Review Problems for Units 4 & 5

1. **<u>Distilling Vodka.</u>** Vodka is made by mashing potatoes, fermenting the potato mash, filtering out the solids and then distilling the resulting solution. The goal of the distillation process is to enrich the vapor phase in ethanol whereby increasing the alcohol content of the final product. The water/ethanol mixture is fed to the distillation column. The vapor phase (ethanol enriched) from the distillation column is sent to a total condenser. The stream exiting the total condenser becomes the final beverage product. The bottoms product from the distillation column (ethanol deplete-liquid phase) is discarded.

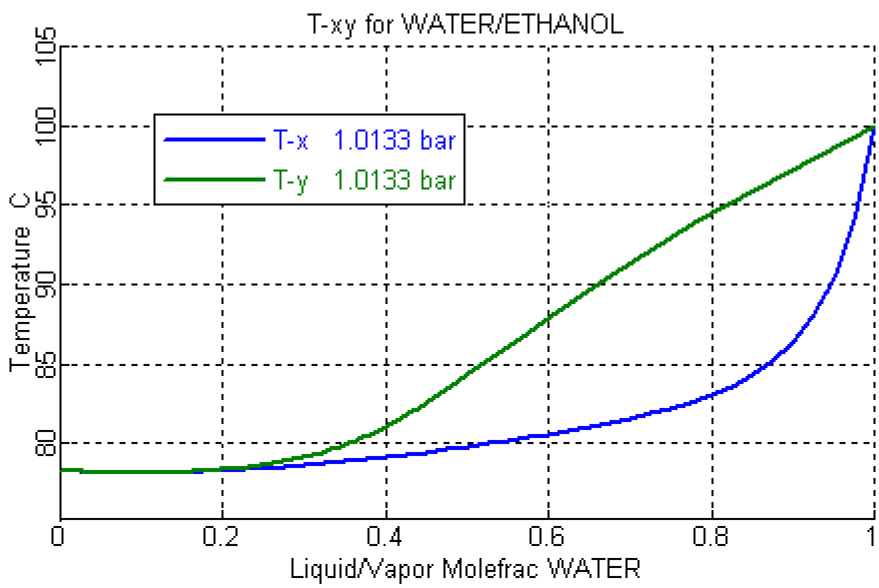
   In a continuous, steady state vodka distillation process, ethanol and water both exist in vapor-liquid equilibrium at 1 atm. The vapor phase (enriched in ethanol) is fed to a total condenser which liquefies the entire vapor phase, creating the final vodka product. The bottoms stream from the distillation column contains 40mol% ethanol.

   a. Draw and fully label a process flow diagram. Remember for VLE problems, all streams require T and P.

   b. What is the bubble point temperature for the distillation process? What is the composition of the first bubble that forms?

   c. Consider the same distillation process but now it is operating at 90°C. What is the composition of the vapor phase (i.e. final vodka product) in ABV? ABV is alcohol by volume (Vethanol/Vvodka).

   d. (3 points) Now, for the process operating 90°C, you want to produce 1 L of vodka in 1 hour. How much feed solution would you need? Perform a DOF analysis. If solvable, outline your problem solving procedure. If it's not solvable, state what more information you would need to solve the problem.



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2. **<u>Zippo Lighters.</u>** At a chemical plant, a waste stream contains a mixture of n-butane and nitrogen at 88°C and 7.5 atm. To convert this waste stream into a higher value product, you design a process to liquefy the n-butane and sell it to Zippo Lighters.

The n-butane/nitrogen mixture is fed to the partial condenser in a 1:1 molar ratio. The feed mixture has a temperature of 88°C, pressure of 7.5 atm and volumetric flowrate of 1,000 L/min before it enters a partial condenser. The partial condenser operates at a pressure of 1 atm. Some of the n-butane is condensed and exits the condenser in the liquid stream (product stream). The mole fraction of n-butane in the vapor stream exiting the condenser is 0.2.

- What is the total volumetric flowrate of the vapor phase mixture exiting the condenser (L/min)?
- What is the operating temperature of the partial condenser (mmHg)?
- What is the volumetric flowrate of the liquid n-butane product (L/min)?

a. Draw and fully label a process flow diagram. Assign variables to all relevant unknowns.

b. 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. Utilize the variables from your process flow diagram.

c. Perform a degree of freedom analysis on all process units. Clearly identify the variables and equations associated with the analysis. Determine the order in which you would solve the problem.

d. 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).

BE SPECIFIC

- Clearly cite any tables or tabulated values used in your analysis.
- If you need a value from a table or chart, <u>write the value</u> 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.