CHEN 320

Individual Homework

1. You need to copy-paste your MATLAB codes and results to the Word processing software, export it as PDF, and then upload the PDF file.
2. You also need to upload the MATLAB file (.m file)

Homework Problems

Question 1

Consider the liquid/liquid stage extraction process with an immiscible solvent shown in figure P4.9.4. Note that stream *W* enters the first stage containing X_{in} weight fraction of material A and solvent S enters the last stage (*N*) containing Y_{in} weight fraction of material A. As the solvent flows through the process, it retains more A, thus extracting A from *W*.

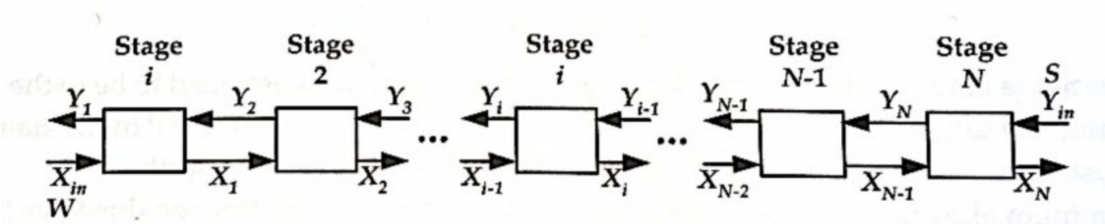

Figure P4.9.4 Countercurrent extraction process.

From each stage (*i*), we assume equilibrium between the weight fraction of A in S (Y_i) and the weight fraction of A in W (X_i), Assuming that each stage is operated at the same temperature, the relationship between X_i and Y_i can be given as

$$Y_i = KX_i$$

Now performing a mass balance on A for the *i*th stage, assuming that X_i and Y_i are small so that *S* and *W* remain constant through the process:

$$X_{i-1}W + Y_{i+1}S = X_iW + Y_iS$$

Using the equilibrium relationship, assuming *K* remains constant and rearranging results in

$$X_{i-1} - (1 + KS/W)X_i + (KS/W)X_{i+1} = 0$$

Applying this equation to the first stage results in

$$-(1 + KS/W)X_1 + (KS/W)X_2 = -X_{in}$$

And for the last stage

$$X_{N-1} - (1 + KS/W)X_N = -(S/W)Y_{in}$$

Note that this system of linear equations has a tridiagonal coefficient matrix. Determine the recovery efficiency (percent A entering in *W* that is recovered in *S*) for the following conditions:

$$S = 1000\ kg/hr \quad W = 2000\ kg/hr \quad X_{in} = 0.05 \quad Y_{in} = 0.0 \quad K = 10 \quad N = 10$$

Question 2

Consider the following reaction network:

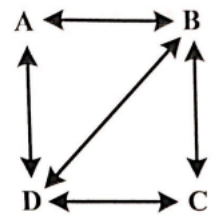

Figure P4.9.6 Reaction network.

where the double headed arrows indicate reversible reactions and each reaction is first order. (i.e., the reaction rate is equal to the product of a rate constant times the concentration of the reactant). Assume that the reaction is carried out in a batch reactor at constant temperature and pressure and the reactor initially contains only component A at a concentration of 1.0 gmole/liter. Then the steady-state macroscopic material balances for each component can be written as:

Component	**Generation**	**-Consumption**	**=0**
A	$k_{BA}C_B + k_{DA}C_D$	$-k_{AB}C_A - k_{AD}C_A$	=0
B	$k_{AB}C_A + k_{CB}C_C + k_{DB}C_D$	$-k_{BA}C_B - k_{BC}C_B - k_{BD}C_B$	=0
C	$k_{BC}C_B + k_{DC}C_D$	$-k_{CB}C_C - k_{CD}C_C$	=0
D	$k_{AD}C_A + k_{CD}C_c + k_{BD}C_B$	$-k_{DA}C_D - k_{DC}C_D - k_{DB}C_D$	=0

Where k_{AB}=0.1, k_{BA}=0.02, k_{BC}=0.5, k_{CB}=0.1, k_{CD}=0.01, k_{DC}=0.1, k_{DA}=0.05, k_{AD}=0.2, k_{BD}=0.3, and k_{DB}=0.1, and where all rate constants have units of reciprocal seconds.

When the condition number is determined for this set of equations, it indicates that there are only three independent equations; therefore, because there are four unknowns, an additional equation is required. The fact that the reactor initially contains only A at a concentration of 1.0 gmole/liter has not been used. After consideration of the reaction scheme and the fact that the stoichiometric coefficient of each reaction is unity:

$$C_A + C_B + C_C + C_D = 1.0$$

Solve for the steady-state concentration of each component in this batch reactor.