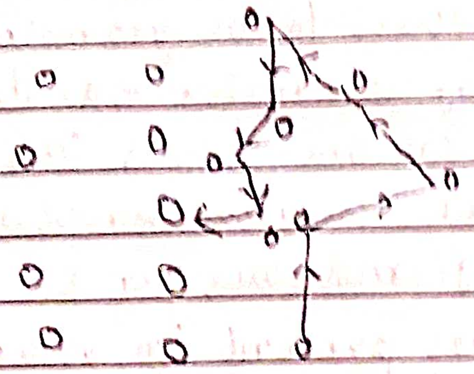
* Mean Free Path :-



In deriving the expression for the pressure of gas on the basis of kinetic energy, the theory, it was assumed that the molecules are of negligible size. They were assumed to be geometrical points. A geometrical point has no dimensions and hence intermolecular collision will not possible. But a molecule has a finite size and moves in the space of the vessel containing it. It collides with other molecules and the walls of containg vessel. The path covered by a molecule between any two consecutive collision is a straight line and is called the free path. The direction of molecule is changed after every collision. After a nos of collision the total path appears to be zig-zag and the free path is not constant. Therefore, a term mean free path is used to indicate the mean distance travelled by a molecule between collisions. If the total distance travelled after N collisions, is S, then the mean free path λ is given by $\lambda = \frac{S}{N}$ —— (i)

Let the molecules be assumed to be spheres of diameter d. A collision between two molecules will take place if the distance between the centres of the two molecules is d. Collision will also occur if the colliding molecule has a diameter

2d and the other molecule is simply a geometrical point. Thus assuming all other molecules to be geometrical points and the colliding molecule of diameter 2d, this molecule will cover a volume $\pi d^2 v$ in one second. This corresponds to the volume of a cylinder of diameter 2d and length v.

Let n be the no. of molecules per cc.

Then the no. of molecules present in volume $\pi d^2 v$

$$= \pi d^2 v \times n$$

This value also represents the no. of collisions made by the molecule in one second.

The distance moved in one second = v and the no. of collisions in one second = $\pi d^2 v \times n$

$$\therefore \text{Mean free Path, } \lambda = \frac{v}{\pi d^2 v n} = \frac{1}{\pi d^2 n} \quad \text{---} \quad (i)$$

This eqn. was deduced by Clausius.

$$\therefore \lambda \propto \frac{1}{d^2} \quad \text{---} \quad (ii)$$

The mean free path is inversely proportional to the square of diameter of the molecules.

Let m be the mass of each molecule. Then $m \times n = \rho$

$$\lambda = \frac{m}{\pi . d^2 \rho} \quad \text{---} \quad (iii)$$

The mean free path is inversely porportional to the desity of gas. The expression for the mean free path according to Boltzmann is $\lambda = \frac{3}{4\pi d^2 n}$ — (iv)

We assumed that all molecules have same average speed. Maxwell derived the expression,

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

We calculated the value of λ on the basis of the law of distribution of ~~vel~~ velocity.

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Table
Mean Free path

	Gas	d (cm)	λ
1	Hydrogen	2.47×10^{-8}	1.83×10^{-5} cm
2	Nitrogen	3.5×10^{-8}	0.944×10^{-5} cm
3	Helium	2.18×10^{-8}	2.85×10^{-5} cm
4	Oxygen	3.39×10^{-8}	0.999×10^{-5} cm

* Determination of mean free Path:—

The relation between coefficient of viscosity and the mean free path of a molecule is given by

$$\eta = \frac{1}{3} m n c \lambda$$

For unit volume $mn = \rho$

$$\therefore \eta = \frac{1}{3}\rho c \lambda$$

$$\lambda = \frac{3\eta}{\rho c} \quad \text{— (vi)}$$

The root mean square velocity c of a molecule can be calculated knowing pressure, density and tempr. The coefficient of viscosity of the gas is determined experimentally. Hence the value of the mean free path of a molecule can be calculated from eqn (vi)