Mean Free Path

A molecule while moving collides with another molecule and its path is changed but average velocity remains the same. The average distance travelled between two successive collision is called the mean free path.

It is denoted by 'λ'.

If a molecule has an average velocity $\langle U_x \rangle$ and if it experiences z_1 collision then mean free path λ is given by -

$$\lambda = \frac{\langle U_x \rangle}{z_1} = \frac{\text{Average velocity}}{\text{Collision no.}}$$

$$\lambda = \frac{\langle U_x \rangle}{\sqrt{2}\,\pi\sigma^2 \langle U_x \rangle n}$$

$$\lambda = \frac{1}{\sqrt{2}\,\pi\sigma^2 n} \quad \text{---(1)}$$

$$\lambda = \frac{1}{\sqrt{2}\,\pi\sigma^2} \cdot \frac{RT}{P} \qquad \left(\text{From } PV = nRT,\ \frac{n}{V} = \frac{P}{RT} \right)$$

Where, $\langle U_x \rangle$ = Average velocity

π = 3.14

σ = Collision diameter

n = no. of molecules

R = Gas Constant

T = Absolute temp^{re}

P = Pressure of gas molecule

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At constant temperature, $\lambda \propto \frac{1}{P}$. Thus, greater is the pressure, smaller will be mean free path.

At constant pressure, $\lambda \propto T$. Thus, higher is the temperature, greater will be mean free path.

from Eqⁿ – (1)

$$\lambda \propto \frac{1}{\sigma^2}$$

So, smaller is the size of molecules larger will be mean free path.

Viscosity of gas :-

When a gaseous molecule moves or tries to moves over the other molecules then a force is generated between two layers in contact. which tries to oppose the relative motion of the two layers. The opposing force is called force of viscous drag and this property of gases are called viscosity of gas.

Let, A = area of each layer of gases

F = force between the two layers.

$\frac{dv}{dx}$ = velocity gradient b/n layers.

η = viscosity coefficient.

Since, $F \propto A$ ——— (1)

& $F \propto \frac{dv}{dx}$ ——— (2)

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From eqⁿ ① & ②

$$F \propto A \frac{dv}{dx}$$

$$\Rightarrow F = \eta A \frac{dv}{dx}$$

$$\therefore \boxed{\eta = \frac{F}{A} \times \frac{dx}{dv}}$$

The coefficient of viscosity is defined as the force per unit area required to estbalished a unit velocity gradient between two adjacent layers of a gas a part from a unit distance.

Units:-

In SI - unit

$Kg\ m^{-1}\ sec^{-1}$.

In CGS - unit

$gm\ cm^{-1}\ sec^{-1}$.

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