Exam.Code:0908
Sub. Code: 6303

2054

B.E. (Biotechnology) Fourth Semester

BIO-413: Chemical Reaction Engineering

Time allowed: 3 Hours **Max. Marks: 50**

NOTE: Attempt five questions in all, including Question No. I which is compulsory and selecting two questions from each Section.

x-x-x

1. Attempt the following:-

a) Recommend and justify suitable reactor/reactors for carrying out an auto-catalyzed reaction.

b) What do you understand by "order of a reaction"?

c) Develop an expression for the specific reaction rate constant based on Arrhenius theory.

d) Differentiate between a chemical process and a bioprocess.

e) For the equation B + 2D → 4T compare the relative rate constants for all the components. Calculate fractional change in volume for the system.

f) Define the distinction between holding time and space time for flow reactors.

g) Describe the ideal contacting patterns.

h) Explain non-elementary reactions.

i) Describe the role of baffles in reactors.

j) Suggest a suitable ordering of reactors (plug, small mixed, large mixed) for any n^{th} order reaction if i) $n>0$ ii) $n<0$.

(1x10)

Section-A

2. To explain the kinetics of the given reaction, it has been postulated that, with hydrogen ions as catalyst, normal unreactive H_3PO_2 is transformed reversibly into an active form, the nature of which is unknown. This intermediate then reacts with the oxidizing agent to give H_3PO_4. For the reaction $H_3PO_2 \rightarrow H_3PO_3$; under the influence of oxidizing agents, hypo phosphorous acid is transformed into phosphorous acid.

   At a low concentration of oxidizing agent, $rH_3PO_3 = k[\text{Oxidizing agent}][H_3PO_2]$

   At high concentration of oxidizing agent, $rH_3PO_3 = k'[H^+][H_3PO_2]$

   Show that this scheme does explain the observed kinetics. (10)

3. A radioactive isotope decays at a rate proportional to the amount of isotope present. If the concentration of the isotope is C (mg l^{-1}), its rate of decay is: $r_C = k_1C$.

   i) A solution of radioactive isotope is prepared at concentration C_0. Show that the half-life of the isotope is equal to ln $\{2/k_1\}$. ii) A solution of the isotope ^{32}P is used to radioactively label DNA for hybridization studies. The half-life of ^{32}P is 14.3 days. As per institutional safety requirements, the solution cannot be discarded until the activity is 1% of its present value. How long will this take?

   (10)

P.T.O.

4. a) For a constant density reaction system (A + B → R + S), find the concentration or partial pressure of the reacting material as a function of the total pressure at any time t and initial partial pressure and initial total pressure of the system.

   b) Milk is pasteurized if it is heated to 63°C for 30 min. but if it is heated to 74°C it requires only 15s for the same result. Find the activation energy of this sterilization process.

(5,5)

Section-B

5. a) The kinetics of the aqueous-phase decomposition of A is being investigated in two mixed flow reactors in series, second reactor having twice the volume of the first reactor. At steady state with a feed concentration of 1 mol A/liter with mean residence time of 96 sec in the first reactor, the concentration liter in the first reactor is 0.5 mol A/ and in the second is 0.25 mol A/liter. Find the kinetic expression for this decomposition.

   b) Explain which type of reactor do you choose for series reaction scheme A→R→ S for achieving the desired product distribution. (5,5)

6. a) Describe the method to evaluate the reactor size for an adiabatic operation in a tubular reactor. What is understood by 'optimum temperature progression'? Illustrate with an example of reversible exothermic reaction using a given feed material.

   b) Discuss that for the reactions in parallel, the key to the proper control of product distribution is the concentration level of the reactants. (6,4)

7. a) Elaborate the competitive and non-competitive inhibition kinetics of an enzymatic reaction. With the help of the appropriate plots differentiate between competitive and non-competitive inhibition from a reaction occurring without any inhibition.

   b) Starting with separate feeds of reactant A and B of given concentration for the following reaction as

$$A + B \rightarrow R \text{ (desired)} \ldots\ldots\ldots r_1$$

$$R + B \rightarrow S \text{ (undesired)} \ldots\ldots\ldots r_2$$

   Sketch the best contacting patterns for the continuous and non-continuous operations

   i) $r_1 = k_1 C_A C_B^2$ & $r_2 = k_2 C_R C_B$ ii) $r_1 = k_1 C_A C_B$ & $r_2 = K_2 C_R C_B^2$

   iii) $r_1 = 1.0 C_A^{1.5} C_B^{0.3}$ & $r_2 = 1.0\, C_A^{0.5}\, C_B^{1.8}$

(6,4)

x-x-x