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R 3129

B.E./B.Tech. DEGREE EXAMINATION, NOVEMBER/DECEMBER 2007.

Sixth Semester

Biotechnology

BT 1352 — CHEMICAL REACTION ENGINEERING

(Regulation 2004)

Time : Three hours Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. The activation energy of a bimolecular reaction is 9150 cal/mol. How much faster is the reaction at 500 K than at 400 K as per Arrhenius Theory?

2. The half life period of a first order reaction is 240 seconds. Calculate its rate constant in minutes.

3. For an enzyme — substrate reaction, the rate of disappearance of the substrate is given by the expression $-r_A = 1760\ C_A E_0/(6+C_A)$ mol/m^3.s where C_A is the concentration of the substrate in mol/m^3 and E_0 is the enzyme concentration in mol/m^3. What are the units of the two constants in the above expression?

4. A pure gaseous reactant A is introduced at 1 lit/s into a mixed flow reactor of volume 1 lit. The reaction stoichiometry is A → 3R. If the conversion in the reactor is 50% determine the Space time and the Holding time in the reactor.

5. In an isothermal batch reactor 70% of reactant A is converted in 13 minutes by a first order reaction. Find the space time needed to effect this conversion in a mixed flow reactor.

6. What is early and late mixing of fluid?

7. What is the residence time distribution function E for an ideal plug flow reactor and an ideal CSTR?

8. What is Langmuir-Hinshelwood kinetics of surface reaction?

9. What is the physical significance of Thiele Modulus?

10. What are the reaction steps in a slurry reactor?

PART B — (5 × 16 = 80 marks)

11. (a) An aqueous solution of ethyl acetate is to be saponified with sodium hydroxide as per the reaction $CH_3COOC_2H_5 + NaOH \rightarrow CH_3COONa + C_2H_5OH$. The initial concentration of ethyl acetate is 5 g/lit and that of sodium hydroxide is 0.1 N. The values of the second order rate constant at 0°C and 20°C are 0.235 and 0.924 lit/mol.min respectively. The reaction is irreversible. Calculate the time required to saponify 95% of the ester at 40°C.

Or

(b) An enzyme catalysed reaction follows the Michaelis Menten kinetics $V/V_{max} = [S]/(K_m+S)$. Determine the Michaelis Menten parameters V_{max} and K_m from the following data :

Concentration of the substrate (kmol/m³)	0.2	0.02	0.01	0.005	0.002
Rate of dissociation of Substrate (kmol/m³.s)	1.08	0.55	0.38	0.20	0.09

12. (a) The liquid phase decomposition of A is studied in an experimental mixed flow reactor. The results of steady state runs are tabulated below. In order to obtain 75% conversion of reactant in a feed with C_{A0} = 0.8 mol/lit what holding time is required in (i) a plug flow reactor (ii) a mixed flow reactor.

Holding time in Seconds :		300	240	250	110	360	24	200	560
Concentration of A mol/lit :	In feed stream	2	2	2	1	1	0.48	0.48	0.48
	In exit stream	0.65	0.92	1	0.56	0.37	0.42	0.28	0.2

Or

(b) A gas mixture consisting of 50 mol% of A and 50 mol% of inert enters a reactor train at 10 atm and 144°C with a flow rate of 6 lit/s. The rate data is as follows :

X_A	0	0.1	0.2	0.3	0.4	0.5
$-r_A$ mol/l.s	0.0053	0.0052	0.005	0.0045	0.004	0.0033
X_A	0.6	0.7	0.8	0.85		
$-r_A$ mol/l.s	0.0025	0.0018	0.00125	0.001		

If the reaction is carried out in two reactors in series with 40% conversion in the first reactor and 85% overall conversion, estimate the total volume of reactors when (i) reactors are both mixed flow (ii) reactors are both plug flow.

13. (a) The concentration readings given below represent a continuous response to a pulse input into a closed vessel.

t (minute)	0	1	2	3	4	5	6	7	8	9	10	12	14
C_{tracer} (mol/lit)	0	1	5	8	10	8	6	4	3	2.2	1.5	0.6	0

This vessel is to be used as a reactor for decomposition of liquid A as per the reaction A $\rightarrow$ Products With the rate $-r_A = kC_A$, mol/lit.min where $k = 0.10\ \text{min}^{-1}$. Calculate the conversion of reactant A in the real reactor.

Or

(b) A reactor is to be used to carry out the reaction A $\rightarrow$ R with the rate law $-r_A = 0.05$ mol/lit.min. The following are the results of a pulse test.

t, min	0	10	20	30	40	50	60	70
C_{tracer} (mol/lit)	35	38	40	40	39	37	36	35

Calculate the conversion as per tanks-in-series model.

14. (a) (i) Derive the conversion versus time relationship when gas film controls the reaction for spherical particles of unchanging size according to unreacted core model. (8)

(ii) A moving grate is fed with a feed having different size fractions. The reacting gas flows cross current to feed. The maximum residence time of feed over the grate is 10 minutes. The feed consists of 25% of 50 μm radius particles, 25% of 80 μm radius particles, 10% of 100 μm radius particles, 15% of 150 μm radius particles and 25% of 200 μm radius particles. The time required for complete conversion of these different size particles are 4, 8, 12, 15 and 18 minutes respectively. Calculate the fraction of solids converted on the moving grate reactor. (8)

Or

(b) A packed bed catalytic reactor is to be used to treat 1650 moles of pure reactant per hour at 190°C and a pressure of 3.8 bar. The fractional volume change during the reaction (ε) is 3.0. The following rate versus concentration data is available :

C_A, mol/litre	0.0415	0.0484	0.0567	0.0692	0.0907
$-r_A$, mol/kg cat.hr	3.389	4.545	6.451	9.523	12.5

If it is desired to have 25% conversion of the reactant, calculate the quantity of the catalyst required in the packed bed.

15. (a) (i) What are the four types of flow regimes possible in a trickle bed reactor and what are the characteristics of these regimes? (6)

(ii) A gas phase catalytic reaction $A \rightarrow 3R$ is carried out in a fluidized bed reactor for 45% conversion of reactant to product. The feed rate to the reactor is 1800 mol/hr of pure A at 3.5 atm pressure and 110°C. The rate expression for the reaction is $(-r_A) = 79.5\ C_A$ mol/kg cat.hr. Calculate the weight of the catalyst required to achieve the desired conversion. (10)

Or

(b) (i) Explain the operation of a slurry reactor. (6)

(ii) Based on the two phase fluidized bed model derive the design equation of a fluidized bed reactor. (10)

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