CHG 3127 Tutorial Session 1: (2019-01-15)

Question A

You have available to you reactive molecular forms of tomato juice (T) and clam juice (C) that react to produce delicious liquid clamato juice (M) according to the following stoichiometric equation:

$$T + 2C \rightarrow 3M$$

Your friend (who has done this before many times) informs you that the reaction rate constant is approximately $\mathbf{k_T = 0.96\ \left(\frac{L^2}{mol^2}\right) s^{-1}}$ and that the reaction is first order with respect to $\boldsymbol{C}$ but doesn't remember what order it is with respect to $\boldsymbol{T}$.

You pour a mixture of $\boldsymbol{T}$, $\boldsymbol{C}$, and inert water ($\boldsymbol{W}$) into a 500 mL isothermal agitated batch reactor. The initial mixture contains 0.5 mol/L of $\boldsymbol{T}$, 1.0 mol/L of $\boldsymbol{C}$, and 0.1 mol/L of $\boldsymbol{W}$.

Given this information, determine the following.

i) What is the reaction order with respect to $\boldsymbol{T}$?

ii) What species is the limiting reactant?

iii) Calculate the initial rate of production of each of the following: T, C, M, and W.

iv) Assuming the reaction rate r_M in this reactor is essentially constant at 0.72 mol/L/min, how long it will take T in the reactor to reach a concentration of 0.3 mol/L. (Please first derive the general mole balance equation for this system and then solve, using the assumption of a constant reaction rate.)

v) How many moles of M were produced when the concentration of T is 0.3 mol/L.

(Question 2 on next page…)

Question B

An isothermal flow reactor is operating at steady state. It is fed a single inlet stream containing species A and B at flow rates of 2.3 mol/min and 1.2 mol/min, respectively. The overall volumetric flow rate of the feed stream is 10 L/min and the reaction $2A + B \rightarrow C$ displays elementary kinetics with respect to A and B with a rate constant in terms of species A, k_A, of 0.0115 (L/mol)/s.

i) Determine the limiting reactant.

The concentrations of species A and B depend on the fractional conversion X according to the following expressions:

$$C_A = C_{A0}(1 - X)\ C_B = C_{A0}(0.5217 - 0.5X)$$

ii) In Excel, reproduce and complete the table below. (Recall that r_A is the production rate of species A and F_{A0} is the inlet molar flow of species A.)

X	r_A	$F_{A0}/-r_A$
	(mol/L)min^{-1}	L
0.00		
0.05		
0.10		
0.15		
0.20		
0.25		
0.30		
0.35		
0.40		
0.45		
0.50		
0.55		
0.60		
0.65		
0.70		
0.75		
0.80		
0.85		
0.90		
0.95		

iii) In Excel, plot $F_{A0}/-r_A$ as a function of X.

iv) What type of plot did you generate above?

v) Given your data, what volume of CSTR is required to achieve 20% conversion of the limiting reactant?

vi) Again, based on the data from the table, what volume would be required for a PFR reactor achieving 20% conversion of the limiting reactant?