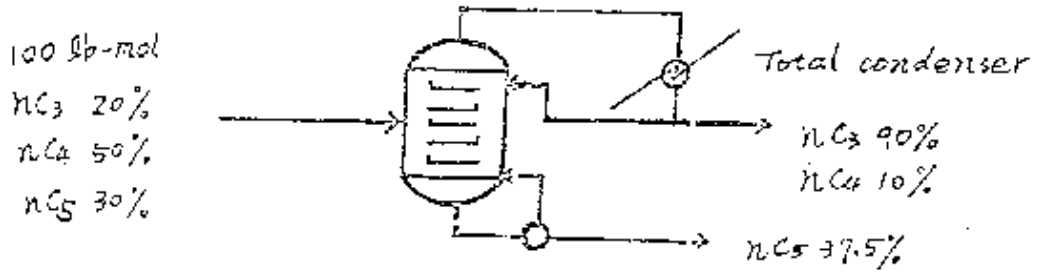
Chemical Engineering Thermodynamics

Answer the following any five questions numbered from 1~7.(3% each)

1.Duhem theorem
2.Effect of pressure on chemical reaction equilibrium 1)gas phase reaction 2)liquid phase reaction
3.Chemical reaction equilibrium criteria
4. Derive the combined first and second laws of thermodynamics
5.Application of Gibbs-Duhem equation
6.Chemical potentials and partial molar properties (illustrate two different examples for each)
7.Application of van Laar correlation model
8.A distillation column under steady-state operation is shown below



Please calculate

1.Top product flow rate 2%
2.Bottom product flow rate 2%
3.Bottom product composition 2%
4."Explain how" to obtain the best temperature of the total condanser (you do not have to calculate) (4%)

9.Write out the energy balance equation for a system of unsteady state flow process. (3%)
10.Write out the two statements of the second law of Thermodynamics. (4%)
11.Explan internal energy and entropy. (4%)
12.Write out the mathematical expressions regarding the second law of thermodynamics. (4%)
13.Derive a fundamental property change relation for a solution of variable composition. (3%)
14.Write out respectively the mathematical expressions for calculating residual enthalpy and entropy (4%)
15.Describe the applications of chemical reaction equilibrium. (3%)

Chemical Reaction Engineering: (50 %)

1. Given the reactions

$$2A \longrightarrow R_{desired}, \quad r_R = k_1 C_A^2 \quad ; \quad k_2/k_1 = 8$$
$$A \longrightarrow S, \quad r_S = k_2 C_A$$

(a) What are the fractional yield expressions $\mathcal{Y}$ (R/A) and $\mathcal{Y}$ (R/R+S) for this system?

(b) In what type of single reactor, plug or mixed, would you expect to find the $C_{R,max}$?

(15 %)

2. Describe briefly the residence time distribution (RTD) function, E(t). What does the E(t) look like for plug and mixed flow respectively?

(10 %)

3. Ethylene is produced by the dehydrogenation of ethane

$$C_2H_{6(g)} \xrightarrow{K} C_2H_{4(g)} + H_{2(g)}$$

Determine the plug flow reactor volume necessary to produce 100 million kilograms of ethylene a year from the above reaction. The reaction is irreversible and elementary. We want to achieve 80 % conversion of ethane, operating the reactor isothermally at 1100 K and a pressure of 6 atm. The rate constant k at 1100 K is 3.07 sec^{-1}.

< Hint > $\displaystyle\int_0^{\chi} \frac{1+\varepsilon\chi}{1-\chi}\, d\chi = (1+\varepsilon)\ln\frac{1}{1-\chi} - \varepsilon\chi$ (15 %)

4. The space time necessary to achieve 80 % conversion in a CSTR is 5 h. (a) Determine the reactor volume required to process 2 ft^3/min. (b) What is the space velocity for this system?

(10 %)