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Class ⇒ B.Sc. Part II Subsidiary
Subject ⇒ Chemistry
Chapter ⇒ (A) Gaseous state (States of Matter)
Topic ⇒ Collision number, Collision frequency, Mean free-path.

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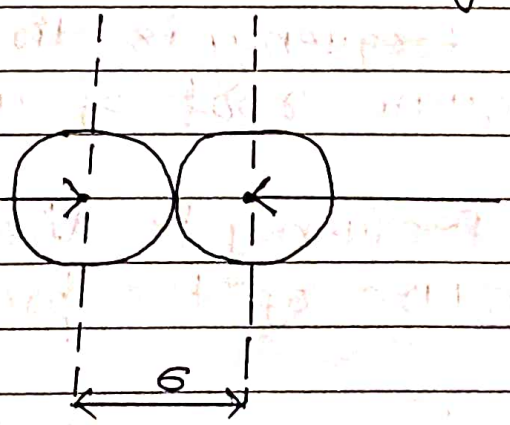
Collision number

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

Collision number is given by

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

Where, Z_1 = Collision no.
σ = Diameter of molecule
$\bar{c}$ = Average velocity
ρ = No. of molecules per unit volume of the gas.



Collision frequency

The no. of molecular collisions occurring per unit time per unit volume of the gas is called collision frequency.

Total no. of molecules colliding per unit volume per unit time is obtained by multiplying collision number by number density ρ.

Thus total no. of colliding molecules $= \sqrt{2}\pi\sigma^2\bar{c}\rho^2$

Since each collision involves two molecules of the same type, number of collisions is given by one half of this

$$Z_1 = \frac{1}{2}\sqrt{2}\pi\sigma^2\bar{c}\rho^2$$

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

It readily follows that number of collisions of molecule of type 1 ~~and~~ with those of type 2 would be given by

$$Z_2 = \frac{1}{\sqrt{2}}\pi\sigma^2\bar{c}\rho_1\rho^2$$

Where ρ_1 and ρ_2 are densities of molecules of type 1 and 2.

* Collision frequency is directly proportional to the square root of absolute temperature.

* Collision frequency is directly proportional to the square of the pressure of the gas.

Mean Free Path

The distance travelled by the molecule before collision is called free path.

The mean distance travelled by a molecule between two successive collisions is called the Mean free path.

Mean free path is denoted by λ.

If l_1, l_2, l_3 are the free paths for a molecule of a gas.

$$\lambda = \frac{l_1 + l_2 + l_3 + \cdots + l_n}{n}$$

Where n = Number of molecules with which the molecule collides.

Evidently, the no. of molecular collisions will be less at a lower pressure or lower density and longer will be the mean free path. The mean free path is also related with the viscosity of the gas.

The mean free path λ is given by the expression.

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

Where P = Pressure of the gas, d = density of the gas η = co-efficient of viscosity of the gas.

* The mean free path is directly proportional to the absolute temperature.

$$\lambda \propto T$$

* The mean free path is inversely proportional to the pressure of a gas at constant temperature.

$$\lambda \propto \frac{1}{P}$$