**Graham's Law :**

rate of diffusion, $\boxed{r \propto \frac{1}{\sqrt{d}}}$ $\quad r \propto \frac{1}{\sqrt{M}}$

**Under conditions of same temperature but different pressure, we have -**

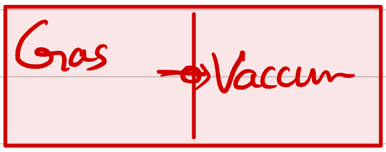
$$\boxed{r \propto \frac{P}{\sqrt{M}}}$$

$$\boxed{\frac{r_1}{r_2} = \frac{P_1}{P_2}\sqrt{\frac{M_2}{M_1}}}$$

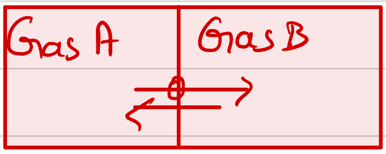
If both gases are present in the same container at same temperature.

$$P \propto n$$

$$\Rightarrow \quad \frac{r_1}{r_2} = \frac{n_1}{n_2}\sqrt{\frac{M_2}{M_1}} \qquad r \propto \left(\frac{n}{\sqrt{M}}\right)$$




Effusion




Diffusion

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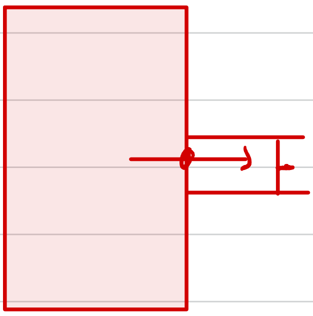


$$r \propto \frac{P}{\sqrt{M}} \propto \frac{n}{\sqrt{M}}$$

(i) $r = \frac{-dn}{dt}$ or $-\frac{\Delta n}{\Delta t}$

(ii) $r = \frac{-dP}{dt}$

(iii) $r = \left(\frac{dV}{dt}\right)$

(iv) $r = \left(\frac{dx}{dt}\right)$

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) $CO_2 > SO_2 > SO_3 > PCl_3$

d

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

b

$r = \frac{dV}{dt} \Rightarrow \frac{r_1}{r_2} = \sqrt{\frac{M_2}{M_1}} = \frac{(dV/dt)_1}{((dV)/(dt))_2} \Rightarrow \frac{20/\cancel{60}^{2}}{V/\cancel{30}} = \sqrt{\frac{\cancel{32}}{\cancel{64}_{2}}}$

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

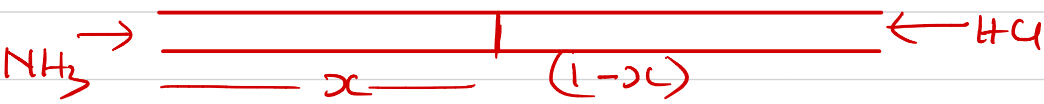
$V = 14.14$ lit

A bottle of dry ammonia and a bottle of dry hydrogen chloride connected through a long tube are opened simultaneously at both the ends. The white ring first formed will be:

(a) at the centre of the tube (b) near the ammonia bottle

(c) near the HCl bottle (d) throughout the length of the tube

c




$\frac{x/t}{(1-x)/t} = \sqrt{\frac{36.5}{17}}$

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

b

$\frac{r_{mix}}{r_{O_2}} = \sqrt{\frac{M_{O_2}}{M_{mix}}} \Rightarrow \frac{1/311}{2/1200} = \sqrt{\frac{32}{M_{mix}}} \Rightarrow \left(\frac{\cancel{1200}^{600}}{311}\right) = \sqrt{\frac{32}{M_{mix}}}$

$\Rightarrow \frac{\cancel{1200}^{600}}{311} = \sqrt{\frac{\cancel{32}^{16}}{\cancel{2}\times(V.D)_{mix}}}$

$M = 2 \cdot (V.D)$

$\sqrt{(V.D)_{mix}} = \frac{311}{\cancel{600}_{150}} \times 4 \Rightarrow (VD)_{mix} = \underline{4.3}$

A certain volume of $H_2$ effuses from an apparatus in one minute. The same volume of ozonised oxygen ($O_3 + O_2$) mixture took 246 sec to effuse from apparatus under identical conditions. Percentage of $O_2$ by mole in mixture is:

(a) 89.87%  (b) 10.13%  (c) 76.54%  (d) 73.12%

a

$$\frac{V/60}{V/246} = \sqrt{\frac{M_{mix}}{2}} \Rightarrow \left(\frac{\cancel{246}^{41}}{\cancel{60}_{10}}\right)^2 = \frac{M_{mix}}{2}$$

$$M_{mix} = \frac{41 \times 41 \times 2}{100} = 33.62 = \frac{x \times 32 + (1-x) \times 48}{1}$$

$$x = 0.8987$$

Calculate composition of the effusing gas (by mass) if the inside gas consist of mixture of $H_2$ and $O_2$ in a molar ratio of 2 : 1 respectively.

(a) $\frac{100}{8}$% $H_2$  (b) $\frac{800}{9}$% $H_2$  (c) $\frac{100}{3}$% $H_2$  (d) $\frac{200}{3}$% $H_2$

c

$$\frac{n_1'/t}{n_2'/t} = \frac{r_1}{r_2} = \frac{n_1}{n_2}\sqrt{\frac{M_2}{M_1}} \Rightarrow \frac{n_1'}{n_2'} = \frac{2}{1}\sqrt{\frac{\cancel{32}^{16}}{\cancel{2}}} = \left(\frac{8}{1}\right) \Rightarrow \frac{16}{32} = \left(\frac{1}{2}\right)$$

$\boxed{H_2 = 2 \\ O_2 = 1}$ → $H_2 =$ , $O_2 =$

$$\% H_2 = \frac{1}{3} \times 100 = \frac{100}{3}$$

One litre of gaseous mixture of $CH_4$ and $H_2$ effuses in 200 seconds while one litre of gas 'X' takes 10 minutes to effuse in identical conditions. If molar ratio of $CH_4 : H_2$ in mixture is 1 : 2. Find molar mass of gas 'X ' in (g/mol) units?

(a) 20  (b) 30  (c) 40  (d) 60

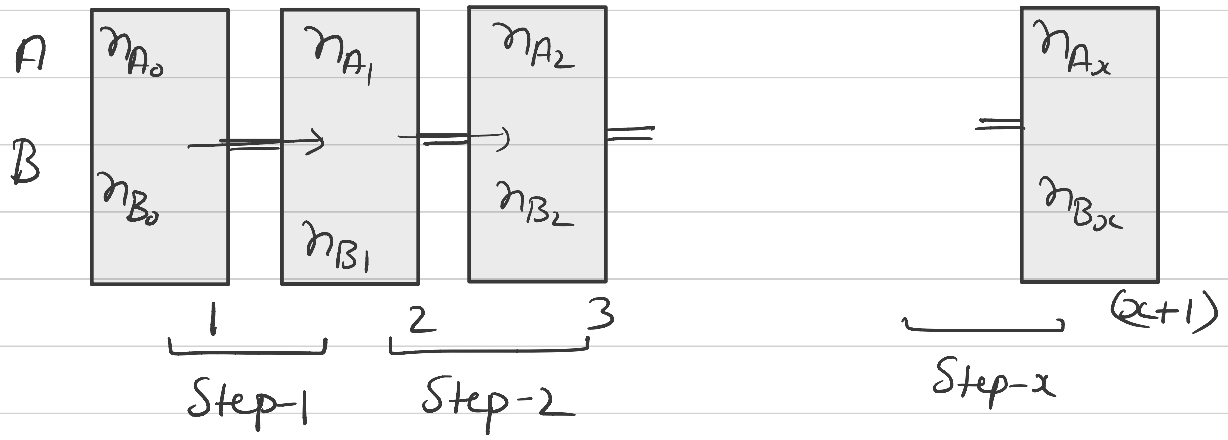
d

$$M_{mix} = \frac{1 \times 16 + 2 \times 2}{3} = \left(\frac{20}{3}\right)$$

$$\frac{r_{mix}}{r_x} = \sqrt{\frac{M_x}{M_{mix}}}$$

$$\frac{1/\cancel{200}}{1/\cancel{600}_{3}} = \sqrt{\frac{M_x}{20/3}} \Rightarrow 9 = \frac{M_x}{20/3} \Rightarrow M_x = 60$$

# Separation factor (F)




$$\frac{r_1}{r_2} = \frac{n_1}{n_2}\sqrt{\frac{M_2}{M_1}} \Rightarrow$$

**Step-1**

$$\frac{r_1}{r_2} = \frac{n_{A_0}}{n_{B_0}} \times \sqrt{\frac{M_B}{M_A}} = \frac{n_{A_1}/t}{n_{B_1}/t}$$

$$\Rightarrow \frac{n_{A_1}}{n_{B_1}} = \frac{n_{A_0}}{n_{B_0}}\sqrt{\frac{M_B}{M_A}} \quad \text{—} (1)$$

**Step-2**

$$\frac{n_{A_2}}{n_{B_2}} = \frac{n_{A_1}}{n_{B_1}}\sqrt{\frac{M_B}{M_A}} \Rightarrow \frac{n_{A_2}}{n_{B_2}} = \frac{n_{A_0}}{n_{B_0}}\left(\sqrt{\frac{M_B}{M_A}}\right)^2$$

**Step-x**

$$\boxed{\frac{n_{A_x}}{n_{B_x}} = \frac{n_{A_0}}{n_{B_0}}\left(\sqrt{\frac{M_B}{M_A}}\right)^x}$$

$$\boxed{\frac{n_{A_x}/n_{B_x}}{n_{A_0}/n_{B_0}} = f = \left(\sqrt{\frac{M_B}{M_A}}\right)^x}$$

**Prob:** If initial mole ratio of $CH_4$ and $H_2$ in container is 2:1 then calculate mole ratio after 4 step in 5th container

$$\frac{n_{CH_4}}{n_{H_2}} = \frac{2}{1}\left(\sqrt{\frac{2}{\cancel{16}\,8}}\right)^4 = \frac{\cancel{2}}{1}\times\frac{1}{\underset{4}{\cancel{8}}}\times\frac{1}{8} = \frac{1}{32}$$