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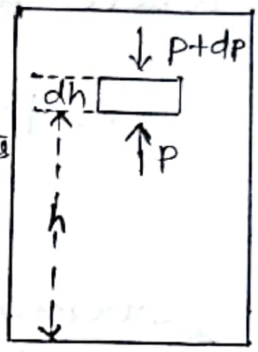
B.Sc (part-1) Hons
paper – II

Determination of Avogadro's Number.

Avogadro's Number :– It has been found that the concentration of the Brownian particles decreases with height due to gravity.

Let us consider two layers of the particles at heights h and h+dh. Let p and p+dp be the pressure respectively at these heights and ρ the density of the gas at a height h. Let us consider a unit area of layer. Hence the force due to gravity acting on the particles between the two layers on unit area.



$$= 1 \times dh \times \rho g = \rho g dh$$

∴ The net force on the layer

$$= (p+dp) - p + \rho g dh$$

Since the gas is in equilibrium state the net force must be equal to zero.

$$\therefore (p+dp) - p + \rho g dh = 0$$

$$\text{or } dp = -\rho g dh \quad \text{——— (1)}$$

∵ For a perfect gas $p = nKT$

$$\therefore \quad dp = dn(KT) \quad \text{and} \quad \rho = mn$$

Hence n is the number of molecules per unit volume and m is the mass of each molecule.

Hence substituting these value in eqn(1)

$$KT\,dn = -mng\,dh$$

$$\therefore \frac{dn}{n} = -\left(\frac{mg}{KT}\right) dh$$

$$\because K = \frac{R}{N}$$

Where R is the gas Constant and N, the Avogadro's number.

$$\therefore \frac{dn}{n} = -\left(\frac{Nmg}{RT}\right) dh \quad \text{———} (2)$$

$$\text{or, } \int \frac{dn}{n} = -\int \left(\frac{Nmg}{RT}\right) dh$$

$$\therefore \log n = -\left(\frac{Nmg}{RT}\right) h + A \quad \text{———} (3)$$

Where A is a Constant of integration

At, $h = h_0$, $n = n_0$

$\therefore$ From equation (3)

$$\log n_0 = -\left(\frac{Nmg}{RT}\right) h_0 + A$$

$$\therefore A = \log n_0 + \left(\frac{Nmg}{RT}\right) h_0$$

putting this value in eqn (3)

$$\log n = -\left(\frac{Nmg}{RT}\right) h + \log n_0 + \left(\frac{Nmg}{RT}\right) h_0$$

$$\text{or, } \log n - \log n_0 = -\left(\frac{Nmg}{RT}\right)(h - h_0)$$

$$\text{or, } \log\left(\frac{n}{n_0}\right) = -\left(\frac{Nmg}{RT}\right)(h - h_0) \quad \text{———} (4)$$

$$\therefore n = n_0 e^{-\left(\frac{Nmg}{RT}\right)(h-h_0)} \quad \text{———} (5)$$

From eqn (4), we get

$$N = \frac{RT \log(n_0/n)}{mg(h - h_0)} \quad \text{———} (6)$$

The effective mass of the suspended particles

$$m = \frac{4}{3}\pi r^3 (d_1 - d_2)$$

Where r is the radius of the particle and d_1 and d_2 are the densities of the particle and intervening fluid respectively.

$$N = \frac{3RT \log(n_0/n)}{4\pi r^3 g (d_1 - d_2)(h - h_0)} \quad \text{———} (7)$$

This measuring d_1 and r, the value ~~off~~ of N Can be obtained. It has been found to be 6.82×10^{26} mol/kg-mole but the accepted value is 6.023×10^{26} ~~Kmol~~ mol/kg-mole