Reactor Design I: Tutorial 2. Reactor Systems

Department of Chemical Engineering, University of Cape Town
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Question 1

Develop the stoichiometric table for case of a single reaction in which M reactants with varying stoichiometric coefficients react to product N products (also with varying stoichiometric ratios). The reaction may therefore be represented as follows:

$$r_1R_1 + r_2R_2 + ... + r_{M-1}R_{M-1} + r_MR_M \rightarrow p_1P_1 + p_2P_2 + ... + p_{N-1}P_{N-1} + p_NP_N$$

You may assume that the reaction is elementary.

Determine the mole fraction of each reactant as a function of conversion, if conversion is defined based on the amount of the first reactant (R_1) and if:

a) the reactor operates in the liquid phase (CSTR and PFR)
b) the reactor operates in the gas phase at less than 15 bar (CSTR and PFR)

Question 2

Consider the following reaction: $A + 2B \rightarrow C$ which has a reaction rate constant k = 0.23 and the reaction is elementary.

The reactor is fed with 50mol/s of A and 150 mol/s of B. All components remain in the liquid phase, and it may be assumed that the reaction mixture density is approximately that of water. The molar mass of A is 0.025kg.mol^{-1} whereas C is 0.060kg.mol^{-1}.

a) If a tank of volume 5.4m^3 containing a high speed mixer is available, what conversion is possible in the reactor?
b) If 3 tanks, each having a volume of 5.4m^3 containing a high speed mixers are available, what is the maximum possible conversion?

Question 3

Consider the following reaction: $2A + B \rightarrow 2C$ which has a reaction rate constant k = 1x10^{-7} , and it is known that the reaction is elementary. The reaction is to occur in a tubular packed (with catalyst) bed reactor.

The molar masses of A and B are 0.035kg/mol and 0.015kg/mol respectively. Density of the catalyst is 2500kg.m^{-3}, particle diameter is half a centimeter, diameter of a tube is 5cm, bed porosity is 0.55, reaction temperature 112^{0}C, rate constant is 1x10^{-7}, gas viscosity is 3x10^{-5}Pa.s.
Reactant feed: [F_A,F_B,F_C] = [100 50 0]. The feed flow to the reactor is at a pressure of 12atm.

Develop the conversion and pressure profiles over a 20kg catalyst tube.