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 $A+B \rightarrow R, -r_A = 200 C_A C_B mol/l\min$ .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 $A+B \Leftrightarrow C, A+X \Leftrightarrow A.X, A.X+B(g) \Leftrightarrow C.X, C.X \Leftrightarrow C+X$ 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

$D_e = 5\times10^{-10}$ m^3/m cat. s ; ρ_s = 1500 kg/m^3 cat ; τ' = 4000 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 mol/m^3 liq, $v_l = 10^{-4}$ m^3 liq/s) and hydrogen (1 atm, v_g = 0.04 m^3 gas/s, H_A = 36845 Pa m^3 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 ($d_p = 5\times10^{-3}$ m catalyst, ρ_s = 4500 kg/m3 catalyst, f_s = 0.6, $D_e=8\times10^{-10}$$m^3$ liq/m catalyst. s) and kept at 14^{o}C. At these conditions acetone is hydrogenated to propanol according to the reaction **7**

$\underbrace{H_2}_{A}\,(g \rightarrow l)$ + $\underbrace{CH_3COCH_3}_{B}\,(l) \xrightarrow{on\ catalyst} CH_3CHOHCH_3$ with rate given by $-r_A^{'} = -r_B^{'} = k'C_A^{1/2}C_B^0$ and $k^{'}$=2.35×10^{-3}m^{3}liq.(mol)$^{1/2}$/kgs(m^{3}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 $A_{(g\rightarrow l)} + B_{(l)} \rightarrow Products_{(l)}$	7
c	Gaseous A absorbs and reacts with B in liquid according to $A_{(g\rightarrow l)} + B_{(l)} \rightarrow R_{(l)}$ $\quad -r_A = kC_AC_B$ in a packed bed under conditions where $k_{Ag}a$ =0.1 mol/hr. m^2 of reactor.Pa ; f_l=0.01 m^{3}liq/m^3 reactor; $D_{Al}=D_{Bl}=10^{-6}$m^2/hr ; $k_{Al}a$ = 100 m^3 liq/m^3 reactor. hr; a = 100 m^2/m^3 reactor ; $H_A = 10^5$ Pa.m^3 liq/mol; k= 10 m^3 liq/mol.hr. At a point in the reactor where p_A = 100Pa and C_B = 100mol/m^3 liquid. (i) Calculate the rate of reaction in mol/hr. m^3 reactor. (ii) Locate the major resistance to reaction (iii) Determine the behaviour in the liquid film	7