AQ–2753

Faculty of Engineering & Technology

M.Tech. (Chemical Engg.) Second Semester (CBS) Examination

CHEMICAL REACTION ENGINEERING

Paper—2 CE 1

Time—Three Hours]   [Maximum Marks—80

INSTRUCTIONS TO CANDIDATES

(1) All questions carry marks as indicated.

(2) Question No. 1 is compulsory.

(3) Due credit will be given to neatness and adequate dimensions.

(4) Assume suitable data wherever necessary.

(5) Diagrams and Chemical equations should be given wherever necessary.

(6) Illustrate your answers wherever necessary with the help of neat sketches.

(7) Solve any **five** from remaining.

(8) Use pen of Blue/Black ink/refill only for writing the answer book.

1. A small reaction bomb lifted with a sensitive pressure measuring device is flushed out and then filled with pure reactant A to one atm pressure. The operation is carried out 298 K, at which the reaction does not proceed to any appreciable extent. The temp is then rapidly increased at 373 K by plunging the bomb into boiling water and the following pressure data are obtained :

t, min	p, atm
1	1.14
2	1.04
3	0.982

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t, min	p, atm
4	0.940
5	0.905
6	0.870
7	0.850
8	0.832
9	0.815
10	0.800
15	0.754
20	0.728

The stoichiometry of the reaction is $2A \rightarrow R$. After leaving the bomb in the bath over the weeks period the content are analysed for A and no A is detected.

Find a rate expression which can satisfactorily represents this data. (Illustrate your answer analytically and graphically).   15

2. A homogenous liquid phase reaction with stoichiometry and kinetics.

$A \rightarrow S, -Y_A = KC_A^2$ takes place with 50 % conversion in a MFR :

(i) Find the conversion if this reactor is replaced by another mixed flow reactor having volume 6 times that of the original reactor-all else remains unchanged.

(ii) Find the conversion if the original reactor is replaced by a PFR of the same size all else are remain unchanged.   13

3. Find a rate equation for gas phase decomposition $A \rightarrow R + S$ occurring isothermally in MFR from the following data :

Run	τ	X_A
1	0.423	0.22
2	5.10	0.63

Run	τ	X_A
3	13.5	0.75
4	44	0.88
5	192	0.96

X_A values are obtained with i,c all runs are conducted with $C_{AO} = 0.002$ mol/l.   13

4. Substance A reacts according to second order kinetics. 95 % conversion of A is achieved in a single flow reactor. We buy a second reactor identical to the first. For the same 95 % conversion by how much is the capacity increased if we operate these two reactors in parallel or in series ?

  (i)   The reactors are both plug flow.

  (ii)   The reactors are both mixed flow.   13

5. Reactant A in a liquid produces R and S by the following reaction :

$$A \begin{array}{c} \nearrow R \\ \searrow S \end{array}$$
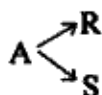
Both these reactions are first order A feed with $C_{AO} = 1$, $C_{RO} = 0$ and $C_{SO} = 0$ enters in two MFRs in series ($\tau_1 = 2$ min, $\tau_2 = 5$ min,). The composition in first reactor is $C_{A1} = 0.40$, $C_{R1} = 0.40$ and $C_{S1} = 0.2$. Find the composition leaving the second reactor.   13

6 For adiabatic operation prove that the conversion is related with temp by the given equation,

$$\chi_A = \frac{C_p \Delta T}{-\Delta H_R} \quad \text{and}$$

for non-adiabatic operations it relates as : $\chi_A = \dfrac{C_p \Delta T - Q}{-\Delta H_R}$.   13

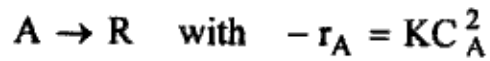7. Explain in detail the mass transfer within packed bed reactors.   13

8. (a) How pore diffusion resistance distorts the kinetics of reaction with Deactivating catalysts ?

  (b) Why catalysts needs regeneration ? How can it be regenerated ?   13

9. Gaseous A decomposes on a solid catalyst as per the following reaction :

$$A \to R \quad \text{with} \quad -r_A = KC_A^2$$

A pilot plant scale tubular reactor packed with 2 l of catalyst is fed with 2 m³/h of pure A at 300° C and 20 atm. 65 % A is converted. It is desired to treat 100 m³/h of feed gas at 40 atm and 300° C consisting of 60 % A and 40 % diluent in a larger plant to obtain 85 % conversion of A. Find the internal volume of reactor. 13

10. The elementary liquid phase reaction A + B → R + S is carried out in a PFR for equimolar amounts of A d B ($C_{Ao} = C_{Bo} = 0.9$ mol/l) 94 % conversion is achieved in it. If a CSTR 10 times as large as the PFR were arranged in a series with existing unit, which units needs to be arranged first (in series) to enhance the production rate ? 13