Quiz 2

Units 4 and 5: Material balances on systems with vapor-liquid equilibrium and equations of state for single-phase systems

Estimated time: 50 minutes

Directions:

i. Write your name on all pages.
ii. I should be able to calculate all desired values using your solution and a calculator. Be sure to transpose all values from charts, tables, etc.

Selected physical property data for water (copied from Table B.1):

Tb at 1 atm	Density (g/L)	MW (g/mol)	SG
100 °C	1,000	18.02	1

Additional tables are attached:

- Table B.1
- Table B.4
- Figure 5.4-3

Quantitative Question: SHOW ALL WORK. WRITE NEATLY.

(100 points) At a nail polish remover plant, the wastewater from cleaning the tanks contains a mixture of water and acetone. The floor operator decides to design a system to recover the acetone. In a continuous, steady state process—the liquid acetone/mixture is fed to a flash evaporator where only the acetone is vaporized. Then the vapor acetone stream is sent to a heated compressor where it is compressed. After compression it is piped elsewhere in the plant for other applications.

In this design, the 2:1 (mol:mol) mixture of water/acetone is fed to a flash evaporation unit where only the acetone is vaporized. The flash evaporator unit operates at 200 mmHg. The mol fraction of acetone in the liquid phase leaving the evaporator is 0.1. The compressor applies a pressure of 23.5 atm to the acetone vapor while heating it to 508 K. The volumetric flowrate of acetone leaving the compressor is 10 L/min.

- What is the operating temperature of the flash evaporator (°C)?
- What is the total volumetric flowrate of the liquid stream leaving the flash evaporator (L/min)?

a. (15 points) Draw and fully label a process flow diagram. Assign variables to all relevant unknowns.

b. (10 points) Translate any additional information from the problem statement into mathematical expressions. Write mathematical expressions or variables to describe the quantities for which you will solve. Use the variables from your process flow diagram.

c. (15 points) Perform a degree of freedom analysis on the COMPRESSOR and EVAPORATOR. Clearly identify the variables and equations associated with the analysis.

d. (60 points) Based on your DOF analysis, list the equations you would use to solve the problem and explain how you would use them to answer the questions posed in the problem statement (i.e. how to calculate the values identified in part b.) DO NOT SOLVE THE EQUATIONS.

BE SPECIFIC

- Clearly cite any tables or tabulated values used in your analysis.
- If you need a value from a table or chart, write the value and cite the table or chart (i.e. A, B, C, z)
- If the calculation requires a T or P, specify which one you are using.
- If you need a “z” value, only do enough calculations to be able to obtain this value. Do not solve the whole problem.