

Name :
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APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
07 THRISSUR CLUSTER

SECOND SEMESTER M.TECH. DEGREE EXAMINATION APR 2017

Chemical Engineering
Process Control

07 CH 6102 ADVANCED CHEMICAL REACTION ENGINEERING

Time : 3 hours

Max.Marks: 60

Answer all six questions. Part 'a' of each question is compulsory.

Answer either part 'b' or part 'c' of each question

Q.no.	Module 1	Marks
1a	Show that equal sized mixed flow reactors in series are equivalent to a plug flow reactor?	4

Answer b or c

- | | | |
|---|--|---|
| b | How will you test the kinetics of autocatalytic reactions? | 5 |
| c | An aqueous feed of A and B (400 L/min, 100 mmol A/l, 200 mmol B/l) is to be converted to product in a PFR. The kinetics of reaction is represented by $A + B \rightarrow R, -r_A = 200C_A C_B \text{ mol/l min}$. Find the volume of reactor needed for 99.9% conversion of A to product. | 5 |

Q.no.	Module 2	Marks
2a	Explain in detail the causes of non ideality?	4

Answer b or c

- | | | |
|---|--|---|
| b | Explain axial dispersion model? | 5 |
| c | Draw the temperature-conversion plots for irreversible, reversible exothermic and reversible endothermic reactions? Write a note on reactor stability? | 5 |

Q.no.	Module 3	Marks
3a	For the reaction $A + B \rightleftharpoons C, A + X \rightleftharpoons A.X, A.X + B(g) \rightleftharpoons C.X, C.X \rightleftharpoons C + X$ Develop rate expression if surface reaction is the rate controlling step.	4

Answer b or c

b Define internal effectiveness factor? What is its significance? 5

c Derive the expression for Thiele modulus? 5

Q.no. Module 4 Marks

4a Explain the mechanism of catalyst deactivation. 4

Answer b or c

b What is meant by fluidized bed? Briefly explain its features and discuss the different types of fluidized beds. 5

c The catalytic decomposition of reactant ($A \rightarrow R$) is studied in a packed bed reactor filled with 2.4 mm pellets and using a very high recycle rate of product gases (assume mixed flow). The results of a long-time run and additional data are given below. 5

t, (hr)	0	2	4	6
X_A	0.75	0.64	0.52	0.39

$$D_e = 5 \times 10^{-10} \text{ m}^2/\text{s} ; \rho_s = 1500 \text{ kg/m}^3 \text{ cat} ; \tau' = 4000 \text{ kg s/m}^3$$

Find the kinetics of reaction and deactivation, both in the diffusion-free and in the strong pore diffusion resistance regime.

Q.no. Module 5 Marks

5a Outline the applications of different kinds of reactors used for solid catalysed Gas-liquid reactions. 5

Answer b or c

b Derive the performance equations for different flow patterns of contacting phases for gas-liquid reaction taking place on the surface of solid catalyst in which the liquid component is in excess. 7

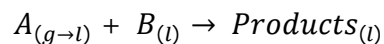
c Aqueous acetone ($C_{B0} = 1000 \text{ mol/m}^3 \text{ liq}$, $v_l = 10^{-4} \text{ m}^3 \text{ liq/s}$) and hydrogen (1 atm, $v_g = 0.04 \text{ m}^3 \text{ gas/s}$, $H_A = 36845 \text{ Pa m}^3 \text{ liq/mol}$) are fed to the bottom of a long slender column (5 m high, 0.1 m^2 cross section) packed with porous Raney nickel catalyst ($d_p = 5 \times 10^{-3} \text{ m catalyst}$, $\rho_s = 4500 \text{ kg/m}^3 \text{ catalyst}$, $f_s = 0.6$, $D_e = 8 \times 10^{-10} \text{ m}^2/\text{s}$) and kept at 14°C . At these conditions acetone is hydrogenated to propanol according to the reaction 7

$\underbrace{H_2}_{A} (g \rightarrow l) + \underbrace{CH_3COCH_3}_B (l) \xrightarrow{\text{on catalyst}} CH_3CHOHCH_3$ with rate given by
 $-r'_A = -r'_B = k' C_A^{1/2} C_B^0$ and $k' = 2.35 \times 10^{-3} \text{ m}^3 \text{ liq. (mol)}^{1/2} / \text{kgs (m}^3 \text{ liq)}^{1/2}$. What will be the conversion of acetone in this unit?

Q.no.	Module 6	Marks
6a	What are the factors to be considered for selecting a contactor for fluid-fluid reactions?	5

Answer b or c

- b** Derive the expression to find the volume of reactor for plug flow gas/plug flow liquid with straight mass transfer (for both concentrate and dilute systems) for the reaction



- c** Gaseous A absorbs and reacts with B in liquid according to



in a packed bed under conditions where

$k_{Ag} a = 0.1 \text{ mol/hr. m}^2 \text{ of reactor.Pa}$; $f_l = 0.01 \text{ m}^3 \text{ liq/m}^3 \text{ reactor}$;
 $D_{Al} = D_{Bl} = 10^{-6} \text{ m}^2 / \text{hr}$; $k_{Al} a = 100 \text{ m}^3 \text{ liq/m}^3 \text{ reactor. hr}$; $a = 100 \text{ m}^2 / \text{m}^3 \text{ reactor}$;
 $H_A = 10^5 \text{ Pa.m}^3 \text{ liq/mol}$; $k = 10 \text{ m}^3 \text{ liq/mol.hr}$. At a point in the reactor where $p_A = 100 \text{ Pa}$ and $C_B = 100 \text{ mol/m}^3 \text{ liquid}$.

- (i) Calculate the rate of reaction in $\text{mol/hr. m}^3 \text{ reactor}$.
- (ii) Locate the major resistance to reaction
- (iii) Determine the behaviour in the liquid film