ECHE 260: MIDTERM

Units 1-5: Material balances on chemical process with chemical reactions and phase change

Name: _____

50 minutes, closed book, closed notes, no calculators, no cell phones

Directions:

i. Write your name on all pages.
ii. You may tear the packet apart, but you must staple you quiz together in the correct order.
iii. You must turn in your tables/equations packet.

Conceptual Questions: *You <u>do not</u> need to justify your answers.*

1. (3 points) Consider the material balances covered in this course. For each of following statements, circle TRUE or FALSE.

   MOLES are ALWAYS conserved in a chemical process: TRUE or FALSE.

   MASS is ALWAYS conserved in a chemical process: TRUE or FALSE.

   VOLUME is ALWAYS conserved in a chemical process: TRUE or FALSE.

2. (2 points) While calculating the temperature of a mixture of non-ideal gasses, you calculate the ideal reduced molar volume and reduced pressure from the pseudocritical properties.

   If $\hat{V}_r^{ideal} = 0.30$ and P_r=2.5, what is the value of the compressibility factor, z?

   Z = _____

Quantitative Question: SHOW ALL WORK. WRITE NEATLY.

(95 points) Acetaldehyde can be produced by the Wacker process in which ethylene is catalytically oxidized to form acetaldehyde. The reaction is described by the gas phase chemical reaction below:

$$2C_2H_4(g) + O_2(g) \rightarrow 2C_2H_4O\ (g)$$

In a continuous, steady state process, a gaseous mixture of ethylene (C_2H_4) and oxygen (O_2) enters a reactor at 2 atm and 600K. C_2H_4 and O_2 are fed to the reactor in a stoichiometric ratio. The molar flowrate of acetaldehyde exiting the reactor is 10 mol/min. The fractional conversion of the ethylene in the reactor is 0.50. The reactor effluent is fed to a partial condenser which operates at a pressure of 1 atm. The liquid product stream of the process consists of pure acetaldehyde and the vapor phase mol fraction of acetaldehyde is 0.1. What is the operating temperature of the condenser? What is the volumetric flowrate of the gas mixture entering the reactor? What is the volumetric flowrate of the liquid acetaldehyde exiting the condenser?

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

b. (10 points) Write mathematical expressions or variables to describe the quantities for which you will solve. Use the variables from your process flow diagram.

c. (10 points) Translate all additional information from the problem statement into mathematical expressions. Use the variables from your process flow diagram.

d. (20 points) Perform a degree of freedom analysis on the REACTOR and CONDENSER. Clearly identify the variables and equations associated with the analysis.

e. (40 points) Based on your DOF analysis, list the equations you would use to solve the problem, in order, and explain your problem-solving process. Clearly cite any tables or tabulated data used in your analysis. DO NOT SOLVE FOR NUMERICAL VALUES.