DIGITAL EDUCATION MARTCOST

CHEMICAL ENGINEERING

Mass Transfer Operations

Hand Notes For GATE, IES, PSUs & Competitive Exam

Hand Notes

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Mass Transfer

Transfer of mass from one pt. to another in a single phase or from one phase to another with the help of a driving force is known as Mass Transfer.

The driving force here is mainly the conc^n diff.

Mass transfer takes place in every case partial pressure diff, temp diff, Magnetic field diff But amount of mass tr. is negligible. So we consider only conc^n diff^n.

* The main driving force of M.T is chemical potential diff.

Types of Mass Transfer

i.) **Molecular diffusion:-** The transfer of mass (moles) or diffusion of a species takes place in a ~~turb~~ stagnent medium.

* If there is a turbulent diffusion, then there must be molecular diffusion.

Molecular diffusion occur due to motion & motion is microscopic but in turbulent diffusion motion is macroscopic.

ii.) **Turbulent or Eddy diffusion:-** If the diffusion of species takes place in a turbulent medium, then the mechanism is known as turbulent or eddy diffusion.

Some imp. things to remember:-

ρ_i => mass concentration of ith species in a solution (kg/m^3)

ρ => total mass " " all " " " " (kg/m^3)

$w_i = \frac{\rho_i}{\rho}$ => mass fraction of the ith species in the solution. (unit less)

C_i => Molar concentration of the ith species in the sol^n ($kmol/m^3$)

C => total molar concentration of all the specie in the sol^n ($kmol/m^3$)

$x_i = \frac{C_i}{C}$ => Mole fraction of the ith species in the solution.

$$\Sigma \rho_i = \rho$$
$$\Sigma C_i = C$$
$$\Sigma x_i = 1$$
$$\Sigma w_i = 1$$

The symbol x_i is mainly used for the liquid soln.
" " y_i " " " " " gaseous "

$$y_i = \frac{\bar{P}_i}{P} = \frac{\text{Partial pressure } i^{th} \text{ species}}{\text{total pressure.}}$$

Mass avg. velocity :- (u)

$$u = \frac{\Sigma \rho_i u_i}{\Sigma \rho_i = \rho} \quad \text{or} \quad u = \Sigma w_i u_i$$

Unit = m/s

u_i = linear velocity of i^{th} species.

Molar avg Velocity :- (U)

$$U = \frac{\Sigma C_i u_i}{\Sigma C_i} \quad \text{or} \quad U = \Sigma x_i u_i$$

Flux :-

The net rate at which a species in a solution passes through unit area, which is normal to the direction of diffusion in unit time.

Kg/m²s , Kmol/m² s
mass flux , molar flux.

Mass flux :- (denoted by small letter)

n_i = Mass flux of the i^{th} species w.r.t a stationary observer
= $\rho_i(u_i - 0)$ → denotes observer is stationary.
= Kg/m²s.

i_i = Mass flux of the ith species w.r.t an observer moving with mass avg. velocity.
= $\rho_i(u_i - u)$
= Kg/m²s

j_i = Mass flux of the ith species w.r.t an observer moving with molar avg. velocity.
= $\rho_i(u_i - U)$
= kg/m²s.

Molar flux :- (denoted by capital letters)

$$N_i = C_i(u_i - 0)$$

$$I_i = C_i(u_i - u)$$

$$J_i = C_i(u_i - U)$$

$$J_i = C_i(u_i - U)$$

$$\Sigma J_i = \Sigma C_i(u_i - u)$$

$$= \Sigma C_i u_i - \Sigma C_i U$$

$$= C \frac{\Sigma C_i u_i}{C} - \Sigma C_i U$$

$$= CU - CU$$

* $\boxed{\Sigma J_i = 0}$

☆ The total molar flux of all the species of a solution wrt an observer moving with molar avg. velocity is zero.

$$i_i = \rho_i(u_i - u)$$

$$\Sigma i_i = \Sigma \rho_i(u_i - u)$$

$$\Sigma i_i = \Sigma \rho_i u_i - \Sigma \rho_i u$$

$$= \rho \frac{\Sigma \rho_i u_i}{\rho} - \Sigma \rho u$$

$$= \rho u - \rho u$$

$$\boxed{\Sigma i_i = 0}$$

☆ ~~Linear~~ Mass flux of all the species in a solution wrt an observer moving with mass avg. velocity is zero.

When there is mass-mass, mole-mole symmetry flux will be zero, otherwise flux will not be zero.

$$\boxed{\begin{array}{c} i_1 + i_2 = 0 \\ J_1 + J_2 = 0 \\ N_1 + N_2 \neq 0 \end{array}}$$