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NATIONAL INSTITUTE OF TECHNOLOGY CALICUT

END SEMESTER EXAM – DECEMBER 2014

B.Tech Chemical Engineering V Semester

CH3003/CHU312 CHEMICAL REACTION ENGINEERING

Time: 3 hours Maxi. marks: 50

1. The presence of substance C seems to increase the rate of reaction of A and B. A + B → AB. It is suspected that C acts catalytically by combining with one of the reactants to form an intermediate, which then reacts further. From the rate data in Table, suggest a mechanism and rate equation for this reaction. (5)

[A]	[B]	[C]	r_{AB}
1	3	0.02	9
3	1	0.02	5
4	4	0.04	32
2	2	0.01	6
2	4	0.03	20
1	2	0.05	12

2. With suitable examples distinguish the following:
   a. Series and parallel reactions (1.5)
   b. Elementary and non-elementary reactions (1.5)

3. The data in Table was obtained for the reaction of sulfuric acid with diethylsulfate in aqueous solution at 22.9°C

$$H_2SO_4 + (C_2H_5)_2SO_4 \rightarrow 2C_2H_5SO_4H$$

Initial concentrations of H_2S0_4 and $(C_2H_5)_2SO_4$ are each 5.5 mol/liter. Find a rate equation for this reaction. (5)

t, min	$C_2H_5SO_4H$, mol/liter	t, min	$C_2H_5SO_4H$, mol/liter
0	0	180	4.11
41	1.18	194	4.31
48	1.38	212	4.45
55	1.63	267	4.86
75	2.24	318	5.15
96	2.75	368	5.32
127	3.31	379	5.35
146	3.76	410	5.42
162	3.81	∞	(5.80)

4. For the elementary reactions in series

$$A \xrightarrow{k_1} R \xrightarrow{k_2} S, \quad k_1 = k_2, \quad \text{at } t = 0 \quad \begin{cases} C_A = C_{A0}, \\ C_{R0} = C_{S0} = 0 \end{cases}$$

Find the maximum concentration of R and when it is reached. Also present the concentration-time plots. (5)

5. It is desired to produce 250 tons per day of ethylene glycol. A mixed flow reactor is to be operated isothermally. A 16 kmol/m^3 solution of ethylene oxide in water is fed to the reactor together with an equal volumetric solution of water containing 0.9 wt% H_2SO_4. The volumetric flow rate of ethylene oxide, before mixing is 1.7 m^3/min. How many 3 m^3 reactors would be required if they are arranged in series? What is the corresponding conversion? The specific reaction rate constant is 0.311 min^{-1}. (4)

6. The elementary gas phase reaction $A_3 \rightarrow 3\ A$ is carried out in a flow reactor. The rate constant at 50°C is 10^{-4} / min and the activation energy is 85 kJ/mol. Pure A_3 enters the reactor at 10 atm and 127°C and a molar flow rate of 2.5 mol/min. Calculate the reactor volume and space time to achieve 90% conversion in a CSTR. (4)

7. A specific enzyme act as a catalyst in the fermentation of reactant A . At a given enzyme concentration in the aqueous feed stream, the kinetics of the fermentation is given by

   $A \rightarrow R \quad -r_A = 0.1\ C_A / (1+0.5\ C_A)$ mol/liter-min.

   Find the volume of the plug flow reactor needed for 95 % conversion of 2mol/ liter of reactant A. The volumetric flow rate is 25 liter/min. (4)

8. a) Discuss about the factors controlling the product distribution for a competing parallel reaction. (3+2+3)

   b) Consider the aqueous reactions

   $A + B \xrightarrow{k_1} R$, desired, $\quad dC_R/dt = 1.0\ C_A^{1.5} C_B^{0.3}$ mol/liter-min

   $A + B \xrightarrow{k_2} S$, desired, $\quad dC_S/dt = 1.0\ C_A^{0.5} C_B^{1.8}$ mol/liter-min

   For 90% conversion of A find the concentration of R in the product stream., if a) a mixed flow reactor is used b) a plug flow reactor is used. Equal volumetric flow rates of A and B streams are fed to the reactor, and each stream has a concentration of 20 mol/lit of reactant.

9. Explain the conversion calculations directly from tracer studies. (4)

10. In detail explain the fitting of dispersion model for large deviation from plug flow.(4)

11. Draw and explain the RTD curves for tanks in series model. (4)