New Problems Chapter 22

22.1-9 ***More Interface Concentrations and Overall Mass-Transfer Coefficients.*** The data below for an Ethanol - Water system at 298K.

x_{EtOH}	P_{EtOH} (Torr)
0.00	0.00
0.02	4.28
0.05	9.96
0.08	14.84
0.10	17.65
0.20	27.02
0.30	31.23
0.40	33.93
0.50	36.86
0.60	40.23
0.70	43.94
0.80	48.24
0.90	53.45
0.96	56.87
0.98	58.02
1.00	59.20

A Stripping tower, operating at 298K and 1 atm, was used to strip ethanol out of water into air. At one point in the apparatus, the mole fraction of ethanol in water was $x_A = 0.1$ and the partial pressure of ethanol in air was 8 Torr. The individual film mass-transfer coefficients at 298K and 1 atm were

$$k_G = 5.266\times10^{-5}\frac{kgmole}{m^2\cdot s\cdot torr} \text{ and } k_x = 1.1\times10^{-3}\frac{kgmole}{s\cdot m^2}$$

a) What is Y_{Ai} and X_{Ai}?

b) Fill in the table below all N_A's should equal [kgmole/(m^2*s)]

k_y =	$Y_{Ab} - Y_{Ai}$ =	N_A =
k_x =	$X_{Ab} - X_{Ai}$ =	N_A =
K_y =	Y_A^* - Y_{Ab} =	N_A =
K_x =	$X_{Ab} - X_A^*$ =	N_A =

c) What percentage of the overall mass-transfer resistance is in the liquid film?

22.2-1 ***Column Internals.*** A company known for selling "Mass Transfer equipment" is Koch-Glitsch. Go to their web site (https://www.koch-glitsch.com/Products-Overview). Briefly describe the major types of products sold under the tabs "Trays" and "Packing and Internals" (look at bottom of web page).

22.3-1 ***Finding diameter of an Ammonia Adsorption Tower.*** A gas stream contains 5.0 mol % NH_3 and its ammonia content is reduced to 1.0 mol % in a packed absorption tower at 293 K and 1.013×10^5 Pa. The inlet pure water flow is 154.5 kg mol/h and the total inlet gas flow is 100 kg mol/h. What is the tower diameter if the tower is packed with 2in ceramic berl saddles?

22.4-1 ***Comparing operating lines.*** You are designing a CO_2 absorber to reduce the CO_2 concentration to 0.1% for the feed to an ammonia reactor. The inlet flow rate to your absorber will be 8000 kgmol/hr. The composition (mole fraction) of the gas is 60% H_2, 20.6% N_2 and 19.4 % CO_2. The liquid used to absorb the CO_2 is a dilute aMDEA + water solution that has a μ = 2.0 cp and a ρ_L = 1050 kg/m3. The column will be filled with IMTP (2 in) random packing. From years of experience the liquid flow rate should be 6.7 times the gas flow rate on a mass basis. Draw an operating line with absorbing free balance and a simple CO_2 balance assuming the vapor and liquid rates are constant. Assume for both operating lines that x_{in} = 0 and x_{out} = 0.032 on a mole fraction basis.

22.5-15 ***Is an Existing Absorption Tower Acceptable?*** It is desired to reduce the ammonia content of a 0.06 m3/s of an ammonia-air mixture (300K and 1 atm) from 1.0% to 0.04% by volume by water scrubbing. In the "bone yard" There is available a 0.3 m diameter tower packed with 25 mm ceramic Raschig rings to a depth of 3.5 m. Is the tower satisfactory, and if so, what water rate (kg/min) should be used? The equilibrium line is straight with a slope of 1.414. Use equation 22.6-7 to find HETP then convert to Hoy.

Data:

	Liquid	**Vapor**
Density	998 kg/m3	
Viscosity	0.8 cp	1.84×10^{-5} Pa-s
Diffusivity	1.64×10^{-5} cm2/s	0.28 cm2/s

22.6-4 ***Estimation of the Tower Diameter of a Sieve Tray.*** A steam stripper is operating isothermally at 100.0°C. Entering liquid stream contains 0.03 mol% nitrobenzene in water at 100.0°C. Flow rate of entering liquid is 20 kmol/min. Entering steam is pure water at 100.0°C. Outlet liquid mole fraction is 0.00003 nitrobenzene. L/V = 12.0. Total liquid and gas flow rates are constant. What is the diameter of the column assuming it operates at 85% of flooding and σ = 23 dyn/cm? Use Equation 26.6-1 and Figure 26.6-1 (y axis = Kv) with a tray spacing of 2 ft.

22.7-5 ***Design of a Stripping Tower.*** While working at the company formally known as Tri-State Chemicals, you are asked to design a stripping tower to remove carbon tetrachloride (CCl_4-MW 153.8) a volatile organic compound found in groundwater near the plant $\left(L_{in} = 1000\frac{kgmole}{hr}\right)$. Your goal is to reduce the CCl_4 down to 0.5 mole% from 2.0 mole%. The stripping gas is pure air (MW 29) with its μ = 0.015cp, ρ_g = 2 kg/m3. The liquid is mostly water that has a μ = 1.0 cp and a ρ_L = 1000 kg/m3. The column will be filled with 1in Raschig rings with a $K_X a = 200\frac{kgmole}{m^3 \cdot hr}$. The total pressure in the column is 2.0 atm and the Henry's law constant 16.0 atm/ mole frac CCl_4 .

i. Draw a picture and complete the Material Balance
ii. Draw both the equilibrium line and operating line, assuming both are straight.
iii. Calculate the diameter of the column (ft)
iv. Calculate the N_{ox} using the log-mean equation
v. Calculate the H_{ox} (ft)
vi. Calculate the Height (ft)

22.8-3 ***Prediction of liquid film coefficient for Adsorption of hydrofluoric acid (HF) from air.*** While working at Thunder Chemicals you are asked to design and absorber tower to remove hydrofluoric acid (HF) from air. Your goal is to recover at least 98% of the HF. The gas contains 97% air (MW 29) and 3% HF (MW 20). The inlet flow rate of the gas to your absorber will be 150 kgmol/hr at 25°C. Its μ = 0.015cp, ρ_g = 2 kg/m3. The liquid used to absorb the HF is water that has a μ = 1.0 cp and a ρ_L = 1000 kg/m3. The column will be filled with ceramic Berl saddles (1 in) random packing and the diameter of the column is 1.2m. The total pressure in the column is 1.6 atm and the Henry's law constant 4.0 atm/ mole frac acetone. Calculate the liquid film coefficient H_X if $D_{AB} = 3.1\times10^{-5}\frac{cm^2}{s}$.

22.9-2 ***Calculation of Equilibrium line.*** The following data for H_2S follows an Arrhenius type relationship in which the Henry's law constant is a function of temperature. Using this data along with the column's temperature profile calculate and plot the equilibrium line across the column.

Temperature (°C)	Henry's Law constant (Unitless)
5	293
10	418
15	470
20	499
25	517
30	529

Location in column	y_A	Temperature (°C)
Entrance	0.05	20
Middle	0.022	35
Exit	0.01	49