Q:18 equal moles of hydrogen and oxygen gases are placed in container with pin-hole through which both can escape. What fraction of oxygen escapes in time required for one-half (1/2) of hydrogen to escape?

⟹

Kinetic theory of gases (KTG):

- this theory is 100% applicable over ideal gas but partially applicable over realgas.

Following are main postulates:

I) gas consist of large amount (no.) of small particles, called molecules.

II) Volume occupied by gasous molecule is negligible as compared to total volume of gas.

III) There is continuous rapid random motion of gas molecules so molecules colloid with each other and wall of container.

iv) molecules are perfect, elastic body and there is no loss of kinetic energy after collision with each other.

v) there is no force of attraction between gaseous molecules so potential energy of gaseous molecule is zero.

vi) velocity of gaseous molecule is different so kinetic energy of that molecule should be different.

(vii) Kinetic energy of gaseous molecule is only dependent on absolute temperature and it it directly proportional to temperature ($KE \propto t$)

⟹ mathematical part of KTG:

∴, Kinetic gas eqn

$$\boxed{PV = \frac{1}{3} mN \, v^2 rms.}$$

here; P = pascal $\quad V = m^3$

m = mass of single molecule (kg)

N = no. of molecules.

$$\boxed{V_{rms} = \sqrt{\frac{v_1^2 + v_2^2 + v_3^2 \ldots\ldots V_n^2}{N}} \ \text{mt/sec.}}$$

root mean square.

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Q:19 In a one litre container there are 10^{25} Nos of gaseous molecule. Mass of each molecule is 10^{-22} kg. If VR Vrms value is 10^5 cm/sec. Then find out 'P' of gas in Pa.

$\Longrightarrow$ $V = 1\,ltr = 10^{-3} m^3$ $\quad P = ?$ $\quad N = 10^{25}$ $\quad m = 10^{-22}$

$v = 10^5$ cm/sec $\longrightarrow 10^3$ m/s

$$\therefore, PV = \frac{1}{3} mNv^2$$

$$P = \frac{1}{3 \times 10^{-3}} \times 10^{25} \times 10^6 \times 10^{-22}$$

$$P = \frac{1}{3} \times 10^{34-26} \longrightarrow \boxed{\frac{1}{3} \times 10^{12} \text{ Pa}}$$

Relation between avg. KE & absolute temperature:

(a) avg KE for 'n' mole of gas from KGE

$$PV = \frac{2}{3} \frac{NmV_{rms}^2}{2} \qquad N \cdot m = \frac{M \times V^2}{2}$$

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

$$\boxed{KE = \frac{3}{2} PV} \quad \text{or} \quad \boxed{KE = \frac{3}{2} nRT.}$$

(b) avg. KE for 1mole of gas

$$\boxed{KE = \frac{3}{2} RT.}$$

(c) avg. KE for 1molecule of gas:

$$\therefore, KE = \frac{3}{2}\left(\frac{RT}{NA}\right)$$

$$\boxed{KE = \frac{3}{2} KT}$$

Here,

K = Boltzmann's constant

$$= \frac{8.31}{6.02 \times 10^{23}} \qquad \boxed{1.38 \times 10^{-23}\ J/K.}$$

Different velocities for gaseous molecules:

(A) most probable velocity (V_{mp}):

- the velocity possessed by maximum number of gaseous molecules at given temperature.
- mathematically, it can be calculated by.

$$\boxed{V_{m.p} = \sqrt{\frac{2RT}{M}}} \quad m/s$$

Here,

M = molar mass (Kg).

$R = \frac{25}{3}$ or 8.31

(B) average velocity:

$$\boxed{V_{avg} = \frac{V_1 + V_2 + V_3 + \dots + V_n}{N}}$$

$$\boxed{V_{avg} = \sqrt{\frac{8RT}{\pi M}}}$$ m/s

(C) Root mean square velocity (Vrms):

$$\boxed{V_{rms} = \sqrt{\frac{V_1^2 + V_2^2 + V_3^2 \dots V_n^2}{N}}}$$

only when (T) not given

$$\boxed{V_{rms} = \sqrt{\frac{3RT}{M}}}$$ m/s

$$\boxed{V_{rms} = \sqrt{\frac{3P}{d}}}$$

Q:20 Find out the ratio of different velocities of gaseous molecules w.r.t to Vmp, Vavg & Vrms.

⟹

$$\sqrt{\frac{2\cancel{RT}}{\cancel{M}}} = \sqrt{\frac{8\cancel{RT}}{\pi \cancel{M}}} = \sqrt{\frac{3\cancel{RT}}{\cancel{M}}}$$

$$\sqrt{2} = \sqrt{\frac{8}{\pi}} = \sqrt{3}$$ (π l.c.m)

$\therefore$ $\underline{\underline{\sqrt{2\pi} : \sqrt{8} : \sqrt{3\pi}}}$

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Q:21 arrange different velocities of gaseous molecules in their increasing order of values.

$\Longrightarrow$ $$V_{m.p} < V_{avg} < V_{rms}$$
$$\sqrt{2} \qquad \sqrt{\frac{8}{\pi}} \qquad \sqrt{3}$$

Q:22 four numbers of gaseous particles have their velocities 2; 3; 4 and 5 m/s respectively. Find Vrms

$\Longrightarrow$

$$V_{rms} = \sqrt{\frac{(2)^2+(3)^2+(4)^2+(5)^2}{4}}$$

$$= \sqrt{\frac{4+9+16+25}{4}} = \sqrt{\frac{\cancel{54}^{27}}{\cancel{4}_2}} \quad \sqrt{\frac{27}{2}}$$

$$\text{or } \frac{3\sqrt{6}}{2}$$

Q:23 find Vrms of hydrogen gas at 27°c.

$\Longrightarrow$ $T = 27+273 \longrightarrow 300\,K$

$M = 2$ gm/mole $\quad 2\times10^{-3}$ Kg

$R = 25/3$

$$V_{rms} = \sqrt{\frac{(\cancel{3})\left(\frac{25}{\cancel{3}}\right)(\cancel{300})^{150}}{\cancel{2}\times10^{-3}}} \quad \sqrt{\frac{405\times10}{10^{-3}}} \rightarrow \sqrt{405\times10^{4}}$$

$$\text{or, } 100\sqrt{405}$$

$$\text{or} \quad 5\sqrt{15\times10^{4}} \longrightarrow 500\sqrt{15}$$

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Molar mass of $n^0 = 1.67 \times 10^{-24} \times N_A$

Q324 find V_{mp} of neutron at 20°C.

$\Rightarrow$ $M = 1.67 \times 10^{-24} \times N_A$

$T = 273 + 20 \longrightarrow 293\ K$

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

$$\longrightarrow \sqrt{\frac{2 \times 25 \times 293}{3 \times 1.6 \times 10^{-27} \times 6 \times 10^{23}}}$$

(roughly) $\Rightarrow \sqrt{\frac{50 \times \cancel{294}}{\cancel{3} \times 9.6 \times 10^{-4}}}$

$$= 5\sqrt{\frac{100}{9.6 \times 10^{-4}}}$$

$\therefore\ 5 \times 10^2 = 500\sqrt{\frac{10}{9.6}}$

Q25 find V_{rms} of gas ; $\rho = 4\ kg/m^3$ pressure $= 1.2 \times 10^5\ Pa$

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

$\Rightarrow$ $\frac{PM}{RT} = d$ or $PM = dRT$

$\therefore\ M = \frac{dRT}{P}$

now; $V_{rms} = \sqrt{\frac{3(RT)}{\frac{d(RT)}{P}}}$

$$= \sqrt{\frac{3\cancel{(RT)} \times P}{4 \times \cancel{(RT)}}} \longrightarrow \sqrt{\frac{3 \times \cancel{1.2}^{0.3} \times 10^5}{\cancel{4}}}$$

$V_{rms} = \sqrt{\frac{3P}{d}}$ [applicable only when Temperature not given]

$\Longrightarrow \sqrt{0.9 \times 10^5}$, $\boxed{300}$

$= \sqrt{9 \times 10^4}$

Q: 26 find Kinetic energy of hydrogen gas if V_{mp} of 8 gm H is 200 m/s. $M = 8 \times 10^{-3}$ kg

$\Longrightarrow V_{mp} = 200$ m/s

$V_{mp} = \sqrt{\frac{2RT}{M}} \longrightarrow 200 = \sqrt{\frac{\cancel{2}RT}{\cancel{2} \times 10^{-3}}}$

$\longrightarrow 200 = \sqrt{\frac{RT}{1 \times 10^{-3}}}$ (8 g)

$40000 = \frac{RT}{1 \times 10^{-3}} \longrightarrow RT = 4 \times 10^4 \times 10^{-3}$
$= 40$

now;

$KE = \frac{3}{2} nRT$ mole = Given mass / mol. mass

$= \frac{3}{\cancel{2}} \times \frac{\cancel{8}^{4}}{\cancel{2}} \times 40 \longrightarrow \boxed{240}$

15