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

CLASS: BE **SEMESTER : V**
BRANCH: CHEMICAL & POLYMER/CHEMICAL **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.**

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]

$$A \xrightarrow{Enzyme} R \qquad -r_A = \frac{0.1\,C_A}{1 + 0.5\,C_A}\,\frac{mol}{liter.min}$$

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]

$$A \rightarrow R + S\,(desired) + T$$

$$\frac{dC_R}{dt} = 1\,\frac{mol}{liter.min}$$

$$\boldsymbol{\frac{dC_S}{dt} = 2C_A\,\frac{mol}{liter.min}}$$

$$\frac{dC_T}{dt} = C_A^2\,\frac{mol}{liter.min}$$

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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