(32)

Exam.Code:0908
Sub. Code: 6703

1059

B.E. (Biotechnology) Fourth Semester

BIO-413: Chemical Reaction Engineering

Max. Marks: 50

llowed: 3 Hours

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

x-x-x

a) Compare the performances of the plug flow and the stirred tank reactors behaving ideally.
b) Derive expressions for the overall conversions for a reaction of known order.
c) A simple autocatalytic reaction is represented by A+B→B+B. starting with a small concentration of B, show in a plot how the rate will rise as B is formed.
d) What is the relation between initial concentration (Co) and final concentration (C4) for a system of 4 equal sized mixed reactors in series? Assume reaction is of first order and t is the residence time.
e) Differentiate between an elementary and a non-elementary reaction with suitable examples.
f) What is understood by order of a chemical reaction? How is this different from "molecularity of the reaction", if a difference between the two exists?
g) Given the reaction $2NO_2 + 1/2O_2 \rightarrow N_2O_5$. What is the relation between the rate of formation and disappearance of the three components of the reaction?
h) For a gas reaction the rate is reported as $-dp_A/dt = kp_A^2$ atm/hr. What are the units of rate constant?
i) State the distinguishing characteristic of each of the following reactions. Single, multiple, elementary and non-elementary.
j) Define temperature dependency as per Arrhenius law. (1 x 10)

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) 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: $r_C = k_1 C$.

i) A solution of radioactive isotope is prepared at concentration C_0. Show that the half-life of the isotope is equal to $\{\ln 2/k_1\}$.

P.T.O.

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?

b) Distinguish between the methods available for establishing the kinetics of chemical reactions from the data obtained in a batch or continuous reactor. (5,5)

4. *Aspergillus niger* is used to produce gluconic acid. Product synthesis is monitored in a fermenter in a fermenter; gluconic acid concentration is measured as a function of time for the first 39 hours of culture.

Time (h):	0	16	24	28	32	39
Acid Concentration:	- 3.6	22	51	66	97	167

i) Determine the rate constant.

ii) Estimate the product concentration after 20 h. (10)

SECTION-B

5. A homogeneous first order reaction is carried out in a batch reactor under adiabatic conditions. Develop a suitable method to find the relation temperature-conversion-time. State the assumptions made. (10)

6. Suggest methods for evaluating the rate constants of the M-M equation. Discuss any one method in detail. (10)

7. a) 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) $r1 = k_1 C_A C_B^2$ & $r_2 = k_2 C_R C_B$ ii) $r1 = k_1 C_A C_B$ & $r_2 = K_2 C_R C_B^2$

iii) $r1 = 1.0 C_A^{1.5} C_B^{0.3}$ & $r_2 = 1.0\, C_A^{0.5}\, C_B^{1.8}$

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)

x-x-x