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 eachquestion

Q.no.	Module 1	Marks
1a	Liquid A decomposes by second order kinetics, and in a batch reactor 50% of A is converted in a 5 minute run. How much longer would it take to reach 75% conversion?	**4**
	Answer b or c	
b	Derive the performance equation for a steady-state back mixed flow reactor.	**5**
c	The homogeneous gas decomposition of A, $4A \rightarrow R+6S$ proceeds at 649^0C with the first order rate $-r_A=$ (10/hr) C_A. What size of plug flow reactor operating at 649^0C and 460kPa can produce 80% conversion of 40 mol of pure A per hour?	**5**

Q.no.	Module 2	Marks
2a	Explain general graphical design procedure for finding out the volume required for a particulat reactor.	**4**
	Answer b or c	
b	Derive the expression for finding the conversion of adiabatic and nonadiabatic operations in PFR/MFR.	**5**

c	The concentration readings in table given below represent a continuous response to a pulse input into a closed vessel which is to be used as a chemical reactor. Calculate the mean residence time of fluid in the vessel t, and tabulate and plot the exit age distribution E.	**5**

Time t, min	0	5	10	15	20	25	30	35
C_{pulse} gm/l fluid	0	3	5	5	4	2	1	0

Q.no.	Module 3	Marks
3a	A gas containing A (2mol/m^3) is fed (1 m^3/hr) to a plug flow reactor with recycle loop (0.02 m^3 loop volume, 3 kg of catalyst), and the output composition from the reactor is 0.5 mol A/m^3. Find the rate equation for the decomposition of A for very large recycle, A→3R, first order kinetics, 50%A-50% inerts in feed.	**4**
	Answer b or c	
b	Derive the expression for effectiveness factor for a first order reaction on a porous catalyst.	**5**
c	Derive performance equation for reactions containing porous catalyst for plug flow reactor.	**5**

Q.no.	Module 4	Marks
4a	Describe in detail different contacting patterns of fixed bed reactors for uniform temperature distribution.	**4**
	Answer b or c	
b	Explain the K-L Model of bubbling fluidised bed by stating the assumptions and salient equations.	**5**
c	A single 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, and the inlet temperature is 600K, 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. • 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.	**5**

- The temperature of all fluid streams.

Work out a good design for 80% conversion of feed consisting of 1molA and 7mol inert.

X_A	0.8	0.78	0.7	0.6	0.5	0.1	0
$-r_A$	0.05	0.1	0.2	0.225	0.2	0.05	0.03

Q.no.	Module 5	Marks
5a	Write the general rate expression for the reaction on catalyst surface $A_{(g\rightarrow l)}+bB_{(l)} \rightarrow$ products And also the rate expression if i. The system with pure liquid B and slightly soluble gas A ii. The system with dilute liquid B and highly soluble gas A	**5**

Answer b or c

b Hydrogen gas is bubbled into an agitated tank (Vr=2 m3r) containing liquid butynediol (C_{B0}=2500mol/m^3 l) plus a dilute suspension of palladium-impregnated porous catalyst pellets ($d_p=5*10^{-5}$ m cat, ρ=1450 kg /m^3 cat, $D_e=5*10^{-10}$ m^3l/m cat.s, f_s= 0.0055). Hydrogen dissolves in the liquid (H_A=148000 Pa.m^3l/mol) and reacts with the butynediol on the catalyst surface as follows: **7**

$H_2(g\rightarrow l)$ +butynediol (l)→butynediol and at 35^0C.

$-r_A=k'C_AC_B$ and $k'=5*10^{-5}$ m^6l/kg.molcat.s

Unused hydrogen is recompressed and recirculated, and the whole operation takes place at 1.46 atm and 35^0C. Find out how it will take for 90% conversion of reactant. The mass transfer rates are given as $(KAi^ai)_{g+l}$=0.2777 m^3l/m^3r.s, $K_{AC}=4.4*10^{-4}$ m^3l/m^3r.s

c Dilute aqueous ethyl alcohol is oxidised to acetic acid by the action of pure oxygen at 10 atm in a trickle bed reactor maintained at 30^0C and packed with Pd-Al_2O_3catalyst pellets. The reaction proceeds as follows: **7**

$O_2(g\rightarrow l)+ CH_3CH_2OH(l)\rightarrow CH_3COOH(l)+H_2O$

The reaction is first order with respect to Hydrogen and zero order with respect to ethyl alcohol with rate constant K' at $30^0C=1.77*10^{-5}$ m^{3l}/(kg cat.s)

Calculate the fractional conversion of ethyl alcohol if gas and liquid are fed to the top of a reactor.

Data:

Gas: v_g=0.01 m^3 /s, H_A=86000Pa.m^3/mol

Liquid: v_l=2*10^{-4} m^3 /s, C_{B0}=400 mol/m^3

Reactor:5 m high, 0.1 m^2 cross section, fs=0.58

Catalyst: dp=5mm,ρ=1800 kg/m^3, De=4.16*10^{-10} m^3/ mcat.s

Kinetics: k_{Ag}ai=3*10^{-4} mol/m^3 Pa.s, k_{Alai}=0.02 s^{-1},k_{AC}=3.86*10^{-4} m/s

Q.no.	Module 6	Marks
6a	Derive the rate equation for straight mass transfer for gas liquid reaction. $A_{(g)} + bB_{(l)} \longrightarrow R_{(l)}$.	5
	Answer b or c	
b	Air with gaseous A bubbles through a tank containing aq. B. Raction occurs as follows. $A_{(g)} + 2B_{(l)} \longrightarrow R_{(l)}$., $-rA = kC_A\, C_B2$, k=$10^6$$m^6$/$mol^2$.hr. For this system, $k_{Ag}a$ = 0.01 mol/hr.m^3.Pa, f_l = 0.98, $k_{Al}a$ = 20hr^{-1}, H_A = 10^5 Pa. m^3/mol. very low solubility. D_{Al} = D_{Bl} = 10^{-6} m^2/hr. A = 20 m^2/m^3 for a point in the absorber-reactor where, pA = 0.0005Pa. and C_B = 100 mol/m^3 1. locate the resistance to reaction (what % in gas film, in the liquid film, in the main body of liquid) 2. locate the reaction zone. 3. Determine the behaviour in the liquid film (Whether pseudo first order reaction, instantaneous, physical transport etc) 4. Calculate the rate of reaction (mol/m^3/hr)	7
c	Illustrate the design procedure for straight mass transfer in countercurrent towers.	7