New Problems Chapter 19

19.1-22. ***Equilmolar Counter-diffusion.*** Two bulbs are connected by a tube, 0.002 m in diameter and 0.2 m in length. Initially bulb 1 contains argon (y_{A1} =0.75) + xenon and bulb 2 contains argon (y_{A2} = 0.2) + xenon. The pressure and temperature are maintained at 1 atm and 105°C, at which the diffusivity of both gasses is 0.18 cm^2/s.

a) What is the molar flux $\left(\frac{mole}{cm^2 \cdot s}\right)$ and molar velocity $\left(\frac{mole}{s}\right)$ of argon and what direction is this flux?

b) Derive an equation that predicts the mole fraction as a function of distance from bulb 1 to bulb 2, $y_A = f(x)$, then derive an equation that predicts velocity as a function of mole fraction v_A=f (y_A). Combine the two equations and plot the velocity of argon from bulb 1 to bulb two.

c) Calculate both the mass and molar average velocity of the mixture at the midpoint of the tube.

19.1-23. ***Equilmolar Counter-diffusion***. A 2 meter tube containing a mixture of carbon dioxide and air at a temperature of 317 K and a total pressure of 1 atm. At one end of the pipe, the mole fraction of carbon dioxide is 0.07 and at the other end, the mole fraction of carbon dioxide is 0.7. Find the molar flux $\left(\frac{mole}{m^2 \cdot s}\right)$ of carbon dioxide and the mass flux $\left(\frac{gm}{m^2 \cdot s}\right)$ of carbon dioxide at steady state.

19.2-7. ***A through stagnant B.*** In the second classic case of diffusion, A diffuses through stagnant, non-diffusing B (N_B =0). Starting with the general design equation $\left(N_A = -D_{AB}\frac{dC_A}{dz} + \frac{C_A}{C_T}(N_A + N_B)\right)$, solve this DVQ to get N_A and a function of concentration.

19.2-8. ***A through stagnant B.*** A large cylindrical tank with a diameter of 6 ft contains water at 50°F. The tank is open to the atmosphere (assume dry air). If the water diffuses into the air, and the stagnant air layer is .25 ft thick. Calculate the rate of evaporation at steady state in lbs/hr. D_{AB} = 0.969 ft^2/hr and the vapor pressure of water is 0.175 psi.

19.3-9. ***Diffusion through a thin film using permeability.*** A thin Nylon film 100 μm thick at 30°C has a partial pressure of N_2 outside the film of 0.79 atm and an inside partial pressure of 0.1 atm. Using permeability data from Table 19.3-1 calculate the diffusion flux $\left(\frac{mole}{m^2 \cdot s}\right)$ of N_2 at steady state. Assuming that the total pressure on both sides of the film is 1 atm and any other resistances to mass transfer other than the Nylon film are negligible.

19.4-5. ***Transition Region Diffusion.*** A mixture of CS_2 and H_2 is diffusing at 1.013 x 10^5 Pa total pressure and 298 K through a capillary having a radius of 300 Å. At one end of the capillary the y_{CS2} = 0.65 and at the other end (Δz = 12 cm) y_{CS1} = 0.15. Given: $D_{AB} = 0.458\frac{cm^2}{s}, \mu = 0.009cp$

a) Calculate the flux of H_2

b) At what radius will the capillary have to be before H_2 enters the transition region?

c) If I ask the same question (b) of CS_2 do you think the radius will be larger or smaller as compared to H_2? Explain with reasoning and calculations.

19.5-5. ***Prediction of Diffusivity of B-galactosidase***. Predict the diffusivity of the enzyme B-galactosidase $\left(\rho = 1.4\frac{gm}{cm^3},\ \text{MW} = 540{,}000\frac{gm}{mole}\right)$ in a dilute solution of water at 1 atm and 20°C using the modified Polson equation (18.2-18) and compare the result from that calculated by the Stokes-Einstein equation (18.2-13)

19.6-1. ***Diffusion and homogeneous reaction in a single phase.*** A chemical reaction of A → C occurs in a single phase. At one end of the phase (z_1 = 0 m) the concentration of A is C_{A1} = 1M, at the other end (z_2 = 0.1 m) the concentration of A is C_{A2} = 0.5M. If the rate constant $k' = 0.002\frac{1}{s}$ and $D_{AB} = 1\times10^{-5}\frac{m^2}{s}$ what is the steady state concentration of A at z = 0.05 in the homogeneous phase?

19.7-5. ***Numerical Method for Steady-State Diffusion with a Distribution Coefficient.*** For the two dimensional solid shown below, determine the steady-state concentration of all nine nodes given the following. The outside mass transfer coefficient is $k_c = 1.0 \times 10^{-8}$ m/s, the diffusivity in the solid is $D_{AB} = 1.5 \times 10^{-9}$ m^2/s. The grid size is Δx = Δy = 5mm and finally the distribution coefficient K = 3.5.