Department of Chemical Engineering

CHL 103; Major, 40 marks Time Duration = 2 hours; Closed Book/ Notes

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Fundamentals of Flow reactors and Reactor Design:

1. Find the reactor volume required to obtain 90% conversion in the reaction involving ideal gases, in a CSTR and in a PFR, where the reaction is first order irreversible; Initial concentration of A is about 2 mol/l, k = 0.5 min^{-1} and flow rate of feed is 4 l/min.
   The reaction is A → n B
   Do this calculation for n = 1, 2 (6)

2. The reaction A → B, r = k C_A occurs in equal volume CSTRs in series, each with a residence time τ, with an overall conversion of 90%. If k = 0.5 min^{-1}, C_A = 2 Mol/l and q = 4 l/min. How many CSTRs are necessary in series in order to approach the PFR performance up to within 5%. (6)

Heat Effects

3. Consider a CSTR with a reaction, A → B, which is first order, exothermic. If we were to carry out the reaction adiabatically, please derive the X vs T expression, based upon the – (a.) Material Balance and (b.) the Energy balance. Make appropriate assumptions and use the necessary expressions for concentration, flow rate, specific heat capacity etc. (8)

Heterogeneous Catalytic Reactions

4. Consider the case of the heterogeneous reaction: H_2 + ½ O_2 → H_2O taking place on a Platinum catalyst. Usually a poison like CO finds its way into the hydrogen stream, in very small amounts but due to its high heat of adsorption, preferentially adsorbs on the same sites that hydrogen is adsorbing on to. Express the reaction rate, in terms of measurable quantities, assuming surface reaction to be rate-limiting. Consider the inhibition of the reaction by the poison, as well. (10)

5. Derive an expression for the Effectiveness Factor for a cylindrical ring pellet of internal radius r_i and external radius r_o and length L. Make sure you obtain the final differential equation and the necessary boundary conditions, assuming that the reaction is a first order system. (10)