

Time allowed: 3 Hours

Max. Marks: 50

NOTE: Attempt five questions in all, including Question No. 1 which is compulsory and selecting two questions from each Section.

x-x-x

1. Attempt the following:-

- Recommend and justify suitable reactor/reactors for carrying out an auto-catalyzed reaction.
- What do you understand by "order of a reaction"?
- Develop an expression for the specific reaction rate constant based on Arrhenius theory.
- Differentiate between a chemical process and a bioprocess.
- For the equation  $B + 2D \rightarrow 4T$  compare the relative rate constants for all the components. Calculate fractional change in volume for the system.
- Define the distinction between holding time and space time for flow reactors.
- Describe the ideal contacting patterns.
- Explain non-elementary reactions.
- Describe the role of baffles in reactors.
- Suggest a suitable ordering of reactors (plug, small mixed, large mixed) for any  $n^{\text{th}}$  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,  $r_{H_3PO_3} = k[\text{Oxidizing agent}][H_3PO_2]$

At high concentration of oxidizing agent,  $r_{H_3PO_3} = k'[H^+][H_3PO_2]$

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  $C$  ( $\text{mg l}^{-1}$ ), its rate of decay is:  $r_C = k_1 C$ .

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  $^{32}\text{P}$  is used to radioactively label DNA for hybridization studies. The half-life of  $^{32}\text{P}$  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.

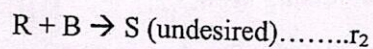
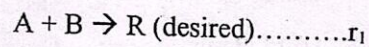
(2)

4. a) For a constant density reaction system ( $A + B \rightarrow R + S$ ), 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  $63^\circ\text{C}$  for 30 min. but if it is heated to  $74^\circ\text{C}$  it requires only 15s for the same result. Find the activation energy of this sterilization process.

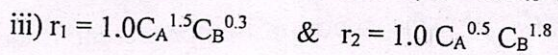
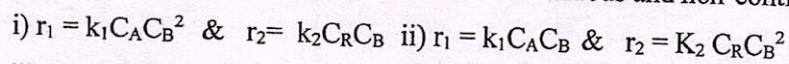
(5,5)

**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  $A \rightarrow R \rightarrow S$  for achieving the desired product distribution.
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.
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



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



(6,4)

x-x-x