

**BIRLA INSTITUTE OF TECHNOLOGY, MESRA, RANCHI
(END SEMESTER EXAMINATION)**

CLASS: BE
BRANCH: CHEMICAL & POLYMER/CHEMICAL

SEMESTER : V
SESSION : MO/18

SUBJECT: CL5005 REACTION ENGINEERING

TIME: 3.00 HOURS

FULL MARKS: 60

INSTRUCTIONS:

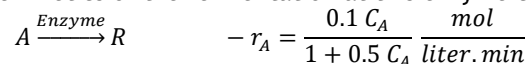
1. The question paper contains 7 questions each of 12 marks and total 84 marks.
 2. Candidates may attempt any 5 questions maximum of 60 marks.
 3. The missing data, if any, may be assumed suitably.
 4. Before attempting the question paper, be sure that you have got the correct question paper.
 5. Tables/Data hand book/Graph paper etc. to be supplied to the candidates in the examination hall.
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- Q.1(a) What type of reactor (PFR or MFR) is more suitable for exothermic gas phase reaction and why? [2]
 Q.1(b) What is the difference between Arrhenius theory and Collision theory in terms of reaction kinetics? [4]
 Q.1(c) For an irreversible liquid phase reaction, the following data is obtained from a laboratory batch experiment. [6]

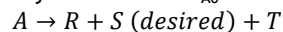
t, min	0	50	100	150	200	250	300
C _A , mol/lit	0.05	0.038	0.0306	0.0256	0.0222	0.0195	0.0174

Find the rate expression for the reaction.

- Q.2(a) Define space time and space velocity. [2]
 Q.2(b) Why Mixed flow reactor is called an ideal reactor? [4]
 Q.2(c) Enzyme E catalyses the fermentation of substrate A (the reactant) to product R. Find the size of mixed flow reactor needed for 95% conversion of reactant in a feed stream (25 liter/min) of reactant (2 mol/liter) and enzyme. The kinetics of the fermentation at this enzyme concentration are given by [6]



- Q.3(a) Recycle reactor are most suitable for what type of reactions and why? [2]
 Q.3(b) Consider the following parallel reaction system where C_{A0} = 2 mol/liter. [4]



$$\frac{dC_R}{dt} = 1 \frac{\text{mol}}{\text{liter} \cdot \text{min}}$$

$$\frac{dC_S}{dt} = 2C_A \frac{\text{mol}}{\text{liter} \cdot \text{min}}$$

$$\frac{dC_T}{dt} = C_A^2 \frac{\text{mol}}{\text{liter} \cdot \text{min}}$$

What will be the best reactor combination for this reaction system.

- Q.3(c) Find the concentration of S under the best operating condition for the above parallel reaction system. [6]
 Q.4(a) Write down different form of rate expressions used in heterogeneous reactor design. How are they related to each other? [2]
 Q.4(b) Explain surface kinetic steps involved in a catalytic reaction system. [4]
 Q.4(c) An irreversible first order gas phase reaction is taking place on the outer surface of a nonporous catalyst pellet. Derive the rate expression for such catalytic reaction and explain the limiting cases of reaction and mass transfer control with diagram. [6]
 Q.5(a) What is exit age distribution function? Explain its significance in non-ideal reactor design. [2]
 Q.5(b) Explain the RTD behavior of an ideal CSRT subjected to pulse tracer input. [4]
 Q.5(c) A pulse of tracer was injected into a reactor, and the effluent concentration as function of time is obtained as below. [6]

t, min	0	5	10	15	20	25	30	35
C(t), g/lit	0	3	5	5	4	2	1	0

Calculate the mean residence time of the fluid in the reactor.

- Q.6(a) How Peclet number is defined? Explain its physical significance. [2]
 Q.6(b) Explain the residence time distribution curve obtained for Tank-in-Series model as the number of tanks in the model varies from 1(one) to infinity. [4]
 Q.6(c) A first order reaction is carried out in a 10 cm diameter and 6.36m in length tubular reactor. The specific reaction rate is 0.25 min^{-1} . Calculate the fractional conversion in the reactor using Tank-in-Series model. The results of the tracer test carried out in the reactor is as given below. [6]

t, min	0	1	2	3	4	5	6	7	8	9	10	12	14
E(t)	0	0.02	0.1	0.16	0.2	0.16	0.12	0.08	0.06	0.044	0.03	0.012	0

- Q.7(a) Define average functionality of stoichiometric and non-stoichiometric mixture. [2]
 Q.7(b) Calculate the extent of reaction when phthalic anhydride and glycerol react in stoichiometric amounts [4]
 Q.7(c) Derive the kinetic expressions for auto catalytic and catalytic step polymerization with assumptions. [6]

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