Membrane Separations

Problem set #3 (deadline 10-1-03)

1. A commercial polyvinyl alcohol (PVA) pervaporation membrane will be utilised to partially dehydrate an ethanol(1)/water(2) mixture containing 75.8% ethanol at a feed temperature of 60ºC. Since PVA membranes are hydrophilic, water will selectively permeate across the membrane. The resulting permeate was found to contain 9.0 wt% ethanol. Given that the permeate flux is 0.40 $kg/m^2 \cdot h$, calculate values of permeability coefficient for water and ethanol if the outlet pressure is 76 mmHg. Recall that the driving force in pervaporation is a difference of chemical potential (or fugacity, or activity), and that the molar flux is equal to the permeability times the driving force. Assume ideal gas and non-ideal liquid behaviour when calculating fugacities.

Membrane Separations

Problem set #3

2. A liquid containing dilute solute A at a concentration c_1=0.030 kmol/m^3 is flowing rapidly by a membrane of thickness L=3.0·10^{-5} m. The distribution coefficient K'=1.5 and D_{AB}=7.0·10^{-11} m^2/s in the membrane. The solute diffuses through the membrane and its concentration on the other side is c_2=0.0050 kmol/m^3. The mass transfer coefficient k_{c1} is large and can be considered as infinite and k_{c2}=2.02·10^{-5} m/s.

a) Derive the equation to calculate the steady-state flux N_A and make a sketch.

b) Calculate the flux and the concentrations at the membrane interfaces.

Membrane Separations

Problem set #3

3. Experiments at 25 ºC were performed to determine the permeabilities of a cellulose acetate membrane. The laboratory test section has a membrane area $A=2\cdot10^{-3}$ m^2. The inlet feed solution concentration of NaCl is $c_1=10$ g NaCl/L solution ($\rho_1=1004$ kg sol./m^3). The water recovery is assumed low so that the concentration c_1 in the entering feed solution flowing past the membrane and the concentration of the reject solution are equal. The product solution contains $c_2=0.39$ g NaCl/L sol. ($\rho_2=997$ kg sol./m^3) and its flow rate is $1.92\cdot10^{-8}$ m^3 sol./s. A pressure differential of 5514 kPa (54.42 atm) is used. Calculate the permeability constants and the solute rejection R.