Assignment - 1

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Q1)

Ans) Given :- $Z = 2mm$

$D_{AB} = 1.894 \times 10^{-9}\ m^2/s$ at 25°c and 1.5 atm

$\rho_1 = 1012\ kg/m^3$ and $\rho_2 = 1003\ kg/m^3$

Here Trichloroacetic acid diffuses and Methanol is non-diffusing

Trichloroacetic acid → A and Methanol → B

Now it is the case of steady state diffusion of A through non-diffusing B.

$$N_A = \frac{D_{AB}}{Z \cdot x_{Bm}} (J/M)_{avg} (x_{A_1} - x_{A_2})$$

Mole fraction of trichloroacetic acid (A) is calculated as follows :-

Molecular weight of trichloroacetic acid = 163.38

Molecular weight of methanol = 32.04

We Consider 100kg of solution

$$x_{A_1} = \frac{\frac{6}{163.38}}{\frac{6}{163.38} + \frac{94}{32.04}} = \frac{0.0367}{0.0367 + 2.933}$$

$$\boxed{x_{A_1} = 0.01235}$$

$$x_{A_2} = \frac{2/163.38}{2/163.38 + 98/32.04} = \frac{0.01224}{0.01224 + 3.0586}$$

$$\boxed{x_{A_2} = 0.003985}$$

$$x_{B_1} = 1 - x_{A_1} = 0.98765$$
$$x_{B_2} = 1 - x_{A_2} = 0.996015$$

Now,

$$x_{Bm} = \frac{x_{B_2} - x_{B_1}}{\ln\left(\frac{x_{B_2}}{x_{B_1}}\right)}$$

$$= \frac{0.008365}{0.008433}$$

$$\boxed{x_{Bm} = 0.9919}$$

~~The~~ Now, Calculate average mol. wt of the solution as M_1 & M_2.

$$M_1 = \frac{100\ kg}{\left(\frac{6}{163.38} + \frac{94}{32.04}\right) Kmol}$$

$$\boxed{M_1 = 33.673\ kg/kmol}$$

$$M_2 = \frac{100\ kg}{\frac{2}{163.38} + \frac{98}{32.04}}$$

$$\boxed{M_2 = 32.564\ kg/kmol}$$

$$C_{avg} = (\rho/M)_{avg} = \frac{1}{2}\left(\frac{\rho_1}{m_1} + \frac{\rho_2}{m_2}\right)$$

$$= \frac{1}{2}\left(\frac{1012}{33.673} + \frac{1003}{32.564}\right)$$

$$= \frac{1}{2}\left(30.053 + 30.8008\right)$$

$$= 30.4269\ kmol/m^3$$

Put all the value in the eqn (1)

$$N_A = \frac{D_{AB}}{Z\, x_{Bm}} \left(\rho/M\right)_{avg} \left(x_{A_1} - x_{A_2}\right)$$

Calculate diffusivity at 20°C and 1 atm.

⇒ In liquid Pressure has no effect on Diffusivity.

$$D \propto T$$

$$(D_{AB})_2 = \frac{T_2}{T_1} (D_{AB})_1$$

$$= \frac{293}{298} (1.894 \times 10^{-9})$$

$$= 1.8621 \times 10^{-9}\ m^2/s$$

Now put all value in eqn (1)

$$N_A = \frac{1.8621 \times 10^{-9} \times 30.4269 \left(0.01235 - 0.003985\right)}{2 \times 10^{-3} \times 6.9919}$$

$$\boxed{N_A = 2.389 \times 10^{-7}\ \frac{Kmol}{m^2 s}}$$