Ex/ChE/T/312/2018(S)

BACHELOR OF ENGINEERING IN CHEMICAL ENGINEERING EXAMINATION, 2018

(3rd Year, 1st Semester, Supplementary)

CHEMICAL REACTION ENGINEERING - I

Time : Three hours Full Marks : 100

(50 marks for each Part)

Use a separate Answer-Script for each Part

PART I

Attempt any two questions. Al questions carry equal marks, i.e. 25.

1. The first-order reversible liquid reaction

$$A \Leftrightarrow R \quad C_{A0} = 0.5 \text{ mol/liter}, C_{R0} = 0$$

takes place in a batch reactor. After 8 minutes, conversion of A is 33.3% while equilibrium conversion is 66.7%. Find the rate equation for this reaction.

2. The following data are obtained at 0°C in a constant-volume batch reactor using pure gaseous A:

Time, (min)	0	2	4	6	8	10	12	14	∞
Partial pressure of A, (mm)	760	600	175	390	320	275	240	215	150

The stoichiometry of the decomposition is A ---> 2.5R. Find a rate equation which satisfactorily represents this decomposition.

3. 100 liters/hr of radioactive fluid having a half-life of 20 hr is to be treated by passing it through two ideal stirred tanks in series, V = 40,000 liters each. In passing through this system, how much will the activity decay?

4. A gaseous feed of pure A (1 mol/liter) enters a mixed flow reactor (2 liters) and reacts as follows:

$$2A \text{ -----> } R, \qquad -r_A = 0.05\, C_A^2$$

Find what feed rate (liter/min) will give an outlet concentration $C_A = 0.5$ mol/liter.

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B.E. CHEMICAL ENGINEERING THIRD YEAR FIRST SEMESTER SUPPLEMENTARY EXAM 2018

CHEMICAL REACTION ENGINEERING- I

Time: Three Hours | Full Marks: 100

Use a separate Answer-Script for each part

Part II

Answer **question 1 and any two** from the rest
Assume any missing data
All terms have usual significance

1.(i) A homogeneous liquid phase reaction

$A \rightarrow R, \quad -r_A = kC_A^2$

takes place with 50% conversion in a CSTR.

a) What will be the conversion if this reactor is replaced by one 6 times as large – all else remaining unchanged?

b) What will be the conversion if the original reactor is replaced by a plug flow reactor of equal size-all else remaining unchanged?

1. (ii) The decomposition of N_2O_5 is postulated to occur by the following mechanism:

$$N_2O_5 \underset{k_2}{\overset{k_1}{\rightleftharpoons}} NO_2 + NO_3^*$$

$$NO_3^* \xrightarrow{k_3} NO^* + O_2$$

$$NO^* + NO_3^* \xrightarrow{k_4} 2NO_2$$

Using the steady state approximation, derive an expression for the rate of decomposition of N_2O_5. **[(5+5) + 8]**

2. (i) An elementary liquid phase irreversible reaction A+B→ C+D is being conducted in a stirred tank reactor under semi-batch mode, wherein reactant B is slowly(continuously) added at a constant molar rate to a batch of reactant A. Derive the differential equations expressing C_A,C_B,C_C and C_D as time dependent variables.

2.(ii) The irreversible 1st order parallel reactions A → 2R (reaction rate constant,k_1); A → 3S (reaction rate constant , k_2)

are conducted in an isothermal liquid phase PFR with a mean residence time of 15 s. The fractional conversion of A is 80%. Moles of R produced per mole of S produced is 3.5. Calculate k_1 and k_2. **[8+8]**

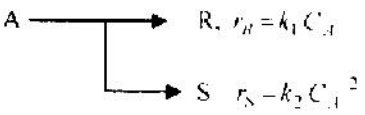
3. (i) Find the overall order of the irreversible reaction $2H_2+2NO \rightarrow N_2 + 2H_2O$ from the following constant volume batch data using equimolar amounts of H_2 and NO. (Graphical solution not required)

Initial total pressure, mm Hg	200	240	280	320	360
Half Life, s	265	186	115	104	67

3. (ii) Find the first-order rate constant for the disappearance of A in the gas reaction $2A \rightarrow R$ .if on holding the pressure constant, the volume of the reaction mixture starting with 80% A ,decreases by 20% in 3 minutes.

[10+6]

4.(i) Substance A in the liquid phase produces R and S by the following reactions



The feed (C_{A0} 1.0, C_{R0} 0, C_{S0}=0) enters two MFRs in series (τ_1=2.5 min, τ_2=5.0 min).Knowing the composition in the first reactor (C_{A1}=0.4, C_{R1}=0.4, C_{S1}=0.2). Find the composition leaving the second reactor.

4. (ii) The first order reversible liquid reaction, takes place in a batch reactor. After eight minutes, conversion of A is 33.3% while equilibrium conversion is 66.7%. Find the rate equation for this reaction. **[10+6]**

5.(i) Explain the graphical method of finding plug flow reactor (PFR) size for adiabatic operations in case of reversible first-order endothermic reaction $A \underset{k_2}{\overset{k_1}{\rightleftharpoons}} R$.

5. (ii) What are the factors governing the most effective use of a given set of ideal reactors (CSTRs and PFRs)? Explain your answer graphically. **[10+6]**