B.Sc. III
Group_A

COLLISION NUMBER

Definition: The number of molecules with which a single molecule will collide per unit time per unit volume of the gas is known as collision number.

Equation:

$$\boxed{Z_1 = \sqrt{2}\,\pi\,\sigma^2\,\bar{c}\,\rho}$$

Where,

Z_1 = collision number

σ = Diameter of molecule

$\bar{c}$ = Average velocity

ρ = Molecule density (per unit volume) of gas

COLLISION FREQUENCY

Total number of collisions by all the molecules of a gas occuring per unit time per unit volume is known as collision frequency.

Collision number (Z_1) multiplying by number density (ρ) and dividing them by 2 since each collision involves two molecules of the same type.

Thus,

$$Z_{11} = \frac{1}{2}\sqrt{2}\,\pi\sigma^2\bar{c}\,\rho^2$$

$$= \frac{1}{\sqrt{2}}\pi\sigma^2\bar{c}\,\rho^2 \quad \text{---- (i)}$$

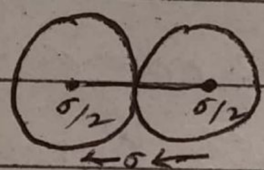
If two different types of molecules are present then

$$Z_{12} = \frac{1}{\sqrt{2}}\pi\sigma^2\bar{c}\,\rho_1\rho_2 \quad \text{---(ii)}$$

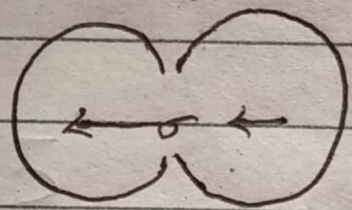
where, $\rho_1 \rho_2$ are the number density of gas 1 and 2.

COLLISION DIAMETER

Collision is an event in which the centres of two identical molecules come within a distance σ from one another



or,



σ is the distance between centres of the molecules at the point of closest approach is called collision diameter.

(λ) MEAN FREE PATH OF MOLECULES OF A GAS

Definition : Distances travelled by a gas molecule between two successive collisions.

Also it is given by the ratio of average velocity divided by collision number.

Thus

$$\lambda = \frac{\bar{c}}{Z_1}$$

$$\lambda = \frac{\bar{c}}{\sqrt{2}\,\pi\sigma^2\,\bar{c}\,\rho}$$

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

where

$\bar{c}$ = Average velocity

σ = Diameter of molecule

ρ = Number density which is given by

Z_1 = Collision number

and $$\rho = \frac{P}{KT} \quad \text{--- (ii)}$$

P = Pressure.
K = Boltzmann constant
T = Temperature

Substituiting eqn. (ii) in eqn. (i)

$\therefore$ Equation (i) becomes

$$\lambda = \frac{1}{\sqrt{2}\pi\sigma^2 P/KT}$$

Rearranging,

$$\lambda = \frac{KT}{\sqrt{2}\pi\sigma^2 P} \quad \text{--- (iii)}$$

Mean free path is also related to the viscosity of the gas.

$$\lambda = \eta \sqrt{\frac{3}{Pd}}$$

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η = coefficient of viscosity of the gas

P = Pressure of the gas

d = Density of the gas