Name :
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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: $A \rightarrow 3R$, $-r_A=(0.6\ min^{-1})C_A$ Find the conversion of A in a 50% A-50% inert feed (v_0=180liter/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 0^0C & 100^0C, determine the equilibrium conversion for the elementary aq. Reaction, **5**

$A \rightleftharpoons R$, ($\Delta_G{}^0{}_{298}$ = -14130 J/mol, $\Delta H^0{}_{298}$= -75300 J/mol), $C_{PA} = C_{PR}$ = 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 117^0C. 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 ar 2.49MPa & 300K, the maximum allowable temperature is 900K unless otherwise noted, the product stream is wanted at 300Kand thermodynamic and kinetics of the exothermic reaction are given to us (Cp= 40J/mol. K, for all materials and at all temperatures, ΔHr= -80000 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}=1000mol/m^{3}l, v_l=10^{-4}m^{3}l/s) and hydrogen (1 atm, vg=0.04 m^{3}g/s,H_A=36845 Pa. m^3 l/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 (dp=5*10^{-3} m cat, ρ_s=4500 kg/m^{3}cat,f_s=0.6,D_e=8*10^{-10} m^{3}l/m cat.s) and kept at 14^{0}C. At these conditions acetone is hydrogenated to propanol according to the reaction **7**

$H_2(g \rightarrow l)+CH_3COCH_3(l) \rightarrow CH_3CHOHCH_3$

With rate given by

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

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

$(K_{Ai}a_i)_{g+l}$=0.02m^{3}l/m^{3}r.s, $K_{AC}a_C$=0.05 m^{3}l/m^{3}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(g) in liquid B. The reaction is given below. **7**

$A(g) + bB(l) \rightarrow R(l)$

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**