CEN 3313

MASS TRANSFER

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Boundary Conditions:

1. Concentration at a surface may be specified ($x_A = x_{A,s}$)

2. Molar flux at a surface may be specified

$$N_A = N_{A,s} = -cD_{AB} \left. \frac{\partial x_A}{\partial x} \right|_{x=0}$$

for impermeable surface

$$\left. \frac{\partial x_A}{\partial x} \right|_{x=0} = 0$$

Boundary Conditions:

3. If diffusion is occurring in a solid,

$$N_A = k_c\,(C_{A,s} - C_{A,\infty})$$

$k_{c;}$ convective mass transfer coefficient
N_A: molar flux
$C_{A,s}$; surface concentration $C_{A,\infty}$; free stream concentration

4. Rate of chemical reaction at a surface may be specified.

$N_{A,s} = k' C_A$ (k': first order rate constant)

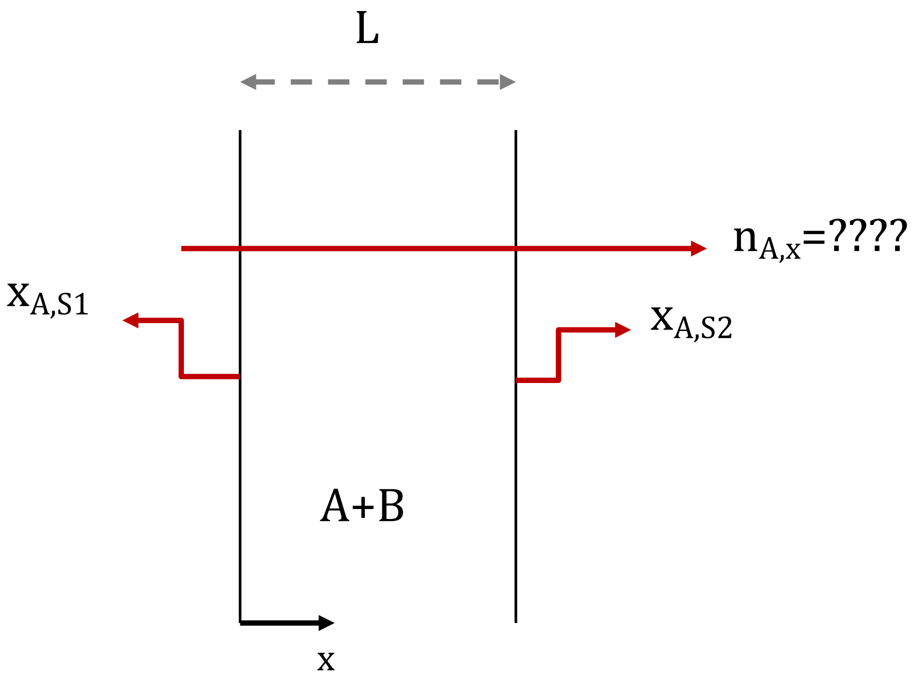
Cylindrical Coordinates:

$$\frac{1}{r}\frac{\partial}{\partial r}\left(CD_{AB}r\frac{\partial x_A}{\partial r}\right)+\frac{1}{r^2}\frac{\partial}{\partial \phi}\left(CD_{AB}\frac{\partial x_A}{\partial \phi}\right)+\frac{\partial}{\partial z}\left(CD_{AB}\frac{\partial x_A}{\partial z}\right)+r_A=\frac{\partial C_A}{\partial t}$$

Spherical Coordinates:

$$\frac{1}{r^2}\frac{\partial}{\partial r}\left(CD_{AB}r^2\frac{\partial x_A}{\partial r}\right)+\frac{1}{r^2\sin^2\theta}\frac{\partial}{\partial \phi}\left(CD_{AB}\frac{\partial x_A}{\partial \phi}\right)$$
$$+\frac{1}{r^2\sin\theta}\frac{\partial}{\partial \theta}\left(CD_{AB}\sin\theta\frac{\partial x_A}{\partial \theta}\right)+r_A=\frac{\partial C_A}{\partial t}$$

Your Turn



Consider tablets that are contained in a blister package composed of a flat lidding sheet and a second, formed sheet that includes troughs to hold each tablet. The formed sheet is L = 50 micron thick and is fabricated of a Polymer material. Each through is of diameter D = 5 mm and depth = 3 mm. The lidding sheet is fabricated of aluminum foil. The binary diffusion coefficient for water vapor in the polymer is $D_{AB} = 6x10^{-14}\ m^2/s$ while the aluminum may be assumed to be impermeable to water vapor. For molar concentrations of water vapor in the polymer at the outer and inner surfaces of $C_{A,s1} = 4.5\ x10^{-3}\ kmol/m^3$ and $C_{A,s2} = 0.5\ x10^{-3}\ kmol/m^3$, respectively. Determine the rate at which water vapor is transferred through the trough wall to the tablet.

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.