CEN 3313

MASS TRANSFER

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Molecular Diffusion in Gases

Equimolar Counter Diffusion in Gasses

$$J^*_{Az} = J^*_{Bz}$$

The molar flux of **A from tank 1 to tank 2** must be the same as the molar flux of **B from tank 2 to tank 1.**

Temperature and Pressure are constant.

Molecular Diffusion in Gases-

Equimolar Counter Diffusion in Gases

$$J^{\star}_{Az} = -J^{\star}_{Bz}$$

$$\left[-D_{AB}\frac{d(c_A)}{dz}\right] = -\left[-D_{BA}\frac{d(c_B)}{dz}\right]$$

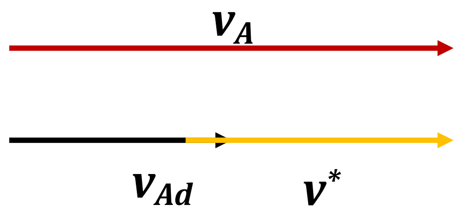
$$\boldsymbol{D_{AB} = D_{BA}}$$

Molecular diffusivity is independent of concentration.

Molecular Diffusion in Gases-

stationary observer:
A is moving faster than the bulk of the phase

Diffusion of A and B Plus Convection



$v_i - v^* =$ ***diffusion velocity---→*** v_{Ad}

v_A= velocity of A   w.r.t. stationary coordinate

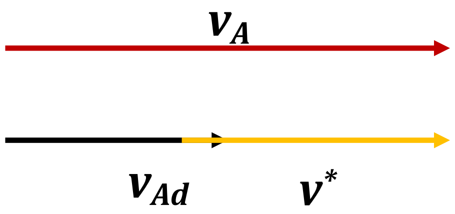
v^*= molar average velocity   w.r.t. stationary coordinate

diffusion velocity indicates the motion of A relative to the <u>local motion of the fluid stream</u>

Molecular Diffusion in Gases-

Diffusion of A and B Plus Convection

stationary observer:
A is moving faster than the bulk of the phase



Molar diffusion flux:

$$J^*_{Az}\frac{kg\ mol\ A}{s\cdot m^2} = c_A v_{Ad}\frac{kg\ mol\ A}{m^3}\frac{m}{s}$$

$$v_A = v_{Ad} + v^*$$

Multiplying by C_A

$$c_A v_A = c_A v_{Ad} + c_A\ v^*$$

?????

Molecular Diffusion in Gases-Diffusion of A and B Plus Convection

(Total flux) = (Diffusion flux) + (Convective flux)

Total flux of A relative to the stationary point	=	Diffusion flux relative to moving fluid	+	Convective flux of A relative to the stationary point
$c_A v_A$ ($= N_A$)		$c_A v_{Ad}$ ($= J^*_{Az}$)		$c_A v^*$

Total convective flux of the whole stream relative to the stationary point :

$$c\ v^* = N = N_A + N_B;\ v^* = \frac{N_A + N_B}{c}$$

Total flux of A	=	**Diffusion flux**	+	**Convective flux of A**
N_A		J^*_{Az}		$c_A\left(\frac{N_A + N_B}{c}\right)$

Molecular Diffusion in Gases-
Diffusion of A and B Plus Convection

$$N_A = -cD_{AB}\frac{d(x_A)}{dz} + \frac{c_A}{c}(N_A + N_B)$$

$$N_B = -cD_{BA}\frac{d(x_B)}{dz} + \frac{c_B}{c}(N_A + N_B)$$

For equimolar counter-diffusion $N_A = -N_B \rightarrow N_A + N_B = 0$

$N_A = J_A^* = -N_B = -J_B^*$

References

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4. Cussler E.L., Diffusion : Mass Transfer in Fluid Systems, Cambridge University Press, 3rd Edition, 2009.

5. Bird R.B., Stewart W.E., Lightfoot E.N., Transport Phenomena, John Wiley & Sons, 1960.