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APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
07 THRISSUR CLUSTER

SECOND SEMESTER M.TECH. DEGREE EXAMINATION APRIL 2018

CHEMICAL ENGINEERING

PROCESS CONTROL

07CH6102 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	The first order reversible liquid reaction $A \rightleftharpoons R$, $C_{A0}=0.5$ mol/liter, $C_{R0}=0$. takes place in a batch reactor. After 8 min, conversion of A is 33.3% while the equilibrium conversion is 66.7%. Find the rate equation for this reaction.	4
	Answer b or c	
b	Derive the performance equation for a steady-state plug flow reactor.	5
c	Gaseous reactant A decomposes as follows: $A \rightarrow 3R$, $-r_A=(0.6 \text{ min}^{-1})C_A$ Find the conversion of A in a 50% A-50% inert feed ($v_0=180$ liter/min, $C_{A0}=300$ m mol/liter) to a 1 m^3 mixed flow reactor.	5
Q.no.	Module 2	Marks
2a	Illustrate about multiple steady states of exothermic irreversible reactions.	4

Answer b or c

- b** Between 0°C & 100°C, determine the equilibrium conversion for the elementary aq. Reaction, **5**

$A \rightleftharpoons R$, ($\Delta G^0_{298} = -14130 \text{ J/mol}$, $\Delta H^0_{298} = -75300 \text{ J/mol}$), $C_{PA} = C_{PR} = \text{constant.}$)

1. Present the results in the form of a plot of temperature – conversion.
2. What restrictions should be placed on the reactor operating isothermally if we want to obtain a conversion of 75% or higher.

- c** Explain different non-idealities in a reactor. **5**

Q.no.	Module 3	Marks
3a	Explain effectiveness factor and its significance in solid catalysed reactions.	4

Answer b or c

- b** Determine the amount of catalyst needed in a packed bed reactor with a very large recycle rate for 35% conversion of A to R for a feed rate of 2000mol/hr of pure A at 3.2 atm and 117°C. For the reaction at this temperature **5**

$A \rightarrow 4R$, $-r'_A = 96C_A$, mol/kg cat.hr

- c** Derive performance equation for reactions containing porous catalyst for plug flow reactor. **5**

Q.no.	Module 4	Marks
4a	Describe the mechanism of catalyst deactivation.	4

Answer b or c

- b** Two catalytic packed bed reactor is to be designed to treat 100mol/s of reactant A and produce product R. Feed gas enters at 2.49MPa & 300K, the maximum allowable temperature is 900K unless otherwise noted, the product stream is wanted at 300K and thermodynamic and kinetics of the exothermic reaction are given to us ($C_p = 40 \text{ J/mol. K}$, for all materials and at all temperatures, $\Delta H_r = -80000 \text{ J/mol}$, same value at all temperatures). Prepare a sketch showing the details of the system you plan to use. **5**
- Type of reactor-plug, recycled or mixed
 - Amount of catalyst needed.
 - Heat duty ahead of the reactor, at the reactor itself and after the reactor.

- The temperature of all fluid streams.

Work out a good design for 85% conversion of feed consisting of pure A.

X_A	0.85	0.785	0.715	0.66	0.58	0.46
$-r_A$	0.05	0.1	0.2	0.28	0.5	1

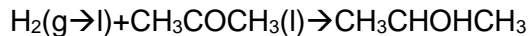
- c Illustrate different models suggested for explaining the behaviour inside bubbling fluidised bed. 5

Q.no.	Module 5	Marks
5a	Explain various ways of running G/L reactions catalysed by solids.	5

Answer b or c

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



With rate given by

$$-r'_A = -r'_B = k' C_A^{1/2} C_B^0 \text{ and } k' = 2.35 \cdot 10^{-3} \text{ m}^3\text{l/kg.s}(\text{mol/m}^3\text{l})^{1/2}$$

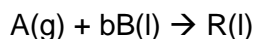
What will be the conversion of acetone in this unit? The mass transfer rate constants are estimated to be

$$(K_{Ai}a_i)_{\text{g+l}} = 0.02 \text{ m}^3\text{l/m}^3\text{r.s}, K_{Ac}a_c = 0.05 \text{ m}^3\text{l/m}^3\text{r.s}$$

Q.no.	Module 6	Marks
6a	What are the basic assumptions made and objectives for gas liquid reactions over other fluid-fluid reactions..	5

Answer b or c

- b Derive the rate expression for mass transfer along with reaction (instantaneous reaction with low C_B) of $A(\text{g})$ in liquid B. The reaction is given below. 7



- c** Illustrate the design procedure and derive the expression for volume required for plug flow G/ plug flow L for the reaction $A_{(g)} + 2B_{(l)} \longrightarrow R_{(l)}$ for mass transfer with not very slow reaction. **7**