# 2. DALTONS LAW AND GRAHAMS LAW

## SOLUTIONS

## TEACHING TASK

## JEE MAINS LEVEL QUESTIONS

**Grahams Law Of Diffusion**

1. Under the same conditions the rates of diffusion of two gases are in the ratio 1 : 4. The ratio of their vapour densities is

1) 2 : 1 2) 1 : 2 3) 16 : 1 4) 1 : 16

**Answer:3**

Solution:According to Graham's Law of Diffusion, the rate of diffusion (r) of a gas is inversely proportional to the square root of its vapour density (D) or molar mass (M): $\frac{r_1}{r_2} = \sqrt{\frac{D_2}{D_1}} = \sqrt{\frac{M_2}{M_1}}$

Given: $\frac{r_1}{r_2} = \frac{1}{4}$

Let's find the ratio of vapour densities (D): $\frac{1}{4} = \sqrt{\frac{D_2}{D_1}}$

Square both sides:

$$\frac{1}{4}^2 = \frac{D_2}{D_1}$$

$$\frac{1}{16} = \frac{D_2}{D_1}$$

$$\frac{D_1}{D_2} = \frac{16}{1}$$

2. Hydrogen diffuses six times faster than a gas 'X'. The molecular weight of 'X' is

1) 36 2) 72 3) 28 4) 48

**Answer:2**

Solution: $\frac{r_{H_2}}{r_X} = \sqrt{\frac{M_X}{M_{H_2}}}$

Given: $r_{H_2} = 6.r_X \Rightarrow \frac{r_{H_2}}{r_X} = 6$

$M_{H_2} = 2g/mol$

Substitute into Graham's Law: $6 = \sqrt{\frac{M_X}{2}}$

Square both sides: $36 = \frac{M_X}{2}$

$M_X = 72$

3. Rate of diffusion of a gas is 720ml/minute. But the gas diffused for 20 seconds only. The volume of the gas diffused in ml is

1) 240 2) 120 3) 60 4) 30

**Answer: 1**



Solution:First, convert the rate to ml/second: $720ml/\min = \frac{720}{60} = 12ml/\sec$

Now, calculate the volume diffused in 20 seconds:

Volume=Rate×Time=12×20=240 ml

4. Assuming that at S.T.P. gas A has a density of 0.09gram per litre and gas B has a density of 1.43 gram per litre, the ratio between the rates of diffusion of A and B is

1) 1 :16 2) 16:1 3) 2 :1 4) 4 : 1

**Answer:4**

Solution:$D_A$= 0.09gram per litre,$D_B$=1.43 gram per litre

$$\frac{r_A}{r_B} = \sqrt{\frac{D_B}{D_A}}$$

$$\frac{r_A}{r_B} = \sqrt{\frac{1.43}{0.09}}$$

$$\frac{r_A}{r_B} = \sqrt{15.88} \approx 4$$

5. Through a narrow apparature 2 litres of $H_2$ diffuses in 2 hours under same conditions time required in hours for the diffusion of 1 litre of oxygen is

1) 1 2) 2 3) 3 4) 4

**Answer:4**

Solution:From Graham's Law, the time of diffusion (t) is directly proportional to the square root of the molar mass (M): $\frac{t_{O_2}}{t_{H_2}} = \sqrt{\frac{M_{O_2}}{M_{H_2}}}$

Given: $M_{H_2} = 2gms, M_{O_2} = 32gms$

$t_{H_2} = 2hours(for 2L) \Rightarrow Rate = \frac{2L}{2h} = 1L/h$

For 1 L of $O_2$:

$$\frac{t_{O_2}}{1} = \sqrt{\frac{32}{2}}$$
$$t_{O_2} = \sqrt{16} = 4hours$$

6. Two grams of $H_2$ diffuses in 10 minutes. The weight of $O_2$ that can diffuse from the same container in the same time under similar conditions is

1) 4 gm 2) 0.5gm 3) 6 gm 4) 8 gm

**Answer:2**

Solution:From Graham's Law of Diffusion, the rate of diffusion (r) is inversely proportional to the square root of the molar mass (M):

$$\frac{r_{H_2}}{r_{O_2}} = \sqrt{\frac{M_{O_2}}{M_{H_2}}}$$

Given:

$$M_{H_2} = 2gms, M_{O_2} = 32gms$$
$$\frac{r_{H_2}}{r_{O_2}} = \sqrt{\frac{32}{2}} = 4$$

This means $H_2$ diffuses 4 times faster than $O_2$.

Now, if 2 g of $H_2$ diffuses in 10 minutes, then the amount of $O_2$ diffusing in the same time is:

$$Amount of O_2 = \frac{Amount of H_2}{Rate ratio} = \frac{2}{4} = 0.5g$$

7. One litre of methane takes 20 minutes to diffuse out of a vessel. How long will it take to diffuse one litre of $SO_2$ through the vessel under the same conditions of temperature and pressure.

1) 40 min. 2) 24 min 3) 20min 4) 10min

**Answer:1**

Solution:From Graham's Law, the time of diffusion (t) is directly proportional to the square root of the molar mass (M): $\frac{t_{SO_2}}{t_{CH_4}} = \sqrt{\frac{M_{SO_2}}{M_{CH_4}}}$

Given: $M_{CH_4} = 16g/mol, M_{SO_2} = 64g/mol, t_{CH_4} = 20\min$

$$\frac{t_{SO_2}}{20} = \sqrt{\frac{64}{16}} \Rightarrow \frac{t_{SO_2}}{20} = \sqrt{4} \Rightarrow \frac{t_{SO_2}}{20} = 2 \Rightarrow t_{SO_2} = 40\min$$

8. The density of gas "A" is four times that of another gas "B". If the molecular weight of A is M, the molecular weight of B will be

1) 2M 2) 4M 3) $\frac{M}{4}$ 4) $\frac{M}{2}$

**Answer:3**

Solution: $D_A=4D, D_B=D, M_A=M, M_B=?$

$$\sqrt{\frac{M_A}{M_B}} = \sqrt{\frac{D_A}{D_B}}$$

$$\sqrt{\frac{M}{M_B}} = \sqrt{\frac{4D}{D}}$$

$$\sqrt{\frac{M}{M_B}} = \sqrt{4}$$

$$\frac{M}{M_B} = 4 \Rightarrow M_B = \frac{M}{4}$$

9. A vessel contains equal number of moles of Helium and Methane. Through a small orifice the half of gas effused out. The ratio of the number of mole of Helium and methane remaining in the vessel is

1) 2 : 1 2) 1 : 2 3) 1 : 4 4) 4 : 1

**Answer:2**

Solution:From Graham's Law, the effusion rate (r) is inversely proportional to the square root of the molar mass (M): $\frac{r_{He}}{r_{CH_4}} = \sqrt{\frac{M_{CH_4}}{M_{He}}} = \sqrt{\frac{16}{4}} = 2$

This means Helium effuses twice as fast as Methane.

Let the initial moles of each gas be 1 mol.

Total gas = 2 mol.

Half effuses out = 1 mol.

Since He effuses twice as fast as CH4, the ratio of effused moles is 2:1.

Thus:He effused: $\frac{2}{3} \times 1 = \frac{2}{3}$

$CH_4$ effused: $\frac{1}{3} \times 1 = \frac{1}{3}$

Remaining moles:He: $1 - \frac{2}{3} = \frac{1}{3}$

$CH_4$: $1 - \frac{1}{3} = \frac{2}{3}$

Thus, the ratio is 1 : 2.

10. A uniform glass tube of 100cm length is connected to a bulb containing Hydrogen at one end and another bulb containing Oxygen at the other end at the same temperature and pressure. The two gases meet for the first time at the following distance from the oxygen end.

1) 80cm 2) 50cm 3) 20cm 4) 6.66cm

**Answer:3**

Soluton:This problem involves diffusion of gases in a tube. Since the tube is uniform and the gases are at the same temperature and pressure, they will diffuse towards each other at rates governed by Graham's Law of Diffusion.

Step 1: Understand Graham's Law

Graham's Law states that the rate of diffusion (r) of a gas is inversely proportional to the square root of its molar mass (M): $\frac{r_{H_2}}{r_{O_2}} = \sqrt{\frac{M_{O_2}}{M_{H_2}}}$

$$M_{H_2} = 2gms, M_{O_2} = 32gms$$

$$\frac{r_{H_2}}{r_{O_2}} = \sqrt{\frac{32}{2}} = 4$$

This means Hydrogen diffuses 4 times faster than Oxygen.

Step 3: Relate Diffusion Rates to Distances Covered

Let:x = distance covered by Oxygen ($O_2$) from its end before meeting Hydrogen.

100-x = distance covered by Hydrogen ($H_2$) from its end before meeting Oxygen.

Since time taken to meet is the same for both gases, and distance = rate × time, we have:

$$\frac{100-x}{x} = \frac{r_{H_2}}{r_{O_2}} = 4$$

$$100 - x = 4x \Rightarrow 100 = 5x \Rightarrow x = 100/5 = 20cm$$

Oxygen travels 20 cm from its end before meeting Hydrogen.

Hydrogen travels 80 cm from its end before meeting Oxygen.

11. One litre of a gaseous mixture of two gases effuses in 311 seconds while 2 litres of oxygen takes 20 minutes. The vapour density of gaseous mixture containing $CH_4$ and $H_2$ is

(A) 4 (B) 4.3 (C) 3.4 (D) 5

**Answer:B**

Solution: Given Data

Volume of mixture effused = 1 L, Time taken = 311 s

Volume of $O_2$ effused = 2 L, Time taken = 20 min = 1200 s

The rate of effusion (r) is given by: $r = \frac{volume effused}{time taken}$

Rate of mixture: $r_{mix} = \frac{1L}{311s}$

Rate of $O_2$: $r_{O_2} = \frac{2L}{1200s} = \frac{1L}{600s}$

Graham's Law states: $\frac{r_{mix}}{r_{O_2}} = \sqrt{\frac{M_{O_2}}{M_{mix}}}$

$$\frac{\frac{1}{311}}{\frac{1}{600}} = \sqrt{\frac{32}{M_{mix}}}$$

$$\frac{600^2}{311} = \frac{32}{M_{mix}}$$

$$M_{mix} = 32 \times (\frac{311}{600})^2 \approx 8.58$$

Relate Molar Mass to Vapour Density

Vapour Density (VD)= $\frac{M_{mix}}{2} = \frac{8.58}{2} \approx 4.3$

12. Pure $O_2$ diffuses through an aperture in 224 second, whereas mixture of $O_2$ and another gas containing 80% $O_2$ diffuses from the same in 234 second. The molecular mass of gas will be

(A) 51.5 (B) 48.6 (C) 55 (D) 46.6

**Answer:D**

Solution:Time for pure $O_2$ =224sec

Time for mixture ($t_{mix}$) = 234 s

Mixture composition: 80% $O_2$, 20% unknown gas (X)

The average molar mass ($M_{mix}$) of the mixture is:

$$M_{mix} = 0.8 \times M_{O_2} + 0.2 \times M_X$$

$$M_{mix} = 0.8 \times 32 + 0.2 \times M_X = 25.6 + 0.2 \times M_X$$

Graham's Law relates time and molar mass: $\frac{t_{mix}}{t_{O_2}} = \sqrt{\frac{M_{mix}}{M_{O_2}}}$

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

$$\frac{234^2}{224}=\frac{M_{mix}}{32}$$

$$M_{mix}=32\times\frac{234^2}{224}\approx 34.91 g/mol$$

Solve for $M_X$:

$$34.91=25.6+0.2\times M_X$$
$$M_X=46.55 g/mol$$

13. A straight glass tube has 2 inlets X & Y at the two ends of 200 cm long tube. HCl gas through inlet X and $NH_3$ gas through inlet Y are allowed to enter in the tube at the same time and under the identical conditions. At a point P inside the tube both the gases meet first. The distance of point P from X is :

(A) 118.9 cm (B) 81.1 cm (C) 91.1 cm (D) 108.9 cm

**Answer:B**

Solution:Length of tube (L) = 200 cm

Gases: HCl enters from X, $NH_3$ enters from Y (opposite ends).

Objective: Find the distance from X where HCl and $NH_3$ meet for the first time.

Graham's Law states that the rate of diffusion (r) of a gas is inversely proportional to the square root of its molar mass (M): $\frac{r_{NH_3}}{r_{HCl}}=\sqrt{\frac{M_{HCl}}{M_{NH_3}}}=\sqrt{\frac{36.5}{17}}\approx\sqrt{2.147}\approx 1.465$

This means $NH_3$ diffuses ~1.465 times faster than HCl.

d = distance covered by HCl from X before meeting $NH_3$.

200-d = distance covered by $NH_3$ from Y before meeting HCl.

Since time taken to meet is the same, and distance = rate × time, we have:

$$\frac{200-d}{d}=\frac{r_{NH_3}}{r_{HCl}}=1.465$$
$$200-d=1.465d$$
$$d=\frac{200}{2.465}\approx 81.1cm$$

The distance of point P from X is 81.1 cm.

14. Two flasks of equal volume are connected by a narrow tube (of negligible volume) all at 27° C and contain 0.70 moles of $H_2$ at 0.5 atm. One of the flask is then immersed into a bath kept at 127° C , while the other remains at 27° C. The number of moles of $H_2$ in flask 1 and flask 2 are :

(A) Moles in flask 1 = 0.4, Moles in flask 2 = 0.3

(B) Moles in flask 1 = 0.2, Moles in flask 2 = 0.3

(C) Moles in flask 1 = 0.3, Moles in flask 2 = 0.2

(D) Moles in flask 1 = 0.4, Moles in flask 2 = 0.2

**Answer:A**

Solution:Step 1: Understand the Initial Conditions

Initial temperature ($T_1$) = 27°C = 300 K

Total moles of $H_2$ ($n_{total}$) = 0.70 moles

Pressure (P) = 0.5 atm (same in both flasks initially)

Volume of each flask = V (equal volumes)

Step 2: After Heating One Flask

Flask 1: Remains at $T_1$ = 300 K

Flask 2: Heated to $T_2$ = 127°C = 400 K

Since the flasks are connected, the pressure will equalize in both flasks at equilibrium.

Step 3: Let Final Moles be $n_1$ (Flask 1) and $n_2$ (Flask 2)

At equilibrium:n1+n2=0.70(Total moles conserved)

The pressure in both flasks is the same, so:$P_1$=$P_2$

Using the Ideal Gas Law (PV = nRT) for both flasks:

$$\frac{n_1RT_1}{V}=\frac{n_2RT_2}{V}$$

$$n_1T_1=n_2T_2$$

$$\frac{n_1}{n_2}=\frac{4}{3}$$

$$n_1=\frac{4}{3}n_2$$

$$\frac{4}{3}n_2 + n_2 = 0.70$$

Substitute into total moles:
$$n_2 = 0.30 moles$$
$$n_1 = \frac{4}{3} \times 0.30 = 0.40 moles$$

15. A teacher enters a classroom from front door while a student from back door. There are 13 equidistant rows of benches in the classroom. The teacher releases $N_2O$, the laughing gas, from the first bench while the student releases the weeping gas ($C_6H_{11}OBr$) from the last bench. At which row will the students starts laughing and weeping simultaneously

(A) 7 (B) 10 (C) 9 (D) 8

**Answer:C**

Solution:Step 1: Understand the Problem

Total rows = 13 (bench 1 is front, bench 13 is back).

$N_2O$ (laughing gas) starts diffusing from bench 1.

$C_6H_{11}OBr$ (weeping gas) starts diffusing from bench 13.

Objective: Find the row where both gases meet simultaneously.

Step 2: Apply Graham's Law of Diffusion

The rate of diffusion (r) is inversely proportional to the square root of molar mass

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

(M): $\frac{r_{N_2O}}{r_{C_6H_{11}OBr}} = \sqrt{\frac{M_{C_6H_{11}OBr}}{M_{N_2O}}} = \sqrt{\frac{179}{44}} \approx 2.02$

This means $N_2O$ diffuses ~2.02 times faster than $C_6H_{11}OBr$.

Step 4: Relate Distances Covered

Let:x = distance (rows) covered by N2O from bench 1.

13-x = distance (rows) covered by $C_6H_{11}OBr$ from bench 13.

Since time taken to meet is the same, and distance = rate × time, we have:

$$\frac{x}{13-x}=\frac{r_{N_2O}}{r_{C_6H_{11}OBr}}=2.02$$
$$x=2.02(13-x)$$
$$3.02x=26.26$$
$$x\approx 8.7$$

16. Two gases A and B having the same volume diffuse through a porous partition in 20 and 10s respectively. The molecular mass of A is 49 u. Molecular mass of B will be [AIPMT 2011]

(A) 12.25 u (B) 6.50 u (C) 25.00 u (D) 50.00 u

**Answer:A**

Solution:Step 1: Understand Graham's Law

The time of diffusion (t) is directly proportional to the square root of molar mass (M):



$$\frac{t_A}{t_B}=\sqrt{\frac{M_A}{M_B}}$$
$$t_A=20s, t_B=10s, M_A=49u$$
$$\frac{20}{10}=\sqrt{\frac{49}{M_B}}$$
$$M_B=\frac{49}{4}=12.25u$$

17. Equal moles of hydrogen and oxygen gases are placed in container with a pin-hole through which both can escape. What fraction of the oxygen escapes in the time required for one- half of the hydrogen to escape? [NEET 2016, Phase I]

(A) 1/4 (B) 3/8 ` (C) 1/2 (D) 1/8

**Answer:D**

Solution:The rate of effusion (r) is inversely proportional to the square root of molar mass (M):

$M_{H_2} = 2gms, M_{O_2} = 32gms$

$\frac{r_{H_2}}{r_{O_2}} = \sqrt{\frac{32}{2}} = 4$

This means H2 effuses 4 times faster than $O_2$.

Step 2: Relate Fractions Escaped

Let:Time taken for half of $H_2$ to escape = t.

Fraction of $O_2$ escaped in the same time = f.

Since effusion is proportional to rate:

$$\frac{f_{O_2}}{f_{H_2}} = \frac{r_{O_2}}{r_{H_2}} = \frac{1}{4}$$

$$f_{H_2} = \frac{1}{2}$$

$$f_{O_2} = \frac{1}{4} \times \frac{1}{2} = \frac{1}{8}$$

The fraction of oxygen escaped is 1/8.

**Daltons Law Of Partial Pressure**

18. Equal masses of so $_2$ and $O_2$ are kept in a vessel at $27^0$ C. The total pressure of the mixture is 2.1 atm. The partial pressure of $SO_2$ is

1) 1.4 atm    2) 7 atm    3) 0.7atm    4) 14 atm

**Answer:3**

Solution:Step 1: Understand the Given Data

Equal masses of $SO_2$ and $O_2$ are present.

Total pressure ($P_{total}$) = 2.1 atm

Temperature = 27°C = 300 K (not directly needed for partial pressure calculation).

Step 2: Calculate Moles of Each Gas

Let the mass of each gas be m grams.

Molar mass of $SO_2$ ($M_1$) = 64 g/mol

Molar mass of $O_2$ ($M_2$) = 32 g/mol

Number of moles: $n_{SO_2} = \frac{m}{64}, n_{O_2} = \frac{m}{32}$

Total moles: $n_{total} = \frac{m}{64} + \frac{m}{32} = \frac{3m}{64}$

Mole fraction of $SO_2$ : $X_{SO_2} = \frac{n_{SO_2}}{n_{total}} = \frac{\frac{m}{32}}{\frac{3m}{64}} = \frac{1}{3}$

Partial pressure is given by: $P_{SO_2} = X_{SO_2} \times P_{total} = \frac{1}{3} \times 2.1 = 0.7 atm$

19. A gas mixture contains Nitrogen and Helium in 7 : 4 ratio by weight. The pressure of the mixture is 760mm. The partial pressure of Nitrogen is

1) 0.2 atm 2) 0.8 atm 3) 0.5 atm 4) 0.4atm

**Answer: 1**

Solution:Step 1: Understand the Given Data

Weight ratio of $N_2$ : He = 7 : 4

Total pressure ($P_{total}$) = 760 mm = 1 atm

Step 2: Calculate Moles of Each Gas

Let the masses be:Mass of $N_2$ = 7 g, Mass of He = 4 g

Moles of each gas: $n_{N_2} = \frac{7}{28} = 0.25 ml, n_{He} = \frac{4}{4} = 1 ml$

$n_{total}$=0.25+1=1.25mol

Mole fraction of $N_2$: $X_{N_2} = \frac{0.25}{1.25} = 0.2$

Partial pressure is given by: $P_{N_2} = X_{N_2} \times P_{total} = 0.2 \times 1 = 0.2 atm$

20. A 200cc flask contains oxygen at 200mm pressure and a 300 cc flask contains Nitrogen at 100mm pressure. The two flasks are connected so that each gas occupies the combined volume. The total pressure of the mixture in mm is

1) 80 2) 60 3) 140 4) 300

**Answer:3**

Solution:Oxygen flask: 200 cc at 200 mm Hg

Nitrogen flask: 300 cc at 100 mm Hg

Combined volume after connection: 200 + 300 = 500 cc

Step 1: Calculate new partial pressures using Boyle's Law (P1V1 = P2V2)

For Oxygen:

P2 = (200 mm × 200 cc)/500 cc = 80 mm Hg

For Nitrogen:

P2 = (100 mm × 300 cc)/500 cc = 60 mm Hg

Step 2: Calculate total pressure

Total pressure = Partial pressure $O_2$ + Partial pressure $N_2$

= 80 mm + 60 mm = 140 mm Hg

21. In a ten litre vessel, the total pressure of a gaseous mixture containing $H_2$, $N_2$ and $CO_2$ is 9.8 atm. The partial pressures of $H_2$ and $N_2$ are 3.7 and 4.2 atm, respectively. The partial pressure of $CO_2$ is

1) 1.9 atm 2) 0.19 atm 3) 2.4 atm 4)0.019 atm

**Answer:1**

Solution:Given:Total pressure ($P_{total}$) = 9.8 atm

Partial pressure $H_2$ = 3.7 atm

Partial pressure $N_2$ = 4.2 atm

Step 1: Apply Dalton's Law of Partial Pressures

$P_{total} = P_{H2} + P_{N2} + P_{CO2}$

Step 2: Solve for $P_{CO2}$

9.8 atm = 3.7 atm + 4.2 atm + $P_{CO2}$

$P_{CO2}$ = 9.8 - (3.7 + 4.2) = 1.9 atm

22. 3grams of $H_2$ and 24 grams of $O_2$ are present in a gaseous mixture at constant temperature and pressure. The partial pressure of $H_2$ is

1) $\frac{1}{3}$ of total pressure 2) $\frac{2}{3}$ of total pressure 3) $\frac{3}{2}$ of total pressure 4) $\frac{1}{2}$ of total pressure

**Answer:2**

Solution:Given:3 grams of $H_2$,24 grams of $O_2$

Constant temperature and pressure

Moles of $H_2$ = mass/molar mass = 3g/2g/mol = 1.5 mol

Moles of $O_2$ = 24g/32g/mol = 0.75 mol

Total moles = 1.5 + 0.75 = 2.25 mol

Mole fraction of $H_2$ ($X_{H2}$) = moles of $H_2$/total moles = 1.5/2.25 = 2/3

Partial pressure of $H_2$ ($P_{H2}$) = Mole fraction × Total pressure = (2/3)$P_{total}$

23. A gaseous mixture was prepared by taking equal moles of CO and $N_2$. If the total pressure of the mixture was found 1 atom, the partial pressure of the nitrogen ($N_2$) in the mixture is

(A) 0.8 atm (B) 0.9 atm (C) 1 atm (D) 0.5 atm

**Answer:D**

Solution:Given:Equal moles of CO and $N_2$

Total pressure = 1 atm

Step 1: Let moles of CO = moles of $N_2$ = x mol

Total moles = x + x = 2x mol

Step 2: Calculate mole fraction of $N_2$

Mole fraction of $N_2$ ($X_{N2}$) = x/2x = 0.5

Step 3: Determine partial pressure

Partial pressure of $N_2$ ($P_{N2}$) = Mole fraction × Total pressure = 0.5 × 1 atm = 0.5 atm

24. Equal weights of CO and $CH_4$ are mixed together in an empty container at 300 K. The fraction of total pressure exerted by $CH_4$ is [2010]

(A) $\frac{16}{17}$ (B) $\frac{7}{11}$ (C) $\frac{8}{9}$ (D) $\frac{5}{16}$

**Answer:B**

Solution:Given:Equal weights of CO and $CH_4$

Temperature = 300 K

Step 1: Let the weight of each gas = w grams

Molar mass of CO = 28 g/mol

Molar mass of CH4 = 16 g/mol

Step 2: Calculate moles of each gas

Moles of CO = w/28

Moles of $CH_4$ = w/16

Step 3: Determine mole fraction of $CH_4$

Total moles = (w/28) + (w/16) = w(1/28 + 1/16)

Mole fraction of $CH_4$ ($X_{CH4}$) = (w/16)/w(1/28 + 1/16) =

$$X_{CH_4}=\frac{\frac{1}{16}}{\frac{1}{16}+\frac{1}{28}}=\frac{\frac{1}{16}}{\frac{28+16}{16(28)}}=\frac{28}{44}=\frac{7}{11}$$

25. A gas (1g) at 4 bar pressure. If we add 2gm of gas B then the total pressure inside the container is 6 bar. Which of the following is true ? [2018]

(A) $M_A = 2M_B$ (B) $M_B = 2M_A$ (C) $M_A = 4M_B$ (D) $M_B = 4M_A$

**Answer:D**

Solution:Given:Initial: 1g of gas A at 4 bar

After adding 2g of gas B: Total pressure = 6 bar

Step 1: Let molar masses be $M_A$ and $M_B$

Moles of A initially = $1/M_A$

Moles of B added = $2/M_B$

Step 2: Apply ideal gas law (PV = nRT)

For initial state (only A): $4V = (1/M_A)RT$

RT/V = 4MA

After adding B:

$6V = (1/M_A + 2/M_B)RT$

Substitute RT/V: $6 = (1/M_A + 2/M_B)(4M_A)$

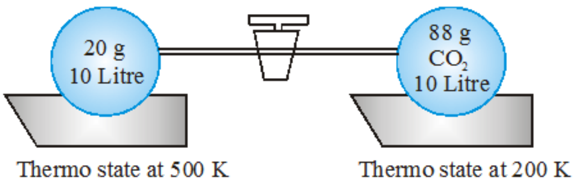
$6 = 4 + 8(M_A/M_B)$

$2 = 8(M_A/M_B)$

$M_A/M_B = 1/4$

$M_B = 4M_A$

26. Flask A of volume 10 litre containing 20 gram of $H_2$ and flask B of volume 10 litre containing 88 gram of $CO_2$ are connected by a connector having negligible volume. When valve of the connector iss opened what is the composition of $H_2$ gas in the flask B after opening the valve.




(A) 10% (B) 13% (C) 15% (D) 20%

**Answer:D**

Solution: Given:

Flask A: 10 L volume, contains 20 g $H_2$

Flask B: 10 L volume, contains 88 g $CO_2$

Connected via a negligible volume connector

Valve is opened, allowing gases to mix

Step 1: Calculate moles of each gas

Molar mass $H_2$ = 2 g/mol ----> Moles of $H_2$ = 20 g / 2 g/mol = 10 mol

Molar mass $CO_2$ = 44 g/mol ------> Moles of $CO_2$ = 88 g / 44 g/mol = 2 mol

Step 2: Determine total volume after mixing

Total volume = 10 L (Flask A) + 10 L (Flask B) = 20 L

Step 3: Calculate new concentrations after mixing

$H_2$:Initially in 10 L ---->Concentration = 10 mol / 10 L = 1 M

After mixing in 20 L ----> New concentration = 10 mol / 20 L = 0.5 M

$CO_2$:

Initially in 10 L -----> Concentration = 2 mol / 10 L = 0.2 M

After mixing in 20 L -----> New concentration = 2 mol / 20 L = 0.1 M

Mass Composition in Flask B

Mass of $H_2$ in Flask B after mixing = 5 mol × 2 g/mol = 10 g

Mass of $CO_2$ in Flask B = 1 mol × 44 g/mol = 44 g

Total mass in Flask B = 10 g + 44 g = 54 g

Mass percentage of $H_2$ = (10 g / 54 g) × 100 ˜ 18.5%

27. A 40 ml of a mixture of $H_2$ and $O_2$ at 18 °C and 1 atm pressure was sparked so that the formation of water was complete. The remaining pure gas had a volume of 10 ml at 18°C and 1 atm pressure. If the remaining gas was $H_2$, the mole fraction of $H_2$ in the 40 ml mixture is :

(A) 0.75 (B) 0.5 (C) 0.65 (D) 0.85

**Answer:A**

Solution:Given:Total volume of $H_2$ and $O_2$ mixture = 40 mL at 18°C and 1 atm

After complete reaction to form water, remaining gas volume = 10 mL at same conditions

Remaining gas is $H_2$

Objective: Find the mole fraction of $H_2$ in the original mixture.

The reaction between $H_2$ and $O_2$ to form water is: $2H_2 + O_2 \rightarrow 2H_2O$

2 volumes of H2 react with 1 volume of O2 to form water (since volume $\alpha$ moles

at constant T & P).

$V_{H2}=2x, V_{O2}=x$

$V_{total}=V_{H2}+V_{O2}=40ml$

$V_{H2}=40-x$

Substitute into the excess $H_2$ equation:(40-x)-2x=10

X=10

$V_{O2}=10$ mL (reacted fully)

$V_{H2}=40-10=30$ mL (original H2)

Mole fraction of $H_2=30/40=0.75$

## JEE ADVANCED LEVEL QUESTIONS

**Multi Correct Answer Type**

1. Dalton's law of partial pressure is not applicable to the following mixture of gases

1) $H_2 + F_2$ 2) $NH_3 + HCl$ 3) $SO_2 + Cl_2$ 4) $H_2 + O_2$

**Answer:2**

Solution:Dalton's Law of Partial Pressures states that the total pressure exerted by a mixture of non-reacting gases is equal to the sum of the partial pressures of individual gases. It is not applicable when gases react chemically or undergo association/dissociation.

$NH_3$ (ammonia) and HCl (hydrogen chloride) react immediately to form solid $NH_4Cl$ (ammonium chloride).

Dalton's law is NOT applicable.

2. The correct mathematical equations for grahams law are at constant temperature and pressure

a. $\frac{r_1}{r_2}=\sqrt{\frac{M_1}{M_2}}$ b. $r\alpha\frac{1}{\sqrt{VD}}$ c. $\frac{r_1}{r_2}=\sqrt{\frac{M_2}{M_1}}$ d. $\frac{r_1}{r_2}=\sqrt{\frac{d_2}{d_1}}$

**Answer:b,c,d**

Solution:Graham's Law of Diffusion/Effusion states: $\frac{r_1}{r_2}=\sqrt{\frac{M_2}{M_1}}=\sqrt{\frac{d_2}{d_1}}$

**Statement Type**

**3. Assertion :** The diffusion rate of oxygen is smaller than that of nitrogen under identical conditions

**Reason :** Molecular mass of nitrogen is smaller than that of oxygen.

**Answer:A**

Solution:Assertion (True):

From Graham's Law, $r\alpha \frac{1}{\sqrt{M}}$

Oxygen ($O_2$, M=32) diffuses slower than nitrogen ($N_2$,M=28) because it is heavier.

Reason (True & Correct Explanation):

The reason correctly explains the assertion since $M_{N_2} < M_{O_2}$ leading to $r_{N_2} > r_{O_2}$

**4. Assertion :** Pressure exerted by a mixture of reacting gases is equal to the sum of their partial pressures.

**Reason :** Reacting gases react to form a new gas having pressure equal to the sum of both.

**Answer:E**

Solution:Assertion (False):Dalton's Law applies only to non-reacting gases.

Reason (False):The product gas's pressure depends on stoichiometry, not the sum of reactants.

**5. Assertion :** If $H_2$ and $Cl_2$ enclosed separately in the same vessel exert pressure of 100 and 200 mm respectively, their mixture in the same vessel at the same temperature will exert a pressure of 300 mm. **[2008]**

**Reason :** Daloton's law of partial pressures states that total pressure is the sum of partial pressures.

**Answer:A**

Solution:This is correct if we assume:"

Ideal gas behavior

No chemical reaction between $H_2$ and $Cl_2$

Same temperature and volume.So, Assertion is TRUE.

Reason:Dalton's law of partial pressures states that total pressure is the sum of partial pressures.This is the correct definition of Dalton's Law.

**Comprehension Type**

1) Rates of diffusion of two gases are in the reciprocal ratio of square roots of their molecular weight

2) Total pressure of a mixture of non reacting gases is given by the algebric sum of their partial pressure

6. $O_2$ is partially atomised due to certain experimental conditions. The mixture of $O_2$ molecules and O atoms diffuses $\sqrt{5}$ times slower than Helium. What is the percentage atomisation of $O_2$?

1) 50% 2) 20% 3) 40% 4) 60%

**Answer:4**

Solution:



$$\frac{r_{He}}{r_{mix}} = \sqrt{5} = \sqrt{\frac{M_{mix}}{M_{He}}}$$

$$5 = \frac{M_{mix}}{4}$$

$$M_{mix} = 20 \rightarrow averagemolecularmass$$

$$Let\%O_2 = 1-x, \%ofO = 2x$$

$$\frac{(1-x)\times 32 + 2x\times 16}{1-x+2x} = 20$$

$$\frac{32-32x+32x}{1+x} = 20$$

$$32 = 20(1+x)$$

$$1.6 = 1+x$$

$$x = 0.6$$

Percentage atomization:0.6x100=60%

7. What is the mass of water vapour in the one $m^3$ of air with 0.4 relative humidity at 300K?

(Aqueous tension at 300 K=3.6 K P1)

1) 22.12 gm 2) 10.53 gm 3) 4.68 gm 4) 2.86 gm

**Answer:2**

Solution:

$$\text{Relative Humidity} = \frac{P_{H_2O}}{Aq.Tension} \Rightarrow 0.4 = \frac{P_{H_2O}}{3.6\times10^3}$$

$$P_{H_2O} = 1.44\times10^3 Pa$$

$$PV = nRT = \frac{WRT}{M}$$

$$W = \frac{PVM}{RT} = \frac{1.44\times10^3\times1\times18}{8.314\times300} = 10.53 gm$$

**Matching Type**

8. **Answer:1-S,2-P,3-Q,4-S**

**Solution:**

| Column I | Column II |
|---|---|
| 1) Diffusion of gas | S) Molecular mass |
| 2) Daltons Law | P) $SO_3$ and $O_2$ |
| 3) Relative Humidity | Q) $\frac{\text{Partial pressure of water in air}}{\text{Vapour pressure of water}}$ |
| 4) Rate of diffusion | S) Molecular mass |

**Integer Type**

9. In what ratio by mass carbon monoxide and nitrogen should be mixed so that partial pressure exerted by each gas is same ?

**Answer:1**

Solution:Molar mass of CO = 28 g/mol

Molar mass of $N_2$ = 28 g/mol

$$\frac{m_{CO}}{28}=\frac{m_{N_2}}{28}$$
$$\frac{m_{CO}}{m_{N_2}}=\frac{1}{1}$$

10. The ratio of the ratio of diffusion of helium and methane under identical condition of pressure and temperature will be ______

**Answer:2**

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

## LARNERS TASK

## CONCEPTUAL UNDERSTANDING QUESTIONS (CUQ's)

### Grahams Law Of Diffusion

1. If some moles of $O_2$ diffuse in 18 sec and same moles of other gas diffuse in 45 sec then what is the molecular weight of the unknown gas

(A) $\frac{45^2}{18^2}\times 32$ (B) $\frac{18^2}{45^2}\times 32$ (C) $\frac{18^2}{45^2\times 32}$ (D) $\frac{45^2}{18^2\times 32}$

**Answer:A**

Solution:

$$\frac{t_{O_2}}{t_x}=\sqrt{\frac{M_{O_2}}{M_x}}$$
$$\frac{18}{45}=\sqrt{\frac{32}{M_x}}$$
$$\frac{45}{18}=\sqrt{\frac{M_x}{32}}$$
$$M_x=(\frac{45}{18})^2.32$$

2. The ratio of rates of diffusion of $SO_2$, $O_2$ and $CH_4$ is

(A) $1:\sqrt{2}:2$ (B) 1 : 2 : 4 (C) $2:\sqrt{2}:1$ (D) $1:2:\sqrt{2}$

**Answer:A**

Solution:

$r \alpha \frac{1}{\sqrt{M}}$

$r_{SO_2} \alpha \frac{1}{\sqrt{64}}$

$r_{O_2} \alpha \frac{1}{\sqrt{32}}$

$r_{CH_4} \alpha \frac{1}{\sqrt{16}}$

$r_{SO_2} : r_{O_2} : r_{CH_4} = \frac{1}{\sqrt{64}} : \frac{1}{\sqrt{32}} : \frac{1}{\sqrt{16}} = \frac{1}{8} : \frac{1}{5.66} : \frac{1}{4} = 1:1.41:2$

$r_{SO_2} : r_{O_2} : r_{CH_4} = 1:\sqrt{2}:2$



4. 50 ml of hydrogen diffuses out through a small hole from a vessel in 20 minutes. The time needed for 40 ml of oxygen to diffuse out is

(A) 12 min (B) 64 min (C) 8 min (D) 32 min

**Answer:B**

Solution:

$r \alpha \frac{V}{t}$

$V_{H_2} = 50ml, t_{H_2} = 20\min, V_{O_2} = 40ml$

$t_{O_2} = \frac{40 \times 4}{2.5} = 64\min$

5. The ratio of the rate of diffusion of helium and methane under identical condition of pressure and temperature will be

(A) 4 (B) 2 (C) 1 (D) 0.5

**Answer:B**

Solution:

$$\frac{r_{He}}{r_{CH_4}} = \sqrt{\frac{M_{CH_4}}{M_{He}}}$$

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

$$\frac{r_{He}}{r_{CH_4}} = \sqrt{4}$$

$$\frac{r_{He}}{r_{CH_4}} = \frac{2}{1}$$

6. Among $N_2$,$O_2$ and $SO_2$ the gas with high rate of diffusion is

1)$O_2$ 2)$SO_2$ 3)$N_2$ 4)All are same

**Answer:3**

Solution: $r \alpha \frac{1}{\sqrt{M}}$

Lighter gases diffuse faster. Molar masses:

$M_{N2}$=28g/mol

$M_{O2}$=32g/mol

$M_{SO2}$=64g/mol

$N_2$ is lightest $\rightarrow$ fastest diffusion.

7. Ansil's Alaram is used to detect ...... in mines

1) $CO_2$ 2) CO 3) $CH_4$ 4) $COCl_2$

**Answer:3**

Solution:Ansil's Alaram is used to detect $CH_4$ in mines

8. The gas which diffuses twice as quickly as $SO_2$ is

1) $CH_4$ 2) $H_2$ 3) $O_2$ 4) He

**Answer:1**

Solution:
$$4 = \frac{64}{M_{gas}}$$
$$M_{gas} = 16g/mol$$

$CH_4$(methane) has =16g/mol

9. Which of the following pair of gases diffuse through a porous plug with the same rates of diffusion

   1) CO, NO  2) $NO_2$, $CO_2$  3) $NH_3$, $PH_3$  4) NO, $C_2H_6$

**Answer:4**

Solution:Gases with the same molar mass diffuse at the same rate.

CO (28 g/mol) and NO (30 g/mol) $\rightarrow$Not same.

$NO_2$ (46 g/mol) and $CO_2$ (44 g/mol) $\rightarrow$ Not same.

$NH_3$ (17 g/mol) and $PH_3$ (34 g/mol) $\rightarrow$Not same.

NO (30 g/mol) and $C_2H_6$ (30 g/mol) $\rightarrow$ Same!

10. A mixture of 3 gases X(density 0.90), Y (density 0.178) and Z (density0.42) is enclosed in a vesel at constant temperature. When the equilibrium is established the

    1) Gas X will be at the top of the vessel

    2) Gas Y will be at the top of the vessel

    3) Gas Z will be at the top of the vessel

    4) Gases will mix homogeneously through out the vessel

**Answer:4**

Solution:Gases mix homogeneously due to random motion, regardless of density. Density affects separation under gravity, but not diffusion in a closed vessel.

11. The ratio of rate of diffusion of carbondioxide and nitrous oxide is

    1) 2 : 1  2) 1 : 2  3) 16 : 1  4) 1 : 1

**Answer:4**

Solution:Molar Masses:$CO_2$: 12+2×16=44g/mol

$N_2O$: 2×14+16=44g/mol

$$\frac{r_{CO_2}}{r_{N_2O}} = \sqrt{\frac{M_{N_2O}}{M_{C2O}}} = \sqrt{\frac{44}{44}} = 1$$

12. Which of the following diffuses slowly

    1) $SO_2$  2) $N_2$  3) $O_2$  4) $Cl_2$

**Answer:4**

Solution: $Cl_2$ has the highest molar mass, so it diffuses the slowest.

13. A bottle of perfume is opened in the corner of a large Hall of volume $1000m^3$. After some time the whole Hall smells of the perfume. The property of gases responsible for this observation is

1) Thermal conductivity 2) Viscosity 3) Diffusion 4) Compressibility

**Answer:3**

Solution: Diffusion is the process by which gas molecules spread out from an area of high concentration (perfume bottle) to low concentration (entire hall).

14. Rate of the diffusion of $NO_2$ is

1) Greater than that of NO 2) Less than that of NO

3) Same as that of NO 4) Half of that of NO

**Answer:2**

Solution: From Graham's Law, the rate of diffusion (r) is inversely proportional to the square root of molar mass (M): $r \alpha \frac{1}{\sqrt{M}}$

Molar mass of $NO_2$ = 46 g/mol

Molar mass of NO = 30 g/mol

Since $M_{NO2} > M_{NO}$, the rate of diffusion of $NO_2$ is less than that of NO.

15. Under identical conditions which of the following has maximum diffusion rate

1) $Cl_2$ 2) $H_2$ 3) $CO_2$ 4) $O_2$

**Answer:2**

Solution: From Graham's Law, the rate of diffusion (r) is inversely proportional to the square root of molar mass (M): $r \alpha \frac{1}{\sqrt{M}}$

$H_2$ (M = 2 g/mol) $\rightarrow$ Lightest $\rightarrow$ Fastest diffusion

$Cl_2$ (M = 71 g/mol), $CO_2$ (M = 44 g/mol), $O_2$ (M = 32 g/mol) $\rightarrow$ Heavier $\rightarrow$ Slower diffusion

16. The correct order of diffusion for the gases $H_2$, $N_2$, $O_2$ and $NH_3$ is

1) $H_2 > N_2 > O_2 > NH_3$ 2) $NH_3 > O_2 > N_2 > H_2$ 3) $H_2 > N_2 > NH_3 > O_2$ 4) $H_2 > NH_3 > N_2 > O_2$

**Answer:4**

Solution: First, list the molar masses:

$H2$ (2 g/mol) $\rightarrow$Fastest

$NH3$ (17 g/mol)

$N2$ (28 g/mol)

$O2$ (32 g/mol) $\rightarrow$ Slowest

Diffusion rate order (lightest to heaviest): $H_2 > NH_3 > N_2 > O_2$

**Daltons Law Of Partial Pressure**

17. The vapour pressure of a dry gas is

    1) Less than that of wet gas
    2) greater than that of wet gas
    3) equal to that of wet gas
    4) double then wet gas

**Answer:1**

Solution:Dry gas: Contains no water vapor.

Wet gas: Contains water vapor, which contributes additional partial pressure.

Since wet gas includes water vapor, its total pressure (vapor pressure) is higher than that of dry gas.

18. Aqueous tension is dependent on

    1) V
    2) P
    3) T
    4)weight of gas

**Answer:3**

Solution:Aqueous tension is the vapor pressure of water in equilibrium with liquid water.

Vapor pressure depends only on temperature (T) for a pure substance.

It is independent of volume, external pressure, or weight of gas.

19. In a given mixture of gases which do not react with one another the ratio of partial pressure of each compound is equal to its

    1) weight percent
    2) Volume percent
    3) Mole fraction
    4)Critical pressure

**Answer:3**

Solution:Dalton's Law states: Partial pressure ($P_i$) = Mole fraction ($X_i$) × Total pressure ($P_{total}$).

Thus, the ratio of partial pressures is equal to the ratio of mole fractions.

20. At the same temperature, HCl gas and $NH_3$ gas are present in two vessels of same volume at a pressure of 'P' atmospheres each. When one jar is inverted over the other so that the two will mix, after some time the pressure in the

vessels will become.

1) $\frac{P}{2}$ 2) $\frac{P}{4}$ 3) Zero 4) P

**Answer:3**

Solution:Initial Conditions:HCl gas: Volume = V, Pressure = P, Moles = n (using PV=nRT).

NH3 gas: Volume = V, Pressure = P, Moles = n.

Chemical Reaction:

When HCl and $NH_3$ mix, they react completely to form solid $NH_4Cl$ (ammonium chloride): $HCl + NH_3 \rightarrow NH_4Cl$

1 mole HCl reacts with 1 mole $NH_3$ to form a non-gaseous product.

After Mixing:

Total initial moles of gas = $n_{HCl}+n_{NH3}=n+n=2n$.

All gas molecules react completely, leaving zero moles of gas in the vessel.

Since pressure is proportional to moles of gas ($P \alpha n$), the final pressure becomes zero.

21. Which gas can be Collected over water

1) $NH_3$ 2) $N_2$ 3) HCl 4) $SO_2$

**Answer:2**

Solution:$N_2$ (Nitrogen) is insoluble in water and chemically inert, making it suitable for collection over water.

Other gases listed ($NH_3$, HCl, $SO_2$) are highly soluble or reactive with water, so they cannot be collected this way.

22. The vapour pressure of a moist gas at 35 $^0$C is 750 mm and aqueous tension at that temperature is 10mm. Then vapour pressure of the dry gas is

1) 750mm 2) 760mm 3)740mm 4) 720mm

**Answer:3**

Solution:Moist gas pressure = Pressure of dry gas + Aqueous tension (water vapor pressure).

Given: $P_{moist} = 750mm, P_{water} = 10mm$

Dry gas pressure = $P_{moist} - P_{water} = 750 - 10 = 740 mm$

## JEE MAINS LEVEL QUESTIONS

### Grahams Law Of Diffusion

**23.** 20 l of $SO_2$ diffuses through a porous partition in 60 seconds. Volume of $O_2$ diffuse under similar conditions in 30 seconds will be :

**(A)** 12.14 l **(B)** 14.14 l **(C)** 18.14 l **(D)** 28.14 l

**Answer:B**

Solution:$V_{SO2}$=20L, $t_{SO2}$=60sec---->$r_{SO2}$=20/60

$V_{O2}$=?, $t_{SO2}$=30sec------>$r_{O2}$=V?30

Graham's Law of Diffusion:

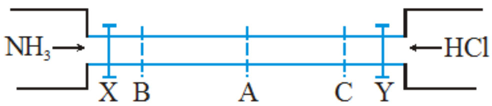
$$\frac{r_{SO_2}}{r_{O_2}} = \sqrt{\frac{M_{O_2}}{M_{SO_2}}}$$

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

$$\frac{10}{V} = \sqrt{\frac{1}{2}}$$

$$V = 10\sqrt{2} = 10(1.414) = 14.14 litres$$

**24.** See the figure-1 :




The valves of X and Y are opened simultaneously. The white fumes of $NH_4Cl$ will first form at:

**(A)** A **(B)** B **(C)** C **(D)** A,B and C simultaneously

**Answer:C**

Solution: White fumes appear first at C because $NH_3$ arrives there before HCl due to its faster diffusion.

**25.** X ml of $H_2$ gas effuses through a hole in a container in 5 sec. The time taken for the effusion of the same volume of the gas specified below under identical conditions is :

**(A)** 10 sec. He **(B)** 20 sec. $O_2$ **(C)** 25 sec. $CO_2$ **(D)** 55 sec. $CO_2$

**Answer:B**

Solution:Graham's Law of Effusion:

The time (t) for effusion is directly proportional to the square root of the molar mass (M):

$$\frac{t_1}{t_2} = \sqrt{\frac{M_1}{M_2}}$$
$$t_{H_2} = 5\sec, M_{H_2} = 2g/mol$$

**(A)** 10 sec. He

$$\frac{5}{t_{He}} = \sqrt{\frac{2}{4}}$$
$$t_{He} = 5(\sqrt{2}) = 7\sec$$

**(B)** 20 sec. $O_2$

$$\frac{5}{t_{O_2}} = \sqrt{\frac{2}{32}}$$
$$t_{O_2} = 5(4) = 20\sec$$

**(C)** 25 sec. $CO_2$ **&(D)** 55 sec. $CO_2$

$$\frac{5}{t_{CO_2}} = \sqrt{\frac{2}{44}}$$
$$t_{CO_2} = 5(\sqrt{22}) = 23.45\sec$$

**26.** Three identical footballs are respectively filled with nitrogen , hydrogen and helium at same pressure. If the leaking of the gas occurs with time from the filling hole, then the ratio of the rate of leaking of gases $(r_{N_2} : r_{H_2} : r_{He})$ from three footballs under identical conditions (in equal time interval) is :

**(A)** $(1:\sqrt{14}:\sqrt{7})$ **(B)** $(\sqrt{14}:\sqrt{7}:1)$ **(C)** $(\sqrt{7}:1:\sqrt{14})$ **(D)** $(1:\sqrt{7}:\sqrt{14})$

**Answer:A**

Solution:

$$r_{N_2} : r_{H_2} : r_{He} = \frac{1}{\sqrt{28}} : \frac{1}{\sqrt{2}} : \frac{1}{\sqrt{4}} = \frac{1}{2\sqrt{7}} : \frac{1}{\sqrt{2}} : \frac{1}{2}$$

$$r_{N_2} : r_{H_2} : r_{He} = \frac{1}{\sqrt{7}} : \sqrt{2} : 1 = 1 : \sqrt{14} : \sqrt{7}$$

**27.** The rates of diffusion of $SO_3$, $CO_2$, $PCl_3$ and $SO_2$ are in the following order -

**(A)** $PCl_3 > SO_3 > SO_2 > CO_2$ **(B)** $CO_2 > SO_2 > PCl_3 > SO_3$

**(C)** $SO_2 > SO_3 > PCl_3 > CO_2$ **(D)** $CO_2 > SO_2 > SO_3 > PCl_3$

**Answer:D**

Solution:Lighter gases diffuse faster

$M_{SO3}$=80,$M_{CO2}$=44,$M_{PCl3}$=137.33,$M_{SO2}$=64

The correct order is $CO_2 > SO_2 > SO_3 > PCl_3$,

**28.** A and B are two identical vessels. A contains 15 g ethane at 1atm and 298 K. The vessel B contains 75 g of a gas $X_2$ at same temperature and pressure. The vapour density of $X_2$ is :

**(A)** 75 **(B)** 150 **(C)** 37.5 **(D)** 45

**Answer:A**

Solution:Vessel A:

Mass of ethane ($C_2H_6$) = 15 g

Molar mass of $C_2H_6$ = 30 g/mol

Moles of $C_2H_6$ = 15/30=0.5moles

Vessel B:

Mass of gas $X_2$ = 75 g

Let molar mass of $X_2$ = Mg/mol

Moles of $X_2$ = 75/M mol

Since both vessels have the same volume (V), pressure (P), and temperature (T), the number of moles must be equal:

$n_{C2H6}=n_{X2}$

0.5=75/M

M=75/0.5=150g

Vapour density (VD) is half the molar mass:VD=M/2=150/2=75

**Daltons Law Of Partial Pressure**

**29.** A sample of $O_2$ gas is collected over water at 23°C at a barometric pressure of 751 mm Hg (vapour pressure of water at 23° C is 21 mm Hg). The partial pressure of $O_2$ gas in the sample collected is

**(A)** 21 mm Hg **(B)** 751 mm Hg **(C)** 0.96 atm **(D)** 1.02 atm

**Answer:C**

Solution:Total Pressure (Barometric Pressure): 751 mm Hg

Vapour Pressure of Water: 21 mm Hg

Partial Pressure of $O_2$:$P_{O2}$=$P_{total}$-P=751-21=730mm Hg

Convert to atm: $730mmHg \times \frac{1atm}{760mmHg} \approx 0.96atm$

**30.** Equal weights of ethane & hydrogen are mixed in an empty container at 25° C, the fraction of the total pressure exerted by hydrogen is:

**(A)** 1: 2 **(B)** 1: 1 **(C)** 1: 16 **(D)** 15: 16

**Answer:D**

Solution:Let mass of each gas = w g.

Moles of $H_2 = \frac{w}{2}$

Moles of $C_2H_6 = \frac{w}{30}$

Mole Fraction of $H_2$: $X_{H_2} = \frac{\frac{w}{2}}{\frac{w}{2}+\frac{w}{30}} = \frac{\frac{w}{2}}{\frac{30w+2w}{2(30)}} = \frac{30}{32} = \frac{15}{16}$

Partial Pressure Contribution: $P_{H_2} = X_{H_2} \times P_{total} = \frac{15}{16} P_{total}$

**31.** A mixture of hydrogen and oxygen at one bar pressure contains 20% by weight of hydrogen. Partial pressure of hydrogen will be

**(A)** 0.2 bar **(B)** 0.4 bar **(C)** 0.6 bar **(D)** 0.8 bar

**Answer:D**

Solution:Assume 100 g of mixture:

Mass of $H_2$ = 20 g $\rightarrow$ Moles=20/2=10mol

Mass of O2 = 80 g $\rightarrow$ Moles = 80/32=2.5mol

Mole Fraction of $H_2$: $X_{H_2} = \dfrac{10}{10+2.5} = 0.8$

Partial Pressure of $H_2$: $P_{H_2} = X_{H_2} \times P_{total} = 0.8 \times 1 = 0.8 bar$

32. A compound exists in the gaseous phase both as monomer **(A)** and dimer ($A_2$). The atomic mass of A is 48 and molecular mass of $A_2$ is 96. In an experiment 96 g of the compound was confined in a vessel of volume 33.6 litre and heated to 273°C. The pressure developed if the compound exists as dimer to the extent of 50 % by weight under these conditions will be :

**(A)** 1 atm **(B)** 2 atm **(C)** 1.5 atm **(D)** 4 atm

**Answer:B**

Solution:

$$A_2 = 2A$$
$$W_A = 48g, W_{A_2} = 48g$$
$$n_A = \frac{48}{48} = 1, n_{A_2} = \frac{48}{96} = \frac{1}{2}$$
$$n_{total} = \frac{3}{2}$$
$$P = \frac{3}{2} \times \frac{0.0821 \times 546}{33.6} = 2atm$$



## JEE ADVANCED LEVEL QUESTIONS

### Multi Correct Answer Type

32. Which gas can be Collected over water

1) $NH_3$ 2) CO 3) $N_2$ 4) $H_2$

**Answer:2,3,4**

Solution:Analysis of Options:

$NH_3$ (Ammonia):

Highly soluble in water (forms $NH_4OH$) $\rightarrow$Cannot be collected over water.

CO (Carbon Monoxide):Insoluble and non-reactive $\rightarrow$ Can be collected over water.

$N_2$ (Nitrogen):Insoluble and inert $\rightarrow$ Can be collected over water.

$H^2$ (Hydrogen):Insoluble and non-reactive $\rightarrow$ Can be collected over water.

33. Dalton's law of partial pressure is not applicable to the following mixture of gases at room temperature.

1) $H_2 + N_2$ 2) $H_2 + O_2$ 3) $O_2 + N_2$ 4) $CO+Cl_2$

**Answer:4**

Solution:Dalton's Law applies only to non-reacting gases.

$CO + Cl_2$ react at room temperature to form $COCl_2$ (phosgene):

$CO + Cl_2 \rightarrow COCl_2$

Other mixtures ($H_2 + N_2$, $H_2 + O_2$, $O_2 + N_2$) do not react at room temperature.

**Statement Type**

**34.** **Assertion :** 1/4th of the gas is expelled if air present in an open vessel is heated from 27° C to 127° C.

**Reason :** Rate of diffusion of a gas is inversely proportional to the square root of its molecular mass.

**Answer:B**

Solution:

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

$$(initialFraction)\frac{V_1}{V_2} = 1 when T = 27^0 C$$

At 127°C the newfraction is $\frac{V_1}{V_2} = \frac{300}{400} = \frac{3}{4}$

air expelled : $1 - \frac{3}{4} = \frac{1}{4}$

Rate of diffusion of a gas is inversely proportional to the square root of its molecular mass.

**35.** **Assertion :** Effusion rate of oxygen is smaller than nitrogen.

**[2004]**

**Reason :** Molecular size of nitrogen is smaller than oxygen

**Answer:C**

Solution:$M_{O2} > M_{N2}$,So Effusion rate of oxygen is smaller than nitrogen.

Molecular size decreases from left to right along a period. Thus, molecular size of nitrogen is greater than that of oxygen.

**36.** **Assertion :** Pressure exerted by a mixture of gases is equal to the sum of their partial pressures.

**Reason :** Reacting gases react to form a new gas having pressure equal to the sum of both.

**Answer:C**

Solution:Assertion (True):

Dalton's Law states: $P_{total} = P_i$ for non-reacting gases.

Reason (False):Reacting gases do not follow Dalton's Law

**Comprehension Type**

Dalton's law of partial pressure states "at a given temperature, the total pressure exerted by two or more non-reacting gases occupying a definite volume in equal to the sum of the partial pressures of the component gases."

$$P_{Total} = p_1 + p_2 + p_3 + \ldots\ldots \text{ (At constant V and T)}$$

$$= \left(\frac{n_1}{V} + \frac{n_2}{V} + \frac{n_3}{V} + \ldots\right)RT = (n_1 + n_2 + n_3 + \ldots\ldots)\frac{RT}{V} = \frac{nRT}{V}$$

Where $n = n_1 + n_2 + n_3 + \ldots\ldots$ = Total moles, V = Total volume

$$P_{Total} = \sum p_i = \frac{RT}{V}\sum n_i$$

Dalton's law of partial pressure is applicable only to non-reacting gases.

**37.** The partial pressure of hydrogen in a flask containing two grams of hydrogen and 32 gm of sulphur dioxide is :

**(A)** 1/16th of the total pressure **(B)** 1/9th of the total pressure

**(C)** 2/3 of the total pressure **(D)** 1/8th of the total pressure

**Answer:C**

Solution:Hydrogen ($H_2$):Molar mass = 2 g/mol, Moles of $H_2$=2/2=1mol

Sulfur Dioxide ($SO_2$):Molar mass = 64 g/mol,Moles of $SO_2$ =32/64=0.5moles

$$X_{H_2} = \frac{MolesOfH_2}{TotalMoles} = \frac{1}{1+0.5} = \frac{2}{3}$$

Partial Pressure of $H_2$: $P_{H_2} = X_{H_2} \times P_{total} = \frac{2}{3} P_{total}$

**Matching Type**

**38. Answer:2**

**Solution:**

| **List -I** | **List-II** |
|---|---|
| A. Effusion | 1. $r\alpha\frac{1}{d}$ |
| B. Velocity of gas | 3. Vector quantity |
| C. Pressure of the gas | 2. Collision of molecules on the walls |
| | 4. Scalar quantity |

1. A-4, B-2, C-3 2. A-1,B-3,C-2 3. A-1,B-2,C-4 4. A-1, B-4, C-3

**Integer Type**

**39.** 3.2g of oxygen (At.wt =16) and 0.2g of hydrogen (At.wt=1) are placed in a 1.12 litre flask at $0^0$C. The total pressure of the gas mixture will be______ atm

**Answer:4**

Solution:$n_{O2}$=3.2/32=0.1moles
$n_{H2}$=0.2/2=0.1 moles
$n_{total}$=0.1+0.1=0.2moles
Apply Ideal Gas Law to Find Total Pressure:
PV=nRT

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

$$P = \frac{0.2 \times 0.0821 \times 273}{1.12} \approx 4atm$$

# KEY

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | TEACHING TASK | | | | | |
| | | | | JEE MAINS LEVEL QUESTIONS | | | | | |
| **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** |
| 3 | 2 | 1 | 4 | 4 | 2 | 1 | 3 | 2 | 3 |
| **11** | **12** | **13** | **14** | **15** | **16** | **17** | **18** | **19** | **20** |
| B | D | B | A | C | A | D | 3 | 1 | 3 |
| **21** | **22** | **23** | **24** | **25** | **26** | **27** | | | |
| 1 | 2 | D | B | D | D | A | | | |
| | | | | JEE ADVANCED LEVEL QUESTIONS | | | | | |
| **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | | |
| 2 | B,C,D | A | E | A | 4 | 2 | 1-S,2-P,3-Q,4-S | | |
| **9** | **10** | | | | | | | | |
| 1 | 2 | | | | | | | | |
| | | | | LARNERS TASK | | | | | |
| **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** |
| A | A | | B | B | 3 | 3 | 1 | 4 | 4 |
| **11** | **12** | **13** | **14** | **15** | **16** | **17** | **18** | **19** | **20** |
| 4 | 4 | 3 | 2 | 2 | 4 | 1 | 3 | 3 | 3 |
| **21** | **22** | **23** | **24** | **25** | **26** | **27** | **28** | **29** | **30** |
| 2 | 3 | B | C | B | A | D | A | C | D |
| **31** | **32** | **32** | **33** | **34** | **35** | **36** | **37** | **38** | **39** |
| D | B | 2,3,4 | 4 | B | C | C | C | 2 | 4 |