac{1}{203} + \frac{1}{83} \right)$$

$$= 0.0109$$

20. (c)
 ${}^n\text{CO}_2 = 0.02906 - 0.0109 = 0.018$

PASSAGE-6

21. (a)
 As CO_2 comes out its KE decreases, so T is lowered.

22. (b)

$$\frac{r_{\text{NH}_3}}{r_{\text{HCl}}} = \frac{36.5}{BC} = \sqrt{\frac{M_{\text{HCl}}}{M_{\text{NH}_3}}} = \sqrt{\frac{36.5}{17}}$$
 $\therefore BC = 24.909 \approx 25 \text{ cm}$

PASSAGE – 7

23. (d)
 Obvious. Flask 2 is at lower temperature Flask 1 when connected overall temperature lies between that of flask 1 and 2.
24. (b)
 Obvious. A is faster and lighter than B.
25. (c)
 (c) can be said for sure.

PASSAGE – 8

26. (c)
 Lower molecular weight than air (29) and hence lower density $\left(d = \frac{PM}{RT} \right)$
27. (b)
 Same molecular weight as He.
28. (b)

$$\text{Payload} = W_{\text{air}} - W_{\text{gas, He}}$$

$$D_{\text{air}} = \frac{PM}{RT} = \frac{1 \times (0.8 \times 28 + 0.2 \times 32)}{\frac{1}{12} \times 300}$$

$$= 1.152 \text{ g/L}$$

$$D_{\text{He}} = \frac{1 \times 4}{\frac{1}{12} \times 300} = 0.16 \text{ g/L}$$

$$\therefore \text{Payload} = V_{\text{balloon}} (d_{\text{air}} - d_{\text{He}})$$

$$= 100(1.152 - 0.16) \approx 100 \text{ g}$$

29. (d)

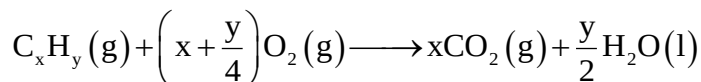
After combustion N_2 remains and when it reacts with excess hydrogen, NH_3 produced.

Answer (d)

V_{HC} ml alkane

V_{O_2} ml O_2

$10 - V_{HC} - V_{O_2}$ ml N_2



Initial	V_{HC}	V_{O_2}	0
Final	0	0	$x V_{HC}$

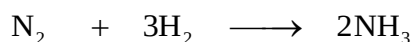
Contraction in volume on passing KOH = Volume of CO_2

$$\frac{2}{V_{HC}} = x \quad \dots(i)$$

All O_2 reacts with alkane, The only gas remain is N_2 .

$$V_{HC} \left(x + \frac{y}{4}\right) = V_{O_2} \quad \dots(ii)$$

30. (b)



Initial	$10 - V_{HC} - V_{O_2}$	0
Final		$2(10 - V_{HC} - V_{O_2})$

$$2(10 - V_{HC} - V_{O_2}) = 8$$

$$V_{HC} + V_{O_2} = 6 \quad \dots(ii)$$

$$V_{N_2} = 4 \text{ ml}$$

31. (c)

Volume of O_2 after first combustion = 0 ml

32. (a)

From equation (i), (ii), (iii)

$$x = 1$$

$$y = 4$$

CH_4

Matching Type:

1. (A) – P, S ; (B) – R ; (C) – P, Q ; (D) – P, S

(A) H_2 {P = 200 atm, T = 273 K}

At high pressure $Z > 1$, attraction force neglected.

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

- (B) $P \sim 0$ atm, gas behave as an ideal gas.
 (C) $\text{CO}_2(\text{g})$ ($P = 1$ atm), $T = 273$ K)
 Low pressure $Z < 1$, attraction force dominates.
 (D) Large molar volume, real gas behave as an ideal gas
 $PV = nRT$

2. (A) – R ; (B) – S ; (C) – Q ; (D) – P

(A) Z for ideal gas = 1

(B) at low pressure

$$\left(P + \frac{a}{V^2}\right)V = RT \Rightarrow Z = \frac{PV}{RT} = 1 - \frac{a}{VRT}$$

(C) at high pressure

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

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

$$(D) T_c = \frac{8a}{27Rb}$$

3. (A) – R ; (B) – P ; (C) – S ; (D) – Q

$$(A) V_{\text{rms}} = \sqrt{\frac{3RT}{M}}$$

$$(B) V_{\text{avg}} = \sqrt{\frac{8RT}{\pi M}}$$

$$(C) V_{\text{mp}} = \sqrt{\frac{2RT}{M}}$$

$$(D) P = \frac{1}{3} \frac{mn(7)^2}{V}$$

4. (A) – P, Q ; (B) – P, S ; (C) – P, Q ; (D) – P, Q, R

$$(A) \text{ Density of gas } d = \frac{PM}{RT}$$

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

$$(C) V_{\text{rms}} = \sqrt{\frac{3RT}{M}}$$

$$(D) \text{ rate } \propto T$$

$$\propto n$$

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

EXERCISE - 2 [C]

Experimental Gas Laws & Ideal Gas Law

1. $P_1 = 250 \text{ kPa}, \quad T_1 = 27^\circ \text{C} = 300 \text{K}$

$P_2 = ?, \quad T_2 = 1800 \text{K}$

$$\frac{P_1}{T_1} = \frac{P_2}{T_2} \Rightarrow P_2 = \frac{T_2}{T_1} P_1$$

$$\Rightarrow P_2 = \frac{1800}{300} \times 250 \times 10^3$$

$$P_2 = 1500 \times 10^3$$

$$P_2 = 1.5 \times 10^6 \text{ Pa}$$

$$P_2 > 10^6 \text{ Pa}$$

i.e. cylinder blows up before it melts.

2. (a) $V = \frac{nRT}{P} = \frac{4 \times 0.0821 \times 295 \times 760}{4 \times 720}$

$$V = 25.56 \text{ litre}$$

(b) $PV = nRT \Rightarrow PV = \frac{m}{M} RT$

$$d = \frac{PM}{RT} = \frac{800 \times 44}{0.0821 \times 760 \times 373} = 1.5124 \text{ gm / litre}$$

3. (a) $\frac{P_1 V_1}{n_1 T_1} = \frac{P_2 V_2}{n_2 T_2} \Rightarrow \frac{P_1}{m_1 T_1} = \frac{P_2}{m_2 T_2} \quad [\because V_1 = V_2 \text{ \& } M_1 = M_2 = M_2]$

$$\Rightarrow m_2 = \frac{P_2 m_1 T_1}{P_1 T_2} = \frac{16 \times 3.2 \times 273}{1 \times 473} = 29.55 \text{ gm}$$

(b) $\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2} \Rightarrow P_2 = \frac{P_1 V_1 T_2}{T_1 V_2}$

$$\Rightarrow P_2 = \frac{750 \times 0.500 \times 323}{760 \times 288 \times 0.400} = 1.383 \text{ atm}$$

$$\Rightarrow P_2 = 1.383 \times 760 = 1051.4 \text{ mm of Hg}$$

4. $T = 27^\circ \text{C} = 300 \text{K}, n_1 = n$

$$T_2 = ?, n_2 = n - \frac{3}{5}n = \frac{2}{5}n$$

$$n_1 T_1 = n_2 T_2$$

$$T_2 = \frac{n_1 \times 300}{\frac{2}{5}} = 750 \text{ K}$$

5. Let $n_{\text{total}} = 100, n_{\text{NO}_2} = x$

$$60.4 = \frac{46x + 92 \times (100 - x)}{100}$$

$$x = 68.7$$

6. By Boyle's law

$$V = \frac{100 \times 750}{745} = 100.67 \text{ ml}$$

$$7. \frac{P_1 V_1}{n_1 T_1} = \frac{P_2 V_2}{n_2 T_2} \Rightarrow \frac{V_1}{n_1} = \frac{V_2}{n_2} (\because P \text{ \& } T \text{ constant})$$

$$\Rightarrow \left(\frac{4}{3} \pi r_1^3 \right) \frac{1}{n_1} = \left(\frac{4}{3} \pi r_2^3 \right) \frac{1}{n_2}$$

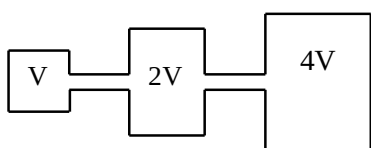
$$\Rightarrow r_2 = r_1 \left(\frac{n_2}{n_1} \right)^{\frac{1}{3}}$$

$$r_2 = 10 \left(\frac{0.75}{1} \right)^{\frac{1}{3}} = 10 \times 0.908$$

$$r_2 = 9.08 \text{ cm}$$

8. By Boyle's Law

$$P = \frac{5 \times 750}{1} = 3750 \text{ mm} = 4.93 \text{ atm}$$



9. (i)

$n \propto V$ at constant temperature and pressure

$$n_A : n_B : n_C = 1 : 2 : 4$$

(ii) As temperature is different in all boxes

$$n \propto \frac{V}{T}$$

$$n_A : n_B : n_C = \frac{V}{300} : \frac{2V}{400} : \frac{4V}{600} = \frac{1}{3} : \frac{1}{2} : \frac{2}{3}$$

$$n_A : n_B : n_C = 2 : 3 : 4$$

$$10. V_f = \frac{100}{288} \times 258 = 89.58 \text{ ml}$$

$$11. \frac{d_1}{d_2} = \frac{T_2}{T_1}$$

$$\frac{24}{18} = \frac{T_2}{300}$$

$$\Rightarrow T_2 = 400 \text{ K}$$

Dalton's Law of partial pressure

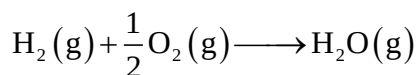
$$12. n_{\text{total}} = \frac{12}{28} + \frac{4}{2} + \frac{9}{32} = 2.71$$

$$P_T = \frac{n_{\text{total}} RT}{V} = \frac{2.71 \times 0.0821 \times 300}{1}$$

$$P_T = 66.74 \text{ atm}$$

$$13. \quad n_{\text{total}} = \frac{10}{2} + \frac{64}{32} = 7$$

$$P_T = \frac{n_{\text{total}}RT}{V} = \frac{7 \times 8.314 \times 473}{10 \times 10^{-3}} = 27.53 \times 10^5 \text{ N/m}^2$$



Initial 5 2

Final 5 - 4 = 1 0 4

$$n_{\text{total}} = 5$$

$$P_T = \frac{n_{\text{total}}RT}{V} = \frac{5 \times 8.314 \times 473}{10 \times 10^{-3}} = 19.66 \times 10^5 \text{ N/m}^2$$

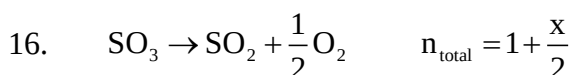
$$14. \quad P_{\text{O}_2} = 800 - 21 = 779 \text{ mm of Hg}$$

$$n_{\text{O}_2} = \frac{779}{760} \times \frac{0.1}{0.0821 \times 296}$$

$$V_{\text{O}_2} \text{ at NTP} = \frac{779}{760} \times \frac{0.1}{0.0821 \times 296} \times 22400 \text{ ml}$$

$$= 94.5 \text{ ml}$$

$$15. \quad P_t = \frac{(250 \times 650) + (380 \times 650)}{1000} = 409.5 \text{ mm}$$



$$1-x \quad x \quad \frac{x}{2}$$

$$n = \frac{PV}{RT} = \frac{1 \times 1}{0.0821 \times 900} = 0.0135$$

$$M_{\text{mix}} = \frac{0.94}{0.0135} = 69.62$$

$$\frac{80}{1 + \frac{x}{2}} = 69.62$$

$$x = 0.3$$

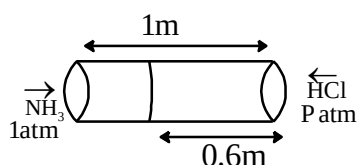
$$P_{\text{SO}_3} = \frac{1-x}{1 + \frac{x}{2}} P_T = \frac{0.7}{1.15} = 0.6 \text{ atm}$$

$$P_{\text{SO}_2} = \frac{x}{1 + \frac{x}{2}} P_T = \frac{0.3}{1.15} = 0.265 \text{ atm}$$

$$P_{\text{O}_2} = 1 - P_{\text{SO}_3} - P_{\text{SO}_2} = 0.135 \text{ atm}$$

Graham's Law

17.



$$r \propto \frac{P}{\sqrt{M}}$$

$$\frac{r_{\text{HCl}}}{r_{\text{NH}_3}} = \frac{P_{\text{HCl}}}{P_{\text{NH}_3}} \sqrt{\frac{M_{\text{NH}_3}}{M_{\text{HCl}}}}$$

$$\frac{0.6}{0.4} = \frac{P}{1} \sqrt{\frac{17}{36.5}}$$

$$P = 2.19 \text{ atm}$$

$$18. \quad \frac{r_{\text{ozone}}}{r_{\text{Cl}_2}} = \frac{6}{5} = \sqrt{\frac{d_{\text{ozone}}}{35.5}}$$

$$d_{\text{ozone}} = 24.65$$

$$19. \quad \frac{r_{\text{Cl}_2}}{r_x} = \frac{100/t}{127/t} = \sqrt{\frac{M_x}{71}}$$

$$\Rightarrow M_x = 44$$

$$20. \quad \frac{r_A}{r_B} = \frac{1}{4} \Rightarrow \frac{r_A}{r_B} = \frac{n_A}{n_B} \left(\frac{M_B}{M_A} \right)^{\frac{1}{2}}$$

$$\Rightarrow \frac{1}{4} = \frac{m_A}{m_B} \left(\frac{M_B}{M_A} \right)^{\frac{3}{2}}$$

$$\Rightarrow \frac{1}{4} = \frac{2}{3} \left(\frac{M_B}{M_A} \right)^{\frac{3}{2}}$$

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

$$\Rightarrow \frac{M_B}{M_A} = \left(\frac{9}{64} \right)^{\frac{1}{3}}$$

$$\frac{m_A}{m_B} = \frac{2}{3}$$

$$\frac{x_A}{x_B} = \frac{n_A}{n_B} = \frac{m_A}{m_A} \times \frac{m_B}{m_B} = \frac{2}{3} \times \left(\frac{9}{64} \right)^{1/3}$$

$$\frac{x_A}{x_B} = \left(\frac{8 \times 9}{27 \times 64} \right)^{\frac{1}{3}} = \left(\frac{1}{24} \right)^{\frac{1}{3}}$$

$$21. \quad \frac{n_{\text{CH}_4}}{n_{\text{O}_2}} = \frac{4}{2} \left(\frac{M_{\text{O}_2}}{M_{\text{CH}_4}} \right)^{\frac{3}{2}} = \frac{4}{2} \left(\frac{32}{16} \right)^{\frac{3}{2}} = 4\sqrt{2}$$

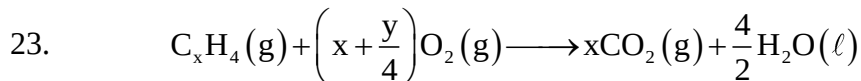
$$\frac{n_{\text{SO}_2}}{n_{\text{O}_2}} = \frac{1}{2} \left(\frac{M_{\text{O}_2}}{M_{\text{SO}_2}} \right)^{\frac{3}{2}} = \frac{1}{2} \left(\frac{32}{64} \right)^{\frac{3}{2}} = \frac{1}{4\sqrt{2}}$$

$$22. \quad \frac{r_x}{r_y} = \frac{4}{1}$$

$$\frac{r_y}{r_z} = \frac{2}{1}$$

$$\text{So, } \frac{r_x}{r_z} = \frac{8}{1} = \sqrt{\frac{M_z}{M_x}}$$

$$\Rightarrow M_x = \frac{128}{64} = 2$$



$$\text{Initial} \quad 10 \quad 80 \quad 0 \quad -$$

$$\text{Final} \quad 0 \quad 80 - 10\left(x + \frac{y}{4}\right) \quad 10x \quad -$$

Final volume occupied by gas = 70 ml

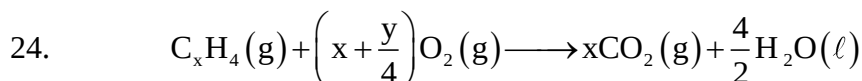
$$80 - 10\left(x + \frac{y}{4}\right) + 10x = 70$$

$$80 - \frac{10y}{4} = 70$$

$$y = 4$$

Contraction in volume on passing KOH = 70 - 50 = 20 ml

$$\frac{x}{1} = \frac{20}{10} \Rightarrow x = 2$$



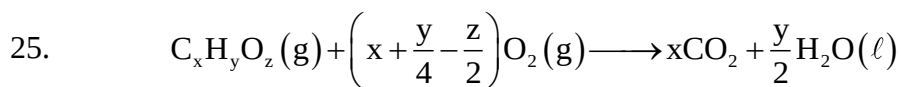
$$\text{Initial} \quad 7.5 \quad 36 \quad 0 \quad -$$

$$\text{Final} \quad 0 \quad 36 - 7.5\left(x + \frac{y}{4}\right) \quad 7.5x \quad -$$

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

$$7.5x = 15$$

$$x = 2$$



$$\text{Initial} \quad 10 \quad 100 \quad 0 \quad -$$

$$\text{Final} \quad 0 \quad 100 - \left(x + \frac{y}{4} - \frac{z}{2}\right)10 \quad 10x_0 \quad -$$

$$100 - \left(x + \frac{y}{4} - \frac{z}{2}\right)10 + 10x = 90$$

$$100 - \left(\frac{y}{4} - \frac{z}{2}\right)10 = 90$$

$$\frac{y}{4} = \frac{z}{2} = 1 \Rightarrow y - 2z = 4 \quad \text{-----(i)}$$

Contraction in volume on passing KOH=20mL

$$\frac{x}{1} = \frac{20}{10} \Rightarrow x = 2$$

Vapour density = 23

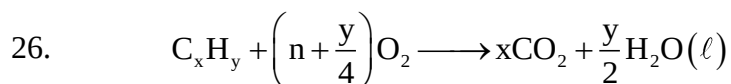
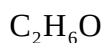
Molecular weight = 46

$$24 + y + 16z = 46$$

$$y + 16z = 22 \quad \dots\dots(ii)$$

On solving equation (i) & (ii)

$$Z = 1, y = 6$$



$$i \quad 30 \quad 200 \quad 0 \quad 0$$

$$f \quad 0 \quad 200 - 30\left(x + \frac{y}{4}\right) \quad 30x \quad 0$$

$$200 - 30x - 7.5y + 30x = 230 - 45 = 185$$

$$7.5y = 15 \Rightarrow y = 2$$

$$30x = 90 \Rightarrow x = 3$$



$$\text{Initial} \quad 50 \quad -$$

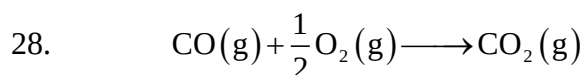
$$\text{Final} \quad 50 - x \quad \frac{2x}{y}$$

$$50 - x + \frac{2x}{y} = 47 \quad \dots\dots(i)$$

$$50 - x = 41 \Rightarrow x = 9 \quad \dots\dots(ii)$$

From (i) & (ii)

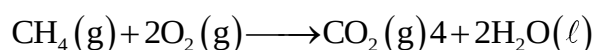
$$y = 3$$



$$\text{Initial} \quad x \quad z_1$$

$$\text{Final} \quad 0 \quad z_1 - \frac{x}{2} \quad x$$

$$N_2 = 10 - x - y \text{ mL}$$



$$\text{Initial} \quad y \quad Z_2 \quad O \quad -$$

$$\text{Final} \quad 0 \quad Z_2 - 2y \quad y \quad -$$

$$\text{Contraction} = (x + z_1 + y + z_2) - \left(x + y + z_1 + z_2 - \frac{x}{2} - 2y\right)$$

$$= \frac{x}{2} + 2y$$

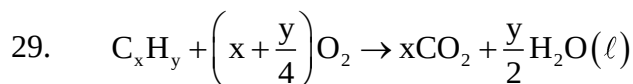
$$\frac{x}{2} + 2y = 6.5 \quad \dots\dots(i)$$

Contraction on passing KOH = 7mL = volume of CO₂

$$x + y = 7 \quad \text{_____ (ii)}$$

$$x = 5, y = 2$$

$$V_{\text{CO}} = 5\text{mL}, V_{\text{CH}_4} = 2\text{mL}, V_{\text{N}_2} = 3\text{mL}$$



$$7.5 \quad 7.5\left(x + \frac{y}{4}\right) \quad 7.5x$$

$$7.5 + 7.5x + \frac{7.5y}{4} - 7.5x = 15$$

$$y = 4$$

$$M_w = 28 = 12x + 4$$

$$\Rightarrow x = 2$$



Kinetic Theory of Gas

$$30. \quad (a) \quad V_{\text{rms}} = \sqrt{\frac{3RT}{M}} = \sqrt{\frac{3RT}{mN_A}}$$

$$V_{\text{rms}} = \sqrt{\frac{3 \times 8.314 \times 298}{9.1 \times 10^{-31} \times 6.023 \times 10^{23}}}$$

$$V_{\text{rms}} = 1.16 \times 10^5 \text{ m/sec}$$

$$= 1.16 \times 10^7 \text{ cm/sec}$$

$$(b) \quad V_{\text{avg}} = \sqrt{\frac{8RT}{\pi m}}$$

$$\frac{V_{\text{avg}}(A)}{V_{\text{avg}}(B)} = \sqrt{\frac{T_A}{T_B} \times \frac{M_B}{M_A}} = \sqrt{\frac{300 \times 16}{900 \times 2}} = 1.632$$

$$31. \quad (a) \quad E = \frac{3}{2}RT = \frac{3}{2} \times 2 \times 300 = 900\text{cal}$$

$$(b) \quad \text{Thermal Energy added} = \frac{3}{2}nR\Delta T$$

$$= \frac{3}{2} \times \frac{3.45}{20.18} \times 2 \times 100$$

$$= 51.29\text{cal}$$

$$32. \quad U_{\text{rms}} = \sqrt{\frac{3RT}{M}} \quad U_{\text{avg}} = \sqrt{\frac{8RT}{\pi m}}$$

$$\sqrt{\frac{3RT}{64 \times 10^{-3}}} = \sqrt{\frac{8R \times 300}{3.14 \times 32 \times 10^{-3}}}$$

$$T = \frac{8 \times 300 \times 2}{3.14 \times 3} = 509\text{K}$$

$$T = 509 - 273 = 236^\circ\text{C}$$

$$33. \quad PM = dRT$$

$$\frac{RT}{M} = \frac{p}{d}$$

$$U_{\text{rms}} = \sqrt{\frac{3RT}{M}} = \sqrt{\frac{3P}{d}} = \sqrt{\frac{3 \times 1.013 \times 10^5}{9 \times 10^{-2}}} = 1.83 \times 10^3 \text{ m/sec}$$

$$34. \quad (a) \quad U_{\text{rms}} = \sqrt{\frac{3p}{d}} = \sqrt{\frac{3 \times 1.013 \times 10^5}{1.2504}} = 494 \text{ m/s}$$

$$(b) \quad U_{\text{arg}} = \sqrt{\frac{8 \times 1.013 \times 10^5}{3.14 \times 1.2504}} = 455 \text{ m/s}$$

$$35. \quad U_{\text{rms}} = \sqrt{\frac{u_1^2 + u_2^2 + u_3^2 + u_4^2 + u_5^2 + u_6^2}{6}}$$

$$= \sqrt{\frac{2^2 + 2.2^2 + 2.6^2 + 2.7^2 + 3.3^2 + 3.5^2}{6}}$$

$$\Rightarrow U_{\text{rms}} = \sqrt{\frac{46.03}{6}} = 2.77 \text{ m/s}$$

$$U_{\text{avg}} = \frac{u_1 + u_2 + u_3 + u_4 + u_5 + u_6}{6}$$

$$\Rightarrow U_{\text{avg}} = \frac{2 + 2.2 + 2.6 + 2.7 + 3.3 + 3.5}{6}$$

$$\Rightarrow U_{\text{avg}} = \frac{16.3}{6} = 2.716 \text{ m/s}$$

$$36. \quad PV = nRT$$

$$T = \frac{Pv}{nR} = \frac{1 \times 1 \times 6.023 \times 10^{23}}{1.03 \times 10^{23} \times 0.0821} = 71.2 \text{ K}$$

$$U_{\text{rms}} = \sqrt{\frac{3RT}{M}} = \sqrt{\frac{3 \times 8.314 \times 71.2}{2 \times 10^{-3}}} = 942 \text{ m/s}$$

Real Gas Behavior

$$37. \quad T_c = 304.2 \text{ K}, P_c = 72.9 \text{ atm}$$

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

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

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

$$\frac{4}{3} \pi r^3 N_A \times 4 = \frac{RT_c}{8P_c}$$

$$r = \left(\frac{3RT_c}{128\pi N_A P_c} \right)^{1/3}$$

$$r = \left(\frac{3 \times 8.314 \times 304.2}{128 \times 3.14 \times 6.023 \times 10^{23} \times 72.9 \times 1.013 \times 10^5} \right)^{1/3}$$

$$r = 0.162 \times 10^{-9} \text{ m}$$

$$r = 1.62 \text{ \AA}$$

$$38. \quad r = \left(\frac{3RT_C}{128\pi N_A P_C} \right)^{1/3}$$

$$r = \left(\frac{3 \times 8.314 \times 151}{128 \times 3.14 \times 6.023 \times 10^{23} \times 48 \times 1.013 \times 10^5} \right)^{1/3}$$

$$T_C = -122 + 273 = 151 \text{ K}$$

$$P_C = 48 \text{ atm}$$

$$P_C = 48 \times 1.013 \times 10^5 \text{ Pa}$$

$$r = 0.147 \times 10^{-9} \text{ m}$$

$$r = 1.47 \text{ \AA}$$

$$39. \quad b = \left(\frac{4}{3} \pi r^3 N_A \right) \times 4$$

$$b = (\text{volume of one mole}) \times 4$$

$$b = \frac{200.59}{13.6} \times 4 = 58.997 \text{ cm}^3$$

$$40. \quad (a) \quad P = \frac{nRT}{V} = \frac{22 \times 8.314 \times 298.15}{44 \times 0.5 \times 10^{-3}} = 2.47 \times 10^6 \text{ Pa}$$

$$(b) \quad P = \frac{0.5 \times 8.314 \times 298.15}{0.5 \times 10^{-3} - 0.5 \times 42.67 \times 10^{-6}} - \frac{0.5 \times 0.5 \times 363.76 \times 10^3 \times 10^{-6}}{0.25 \times 10^{-6}}$$

$$P = 2.589 \times 10^6 - 0.36 \times 10^6$$

$$P = 2.225 \times 10^6 \text{ Pa}$$

$$41. \quad Z = \frac{PV}{nRT}$$

$$m = \frac{PVM}{ZRT} = \frac{10.1325 \times 10^6 \times 100 \times 10^{-3} \times 32 \times 10^{-3}}{0.927 \times 8.314 \times 273.15}$$

$$m = 15.4 \text{ Kg}$$

42. At Boyle's temperature real gases behave like an ideal gas.

$$T_b = \frac{a}{Rb} = \frac{1.36}{0.0821 \times 0.0318} = 521 \text{ K}$$

$$43. \quad (i) \quad T_C = \frac{8a}{27Rb}$$

T_C will be maximum if $\frac{a}{b}$ value maximum $\frac{a}{b}$ for gas A = 15011

T_C will be maximum if $\frac{a}{b}$ value maximum $\frac{a}{b}$ for gas B = 40530

T_C will be maximum if $\frac{a}{b}$ value maximum $\frac{a}{b}$ for gas C = 18998

i.e. T_C will be maximum for Gas B

(ii) larger the value of b, larger the molecular volume.

- i.e. Gas C has maximum molecular volume.
 (iii) least the value of a & b, gases behave as an ideal gas. i.e. Gas A.

44. (i) $P = \frac{nRT}{V} = \frac{15 \times 0.0821 \times 303}{12} = 31.1 \text{ atm}$

(ii) $P = \frac{nRT}{V - nb} - \frac{an^2}{V^2}$
 $= \frac{15 \times 0.0821 \times 303}{12 - 0.0171 \times 15} - \frac{0.2107 \times 15 \times 15}{12 \times 12}$
 $= 21.777 = 0.329$
 $P = 31.44 \text{ atm}$

45. $= 327.6 \text{ atm}$

$T = 776.4 \text{ K}$

$d = 133.2 \text{ gm/L}$

$Z = \frac{PV}{nRT} = \frac{PM}{dRT}$

$Z = \frac{327.6 \times 18}{133.2 \times 0.0821 \times 776.4} = 0.695$

$V_m = \frac{V}{n} = \frac{V}{m} M = \frac{M}{d}$

$V_m = \frac{18}{132.2} = 0.135 \text{ L/mol}$

46. $\frac{P_1 V_1}{Z_1 T_1} = \frac{P_2 V_2}{Z_2 T_2}$

$V_2 = \frac{P_1 V_1 Z_2 T_2}{Z_1 T_1 P_2}$

$V_2 = \frac{300 \times 1 \times 1.375 \times 273}{1.072 \times 473 \times 600}$

$V_2 = 0.370 \text{ litre}$

PYQ : JEE Advanced

Objective Questions I [Only one correct option]

1. (c)
 $\sqrt{\frac{3RT}{2}} \text{ for } H_2 = \sqrt{7} \times \sqrt{\frac{3RT}{28}} \text{ for } N_2$
 $\therefore T_{H_2} < T_{N_2} \quad \left[T_{H_2} = \frac{1}{2} \cdot T_{N_2} \right]$

2. (b)
 $Z = \frac{PV}{nRT} \text{ for ideal gas}$
 As, $Z < 1$, $\therefore \frac{pV}{nRT} < 1$ or $PV < nRT$

Or, $1 \text{ atm} \times V < 1 \text{ mole} \times 0.0821 \text{ L atm K}^{-1} \text{ mol}^{-1} \times 273 \text{ K}$

Or, $V < 0.0821 \times 273 \text{ L}$ or, $V < 22.4 \text{ L}$

3. (c)
Mass of 1 L of water vapour = 0.6 g
$$\therefore V = \frac{\text{Mass}}{\text{Density}} = \frac{0.6}{1.0} = 0.6 \text{ cm}^3$$
4. (d)
$$U_{rms} = \sqrt{\frac{3RT}{M}}, PV = nRT \quad [\text{Ideal gas Eqn.}]$$

or
$$\frac{RT}{M} = \frac{PV}{M} \quad [\because RT = PV]$$

or
$$\frac{RT}{M} = \frac{p}{d} \quad \left[\because \frac{V}{M} = \frac{1}{d} \right]$$

$$\therefore U_{rms} = \sqrt{\frac{3P}{d}}$$

Hence, at constant pressure $U_{rms} \propto \frac{1}{\sqrt{d}}$
5. (c)
 $PV = RT$ (for 1 mole of gas)
or $V = \frac{RT}{P} = \frac{0.082 \times 373}{1} = 30.58 \text{ L}$
6. (c)
 $\frac{PV}{nRT} = Z > 1 \Rightarrow$ repulsive forces are dominant which are due to finite size of atom.
7. (a)
Average K.E., $E = \frac{1}{2} M U_{rms}^2$
$$\therefore U_{rms}^2 = \frac{2E}{M} \text{ or } U_{rms} = \sqrt{\frac{2E}{M}}$$
8. (b)
$$\frac{r_{\text{He}}}{r_{\text{CH}_4}} = \sqrt{\frac{M_{\text{CH}_4}}{M_{\text{He}}}} = \sqrt{\frac{16}{4}} = 2$$
9. (b)
The gas equation, $PV = nRT$, is followed by ideal gases, however no gas is ideal or perfect, so the behaviour of real gases is governed by the van der Waals gas equation.
The pressure correction term $\frac{n^2 a}{V^2}$ corresponds to the attractive forces among the molecules (in the van der Waals equation).
$$\therefore \text{The equation is } \left(P + \frac{n^2 a}{V^2} \right) (V - nb) = nRT$$

10. (c)
Van der Waals' equation is

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

$$PV + \frac{a}{V} = RT \text{ or } PV = RT - \frac{a}{V}$$
 Comparing with $y = mx + c$
 Intercept (c) = RT , slope (m) = $-a$

$$\text{Slope} = \frac{y_2 - y_1}{x_2 - x_1} = \frac{20.1 - 21.6}{3 - 2} = -1.5$$
 Thus, $a = +1.5$
11. (b)
Graph shows symmetrical distribution of speed therefore, the most probable and the average speed should be same. In square of speeds higher speed will give more contribution, therefore the root mean square speed must be greater than the average speed.
12. (d)
Given,

For idea gas X	For ideal gas Y
$m_1 = 10 \text{ g}$	$m_2 = 80 \text{ g}$
$T_1 = 300 \text{ K}$	$T_2 = 300 \text{ K}$
$p_1 = 2 \text{ atm}$	$p_2 = 6 \text{ atm}$

$$\frac{V_{\text{rms}}(X)}{V_{\text{rms}}(Y)} = ?$$
 Substitute the given values in ideal gas equation,
 $pV = nRT$
 (where, symbols have their usual meaning)
 For gas X,

$$2 \times V = \frac{10}{M_X} \times RT \quad \dots(i)$$

$$\left(\because n = \frac{\text{mass}}{\text{molar mass}} \right)$$

$$4 \times V = \frac{80}{M_Y} \times RT \quad \dots(ii)$$
 Divide Eq. (ii) by Eq. (i)

$$2 = \frac{80 \times M_X}{M_Y \times 10} \Rightarrow \frac{M_X}{M_Y} = \frac{1}{4}$$
 Now, we know that, $V_{\text{rms}} = \sqrt{\frac{3RT}{M}}$
 So,
$$\frac{V_{\text{rms}}(X)}{V_{\text{rms}}(Y)} = \sqrt{\frac{M_Y}{M_X}} \Rightarrow \sqrt{\frac{4}{1}} = \frac{2}{1}$$
 Thus,
$$\frac{V_{\text{rms}}(X)}{V_{\text{rms}}(Y)} = \frac{2}{1}$$

Objective Questions II (One or more than one correct option)

1. (b)

From the graph it is clear that the value of Z decreases with increase of pressure. We can explain it as follows:

At high pressure, when P is large, V will be small and one cannot ignore b in comparison to V_m .

However, the term $\frac{a}{V_m^2}$ may be considered negligible in comparison to P in van der Waals equation.

$$\left(P + \frac{a}{V_m^2}\right)(V_m - b) = RT, P(V_m - b) = RT \text{ or, } Z = 1 + \frac{Pb}{RT}$$

Here Z is greater than 1 and it increases linearly with pressure.

Hence statement (b) is false.

2. (a, c)

van der Waals' equation is given as

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

and van der Waals coefficient a and b are independent of temperature.

3. (a, c, d)

4. (c)

$$P(V - b) = RT \Rightarrow PV - Pb = RT$$

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

Hence $Z > 1$ at all pressures.

This means, repulsive tendencies will be dominant when interatomic distances are small.

This means, interatomic potential is never negative but becomes positive at small interatomic distances.

5. (a, b, c)

According to kinetic theory of gases, all gases at a given temperature have same average kinetic energy.

$$E_{av} = \frac{3}{2} RT; E_{av} \propto T \text{ (absolute temp)}$$

Root mean square velocity is directly proportional to square root of absolute temperature and inversely proportional to square root of molecular weight of the gas.

$$U_{rms} \propto \sqrt{T} \text{ (absolute temp.) } U_{rms} \propto \frac{1}{\sqrt{M}}$$

Assertion and Reason

1. (a)

a refers to the magnitude of attractive forces among the gas molecules which increases in ammonia because of H-bonding.

Match the columns

1. (A) $\rightarrow$ P, S ; (B) $\rightarrow$ R ; (C) $\rightarrow$ P, Q ; (D) $\rightarrow$ R

(A) For H_2 gas, the value of a is negligible.

$$\therefore P(V - nb) = nRT \text{ or } \frac{PV}{nRT} = Z = 1 + \frac{Pb}{RT}$$

Therefore compressibility factor of H_2 is always greater than 1.

(B) At extremely low pressure, real gas (H_2) behaves almost ideally, hence for H_2 gas at 0 atm, $PV = nRT$.

(C) CO_2 at room temperature, and van der Waals' force of attraction dominates.

Since P is 1 atm, Z will be less than 1.

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

If V is very high, $PV = nRT$

Fill in the Blanks

1. (1:16)

$$\begin{aligned} \frac{K.E_{O_2}}{K.E_{H_2}} &= \frac{\frac{3}{2}n_{O_2}.RT}{\frac{3}{2}n_{H_2}.RT} = \frac{n_{O_2}}{n_{H_2}} \\ &= \frac{8/32}{8/2} = \frac{1}{16} \text{ or } 1 : 16 \end{aligned}$$

2. (Less)

Average kinetic energy

$$K.E. = \frac{3}{2}RT \text{ or } E > T$$

True/ False

1. **False**

$$K.E. = \frac{3}{2}RT, 0^\circ C = 0 + 273 \text{ or } 273 \text{ K and at this temperature, } K.E. = \frac{3}{2} \times R \times 273$$

2. **False**

The gas pressure is due to collision of gaseous molecules on the walls of the container.

3. **False**

In van der Waals equation ' a ' refers to the intermolecular force of attraction between the gaseous molecules.

Comprehension

1. (d)

As the collision frequency increases, molecular speed decreases.

2. (c)

According to Graham's law, $r \propto \frac{1}{\sqrt{M}}$

As all conditions are identical for X and Y,

$$\frac{r_X}{r_Y} = \sqrt{\frac{M_Y}{M_X}} \Rightarrow \frac{d}{24-d} = \sqrt{\frac{40}{10}} = 2$$

$$d = 48 - 2d \Rightarrow 3d = 48 \text{ or } d = 16 \text{ cm}$$

Integer Answer Type Questions

1. (4)

$$v_{rms} \text{ of } X = \sqrt{\frac{3RT_x}{M_x}}; v_{mp} \text{ of } Y = \sqrt{\frac{2RT_y}{M_y}}$$

$$\text{Given } v_{rms} = v_{mp} \Rightarrow \sqrt{\frac{3RT_x}{M_x}} = \sqrt{\frac{2RT_y}{M_y}}$$

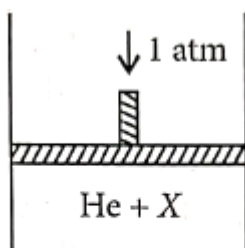
$$\Rightarrow M_y = \frac{2RT_y M_x}{3RT_x} = \frac{2 \times 60 \times 40}{3 \times 400} = 4$$

2. (7)

For any ideal gas, $PV = nRT$

For He, $P = 1 - 0.68 = 0.32 \text{ atm}$

$$0.32 \times V = 0.1 \times 0.0821 \times 273 \Rightarrow V = 7 \text{ litre}$$



For He, $n = 0.1$, $P = 0.32 \text{ atm}$,

$$V = ?, T = 273 \text{ K}$$

(Unknown compound X will not follow ideal gas equation)

3. (4)

Diffusion coefficient $\propto \lambda \mu$

Since $\lambda \propto \frac{T}{P}$ and $\mu \propto \sqrt{T}$

$$\text{Thus } \frac{D_i}{D_f} = \frac{\frac{T\sqrt{T}}{P}}{\frac{4T\sqrt{4T}}{2P}} = \frac{1}{(4 \times 2)/2} = \frac{1}{4} \text{ or } \frac{D_f}{D_i} = \frac{4}{1}$$

4. (2.22)

$$P_A = 5 \text{ bar}$$

$$P_B = 1 \text{ bar}$$

$$V_A = 1 \text{ m}^3$$

$$V_B = 3 \text{ m}^3$$

$$T_A = 400 \text{ K}$$

$$T_B = 300 \text{ K}$$

$$\Rightarrow n_A = \frac{P_A V_A}{RT_A} \text{ and } n_B = \frac{P_B V_B}{RT_B}$$

$$n_A = \frac{5}{400R} \text{ and } n_B = \frac{3}{300R} \Rightarrow x = \frac{11}{9}$$

$$V_A = 1 + x = 1 + \frac{11}{9} = \left(\frac{20}{9}\right) = 2.22$$

5. (100)

Given, compressibility factor (Z) = 0.5

Molar volume (V_m) = $0.4 \text{ dm}^3 \text{ mol}^{-1}$

Temperature (T) = 800 K

Pressure (p) = x atm

Gas constant (R) = 8×10^{-2}

We know that,

$$Z = \frac{pV_m}{RT}$$

$$0.5 = \frac{x \times 0.4}{0.08 \times 800} \Rightarrow x = 80$$

For ideal condition, $Z = 1$ and molar volume will be $y \text{ dm}^3 \text{ mol}^{-1}$.

$$\text{Using } Z = \frac{pV_m}{RT} \Rightarrow 1 = \frac{80 \times y}{0.08 \times 800}$$

$$y = 0.8$$

$$\text{Now, } \frac{x}{y} = \frac{80}{0.8} = 100$$

Subjective Questions:

1. In the evacuated bulb we have a mixture of oxygen and another gas in 1 : 1 ratio and the total pressure due to both is 4000 mm.

Since they are in equal molar ratio, so the pressure of each gas is 2000 mm.

Change in pressure

$$= (2000 - 1500) \text{ mm of mercury} = 500 \text{ mm of mercury}$$

After 74 minutes, pressure of oxygen

$$= 2000 - \frac{500 \times 74}{47} = (2000 - 787.2) \text{ mm} = 1212.8 \text{ mm}$$

Since, the rate of diffusion of gas is inversely proportional to the square root of the molar mass of the gas, therefore

$$\frac{\text{Rate of diffusion of unknown gas}}{\text{Rate of diffusion of } \text{O}_2} = \sqrt{\frac{32}{79}}$$

$$\text{Now, at constant } T, \frac{r_1}{r_2} = \sqrt{\frac{M_2}{M_1}} \times \frac{P_1}{P_2}$$

$\therefore$ Pressure drop of the other gas will be

$$= \sqrt{\frac{(787.2)^2 \times 32}{79}} = 501.01 \text{ mm}$$

Thus, pressure of the other gas

$$= (2000 - 501.01) \text{ mm} = 1498.99 \text{ mm}$$

$$\text{Hence molar ratio } \frac{1498.99}{1212.8} = 1.236$$

i.e. the ratio is 1.236 : 1

2. Total number of moles of gases mixture, $n = \frac{PV}{RT}$

$$= \frac{6 \times 3}{0.082 \times 300} = 0.7308 \text{ mol}$$

Number of moles of unknown gas in the mixture
 $= (0.7308 - 0.7) \text{ mol} = 0.0308 \text{ mol}$

Since $\frac{r_1}{r_2} = \sqrt{\frac{M_2}{M_1}}$

or $\sqrt{M_2} = \frac{r_1}{r_2} \times \sqrt{M_1}$ or $M_2 = \left(\frac{r_1}{r_2}\right)^2 \times M_1$

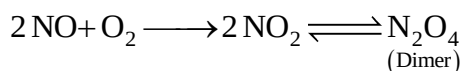
Also $\frac{r_1}{r_2} = \frac{\text{Amount of hydrogen gas}}{\text{Amount of unknown gas}} = \frac{0.7}{0.0308}$

$\therefore M_2 = \left(\frac{0.7}{0.03}\right)^2 \times 2$ [$\because$ Mol. Wt. of $\text{H}_2 = 2$]

Or $M_2 = 1033$

$\therefore$ Molecular weight of unknown gas = 1033

3.



Now, $PV = nRT$ or $n = \frac{PV}{RT}$

Moles of NO in the larger flask

$$= \frac{1.053 \times 0.25}{0.082 \times 300} = 0.0107 \text{ moles}$$

Mole of O_2 in the smaller flask

$$= \frac{0.789 \times 0.1}{0.082 \times 300} = 0.0032 \text{ moles}$$

Therefore, moles of NO reacting completely with 0.0032 moles of $\text{O}_2 = 2 \times 0.0032 = 0.0064$ moles

Hence, moles of NO left unreacted

$$= 0.0107 - 0.0064 = 0.0043 \text{ moles}$$

Oxygen will be completely converted into NO_2 and NO_2 will then be completely converted into N_2O_4 (dimer) which becomes solid at 262 K; hence at 220 K, N_2O_4 is in solid state and only NO is present in gaseous state. Thus the whole volume ($250 + 100 = 350$ ml) of 350 ml is occupied by NO that has been left unreacted.

Therefore the pressure, P of NO gas $= \frac{nRT}{V}$

$$= \frac{0.0043 \times 0.082 \times 220}{0.350} = 0.221 \text{ atm}$$

4.

$$U_{rms} = \sqrt{\frac{3P}{d}}$$

Here, $P = 7.57 \times 10^3 \text{ Nm}^{-2} = 7.57 \times 10^3 \text{ kg m}^{-1} \text{ s}^{-2}$

Density of gas,

$$d = \frac{\text{Mass of } 2 \times 10^{21} \text{ molecules of } \text{N}_2}{\text{Volume of } 2 \times 10^{21} \text{ molecules of } \text{N}_2}$$

Mass of 2×10^{21} molecules of N_2

$$= \frac{28 \times 2 \times 10^{21}}{6.023 \times 10^{23}} = \frac{56}{602.3} = 0.093 \text{ g}$$

$$\therefore \text{Density} = \frac{0.093 \times 10^{-3}}{10^{-3}} = 0.093 \text{ kg/m}^3$$

Substituting these values of P and d , we get

$$U_{rms} = \sqrt{\frac{3 \times 7.57 \times 10^3}{0.093}} \text{ ms}^{-1} = 494.16 \text{ ms}^{-1}$$

Now, $PV = nRT$

$$\text{Here } n = \frac{2.0 \times 10^{21}}{6.023 \times 10^{23}} = 3.32 \times 10^{-3} \text{ mol}$$

$$V = 1 \text{ L} = 10^{-3} \text{ m}^3$$

$$\therefore T = \frac{PV}{nR} = \frac{7.57 \times 10^3 \times 10^{-3}}{3.32 \times 10^{-3} \times 8.34} \text{ K} = 273.39 \text{ K}$$

Since most probable velocity $= 0.82 \times U_{rms}$

$$\therefore \text{Most probable velocity} = 0.82 \times 494.16 \text{ ms}^{-1} = 405.2 \text{ ms}^{-1}$$

5.

Molar ratio of He : $CH_4 = 4 : 1$

$$\therefore \text{Mole fraction of He} = \frac{4}{5} \text{ or } 0.80$$

$$\text{Mole fraction of } CH_4 = \frac{1}{5} \text{ or } 0.20$$

Total pressure of gaseous mixture = 20 bar

Partial pressure of He

$$= \text{Total pressure} \times \text{Mole fraction of He}$$

$$= (20 \times 0.80) \text{ bar} = 16 \text{ bar}$$

Partial pressure of $CH_4 = (20 \times 0.20) \text{ bar} = 4 \text{ bar}$

According to Graham's law of diffusion as applicable to effusion,

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

$$\text{or } \frac{n_1}{n_2} = \sqrt{\frac{M_2}{M_1}} \times \frac{P_2}{P_1} \quad [\text{when } t_1 = t_2]$$

$$\therefore \frac{n_{He}}{n_{CH_4}} = \sqrt{\frac{M_{CH_4}}{M_{He}}} \times \frac{P_{He}}{P_{CH_4}} = \sqrt{\frac{16}{4}} \times \frac{16}{4} = 8 \text{ or } \frac{8}{1}$$

$$\therefore \text{Molar ratio of mixture (composition of the mixture) effusing out initially (He : } CH_4) = 8 : 1$$

6.

Weight of cylinder with gas = 29.0 kg

Weight of empty cylinder = 14.8 kg

Weight of gas in the cylinder = $(29.0 - 14.8) \text{ kg} = 14.2 \text{ kg}$

Pressure in cylinder = 2.5 atm

Number of moles (n) in 14.2 kg ($14.2 \times 10^3 \text{ g}$) of butane

$$= \frac{\text{Weight of butane}}{\text{Molecular wt. of butane}}$$

$$\text{or } n = \frac{14.2 \times 10^3}{58} = 244.83 \text{ mol}$$

Using the gas equation, $PV = nRT$

$$\begin{aligned} \text{We have, } V &= \frac{nRT}{P} \\ &= \frac{244.83 \times 0.082 \times 300}{2.5} = 2409.13 \text{ L} \end{aligned}$$

To calculate final pressure inside the cylinder :

Mass of LPG before use *i.e.* initially = 14.2 kg

Mass of LPG left in the cylinder = $(14.2 - 5.8) \text{ kg} = 8.4 \text{ kg}$

Using gas equation, $PV = nRT$

$$P = \frac{8.4 \times 10^3 \times 0.082 \times 300}{58 \times 2409.13} = 1.48 \text{ atm}$$

To calculate volume of used gas :

Mass of gas used = 5.8 kg or 5800 g

$$\text{Number of moles of butane used} = \frac{5800}{58} \text{ or } 100 \text{ mol}$$

Normal pressure = 1 atm

Normal temperature = $27 + 273 = 300 \text{ K}$

Applying gas equation, $PV = nRT$

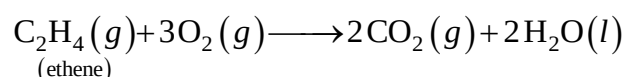
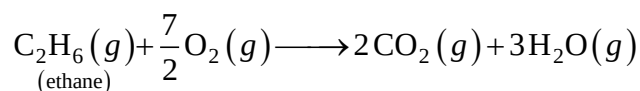
We have $V = 2460 \text{ L}$ or 2.460 m^3

7.

Let the volume of ethane in mixture = $x \text{ L}$

Then volume of ethane in mixture = $(40 - x) \text{ L}$

The combustion reactions are as follows :



Form these equations of combustion, we find volume of O_2 required for combustion of ethane = $\frac{7x}{2}$

and volume of O_2 required for combustion of ethane

$$= (40 - x) \times 3$$

$\therefore$ Total volume of O_2 required for combustion

$$= \frac{7x}{2} + (40 - x) \times 3 = \frac{7x}{2} - 3x + 12 = \frac{x}{2} + 120$$

Total calculate the number of moles of O_2 :

$$P = 1 \text{ atm}, V = \frac{x}{2} + 120, T = 400 \text{ K}, R = 0.082$$

$$\therefore n = \frac{PV}{RT} = \frac{1 \times \left(\frac{x}{2} + 120 \right)}{0.082 \times 400} \text{ or } n = \frac{x + 240}{2 \times 0.082 \times 400} \times 32$$

$$\text{or mass of } n \text{ moles of } \text{O}_2 = \frac{x + 240}{2 \times 0.082 \times 400} \times 32$$

$$\therefore 130 = \frac{(x + 240) \times 32}{2 \times 0.082 \times 400} \text{ or } 130 = \frac{32x + 7680}{2 \times 0.082 \times 400}$$

$$\text{or } 130 \times 2 \times 0.082 \times 400 = 32x + 7680$$

$$\text{or } 32x = (130 \times 2 \times 0.082 \times 400) - 7680$$

$$\text{or } x = \frac{(130 \times 2 \times 0.082 \times 400) - 7680}{32}$$

$$= \frac{8528 - 7680}{32} \text{ or } \frac{848}{32} = 26.5$$

Hence mole fraction (%) of ethane = $\frac{26.5}{40} \times 100$ or 66.25 and

mole fraction (%) of ethane = $100 - 66.25 = 33.75$

8.

Graham's law of diffusion is applicable to effusion,

So we have

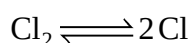
$$\frac{r_{\text{mix}}}{r_{\text{Kr}}} = \sqrt{\frac{M_{\text{Kr}}}{m_{\text{mix}}}}$$

$$\text{or } 1.16 = \sqrt{\frac{84}{M_{\text{mix}}}} \text{ or } 1.16 \times 1.16 = \frac{84}{M_{\text{mix}}}$$

$$\text{or } M_{\text{mix}} = \frac{84}{1.16 \times 1.16} \text{ or } 62.43 \text{ amu}$$

Determination of composition of mixture at equilibrium:

Let the fraction of Cl_2 molecules dissociated at equilibrium = x



Initial 1.0 0

Equi. $(1-x)$ $2x$

Total number of moles = $(1 + 2x - x) = 1 + x$

$$\therefore M_{\text{mix}} = \frac{2x + M_{\text{Cl}} + (1-x)M_{\text{Cl}_2}}{(1+x)}$$

$$\text{or } 62.43 = \frac{2x \times 35.5 + (1-x)71}{1+x} = \frac{71x + 71 - 71x}{1+x} = \frac{71}{1+x}$$

$$\text{or } (62.43)(1+x) = 71$$

$$\text{or } 1+x = \frac{71}{62.43} = 1.137 \text{ or } x = 0.137$$

9.

From the given data, we have,

Weight of the liquid = $(148 - 50\text{g}) = 98 \text{ g}$

Volume of the liquid = $\frac{98}{0.98} = 100 \text{ mL} = \text{Volume of vessel}$

$\therefore$ The vessel of 100 mL contains ideal gas at 760 mm of Hg and 300 K.

Now weight of the gas = $(50.5 - 50) = 0.5 \text{ g}$

Using ideal gas equation, $PV = nRT$, we get

$$\frac{760}{760} \times \frac{100}{1000} = \frac{0.5}{M} \times 0.082 \times 300$$

or M (Molecular weight of gas)

$$= \frac{0.5 \times 0.082 \times 300 \times 10}{1} = 123.0$$

10.

From the given data, we have

$$n = 2 \text{ mol}; V = 4 \text{ L} \quad P = 11.0 \text{ atm}$$

$$b = 0.05 \text{ L mol}^{-1} \quad T = 300 \text{ K}; R = 0.082 \text{ L atm K}^{-1} \text{ mol}^{-1}$$

Using van der Waals equation,

$$\left(P + \frac{n^2 a}{V^2}\right)(V - nb) = nRT \quad (\text{For } n \text{ moles})$$

We get

$$\left(11 + \frac{a \times 4}{16}\right)(4 - 2 \times 0.05) = 2 \times 0.082 \times 300 \quad \text{or} \quad \left(\frac{176 + 4a}{16}\right)(3.9) = 49.2$$

$$\text{or } 4a = \frac{49.2 \times 16}{3.9} - 176 = 201.85 - 176 = 25.85$$

$$\therefore a = \frac{25.85}{4} \quad \text{or } 6.46 \text{ atm L}^2 \text{ mol}^{-2}$$

11.

$$\text{We know, } \frac{r_1}{r_2} = \frac{P_1}{P_2} \times \sqrt{\frac{M_2}{M_1}}$$

$$\text{or } \frac{n_1}{t_1} \times \frac{t_2}{n_2} = \frac{P_1}{P_2} \times \sqrt{\frac{M_2}{M_1}} \quad \text{or } \frac{1}{38} \times \frac{57}{1} = \frac{0.8}{1.6} \times \sqrt{\frac{M_2}{28}}$$

$$\text{or } M_2 = \frac{57 \times 57}{38 \times 38} \times \frac{1.6 \times 1.6}{0.8 \times 0.8} \times 28 = 252$$

Thus we have $\text{XeF}_n = 252$

$$\text{or } 131 + 19n = 252 \quad \text{or } 19n = 252 - 131$$

$$\text{or } 19n = 121 \quad \text{or } n = 6.3 \text{ i.e. } \approx 6$$

12.

$$\text{Number of moles of gas} = \frac{12}{120} = 0.1 \text{ mol}$$

$$P = 1 \text{ atm}; T = (t + 273) \text{ K};$$

Using gas equation, $PV = nRT$, we get

$$1 \times V = 0.1 \times R \times (273 + t) \quad \dots(i)$$

Under new condition

$$1.1V = 0.1 \times R \times (273 + 10 + t)$$

$$\text{or } 1.1V = 0.1 \times R \times (283 + t) \quad \dots(ii)$$

Divided (ii) by (i), we get

$$\frac{1.1V}{1V} = \frac{0.1 \times R \times (283 + t)}{0.1 \times R \times (273 + t)} \quad \text{or } 1.1 = \frac{283 + t}{273 + t}$$

$$1.1t + 1.1 \times 273 = t + 283$$

$$\text{or } 0.1t = 283 - 300.3 \quad \text{or } 0.1t = -17.3$$

$$\text{or } t = -\frac{17.3}{0.1} \quad \text{or } 173^\circ\text{C} \quad \text{or } (-173 + 273)$$

Substituting this value of t in the equation (i),

$$1 \times V = 0.1 \times 0.082 \times (273 - 173)$$

$$\text{or } V = 0.1 \times 0.082 \times 100 = 0.821 \text{ L}$$

13.

For one mole of real gas, we have

$$\left(P + \frac{a}{V^2}\right)(V - b) = RT \quad [\text{Van der Waals Eqn.}]$$

Since the volume occupied by CO_2 molecules is negligible

So $b = 0$, hence the above equation can be written as

$$\left(P + \frac{a}{V^2}\right)V = RT \quad \text{or} \quad P = \frac{RT}{V} - \frac{a}{V^2} \Rightarrow PV^2 - RTV + a = 0$$

$$(RT)^2 = 4aP$$

$$P = \frac{(RT)^2}{4a} = \frac{(22.4)^2}{4 \times 3.592} = 34.92$$

14.

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

Since the actual volume of gas molecules is negligible so we can write

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

The compressibility factor,

$$Z = \frac{PV}{RT} \quad \text{or} \quad V = \frac{Z \cdot RT}{P}$$

Substituting the value of V in (i), we get

$$\left[P + \frac{a \times P^2}{Z^2 R^2 T^2}\right] \left[\frac{ZRT}{P}\right] = RT$$

$$\text{or} \quad Z \left[1 + \frac{aP}{Z^2 R^2 T^2}\right] = 1$$

Now from given data, we have

$$T = 0 + 273 = 273\text{K}; P = 100 \text{ atm}; Z = 0.5$$

Substituting these values, we get

$$0.5 \left[1 + \frac{a \times 100}{(0.5)^2 (0.082)^2 (273)^2}\right] = 1$$

$$\text{or} \quad \frac{a \times 100}{0.5 \times 0.082 \times 0.082 \times 273 \times 273}$$

$$\text{or} \quad a = \frac{0.5 \times 0.5 \times 0.082 \times 0.082 \times 273 \times 273}{100} \\ = 1.253 \text{ atm L}^2 \text{ mol}^{-2}$$

15.

$$(a) \quad d = 0.36 \text{ kg m}^{-3} = 0.36 \text{ g/L}$$

(i) From Graham's law of diffusion

$$\frac{r_v}{r_{\text{O}_2}} = \sqrt{\frac{M_{\text{O}_2}}{m_v}} \quad \text{or} \quad 1.33 = \sqrt{\frac{32}{M_v}} \quad [\text{Where } M_v = \text{Mol. wt. of vapour}]$$

$$\text{or} \quad M_v = \frac{32}{1.33 \times 1.33} = 18.09$$

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

Since, $\frac{0.36}{18.09}$ mol occupies volume = 1 L

$\therefore$ Volume occupied by 1 mol = $\frac{18.09}{0.36}$ L or 50.25 L

So the molar volume of vapour = 50.25 L

(iii) If we assume ideal behaviour of vapour, we have

$$\frac{V_1}{T_1} = \frac{V_2}{T_2} \text{ or } V_2 = 22.4 \times \frac{5000}{273} = 41.025 \text{ L}$$

$$\text{Compressibility factor (Z)} = \frac{(PV)_{\text{obs}}}{(PV)_{\text{ideal}}} = \frac{1 \times 50.25}{1 \times 41.025} = 1.225$$

(iv) Since $Z > 1$, hence repulsive force dominates.

(b) We know, $E = \frac{3}{2}KT = \frac{3}{2} \frac{R}{N} T$

$$= \frac{3}{2} \times \frac{8.31}{6.023 \times 10^{23}} \times 1000 = 2.07 \times 10^{-20} \text{ J per molecules.}$$

16.

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

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

17.

For real gases, van der Waal's equation for one mole is

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

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

For intercept of PV_m vs P graph at y -axis, $P = 0$ and thus, $V_m \rightarrow \infty$.

Thus neglecting $\frac{a}{V_m}$ and $\frac{ab}{V_m^2}$ terms in equation (i)

$$\text{or } PV_m = Pb + RT \quad \dots(ii)$$

Thus, a graph between PV_m vs. P will lead to an intercept RT as equation (ii) represents a straight line equation ($y = mx + c$).