

GUJARAT TECHNOLOGICAL UNIVERSITY**B. E. VIIth Semester–Examination – Nov- 2011****Subject code: 170501****Subject Name: Chemical Reaction Engineering - 1****Date: 19/11/2011****Time: 10:30 am – 01:00 pm****Total Marks: 70****Instructions:**

1. Attempt all questions.
2. Make suitable assumptions wherever necessary.
3. Figures to the right indicate full marks.
- 4.

Q.1 (a) Discuss with examples classifications of Reactions. **07**

(b) The rate constant of a reaction measured at different temperatures is reported below. Calculate the activation Energy and frequency factor for this reaction. **07**

Temp., °C	20	25	30	35
K.min ⁻¹	1.5×10^{-3}	2.67×10^{-3}	4.64×10^{-3}	7.93×10^{-3}

Q.2 (a) Differentiate Elementary and non-Elementary reactions. Mention in brief the steps to establish the mechanism of reaction of Non-elementary reactions. **07**

(b) Discuss method to establish the 'Rate law', while obtaining data from batch reactor using Differential method of analysis. **07**

OR

(b) The rate constant k at 27°C is $1.3 \times 10^{-3} \text{ sec}^{-1}$ and its frequency factor is $2.785 \times 10^{-6} \text{ sec}^{-1}$. Determine its Entropy of activation and Enthalpy of activation. **07**

Q.3 (a) For n^{th} order irreversible reaction derive the design equation. **07**

(b) A first order reversible reaction $A \rightleftharpoons B$ takes place in a batch reactor with $C_{A0} = 0.5$ moles/liter and $C_{B0} = 0$. After 30 minutes conversion of A is 33.3% while equilibrium is 66.7%. Find the rate equation for this reaction. **07**

OR

Q.3 (a) First order unimolecular irreversible reaction in series **07**



takes place with specific reaction rate k_1 and k_2 . Express the variation of concentration of A, R and S with time. Find the expression for the time when formation of R becomes maximum.

(b) A reaction $A \longrightarrow B$ obeys second order kinetics with $k = 0.01 \text{ liter mole}^{-1} \text{ sec}^{-1}$. The initial concentration is $C_{A0} = 2 \text{ mol/liter}$. What time is required for 90% conversion in a batch reactor? **07**

Q.4 (a) Derive Design equation for Plug Flow Reactor. **07**

- (b) The reaction $A \longrightarrow B$, $r = k C_{A0}^2$, occurs in CSTR with 90% conversion. If $k = 0.5$ liter/mole min, $C_{A0} = 2$ mole/liter and $v = 4$ liter/min, what residence time and reactor volume will be required? 07

OR

- Q.4 (a) For given service a single CSTR of volume V is to be replaced by two unequal size CSTRs of volumes V_1 and V_2 , show the procedure to determine V_1 and V_2 . 07

- (b) The thermal cracking of ethane is carried out in a tubular reactor for large scale production of Ethylene. The reaction is $C_2H_6 \longrightarrow C_2H_4 + H_2$. The Ethane fed at the rate of 10 tons/hr, is diluted with steam (0.5 mole of steam : 1 mole of Ethane) before entering the reactor to reduce amount of undesired products. The reaction is maintained at $900^\circ C$ and 1.4 atm total pressures. Reaction is first order irreversible and rate constant is 12.8 sec^{-1} at $900^\circ C$. Calculate the volume of reactor required for 60% conversion of Ethane per pass. 07

- Q.5 (a) For aqueous reaction $A \rightleftharpoons R$, between the temperature range 0° to $100^\circ C$, determine the equilibrium conversion as a function of temperature in graphical form. What should be the maximum temperature so that the conversion of A achieved is 75% or higher? 07

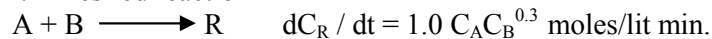
For $C_R^\circ = C_A^\circ = 1$ mol/liter,

$$\Delta G_{298}^\circ = -3375 \text{ cal/mol}$$

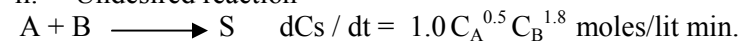
$$\Delta H_{r,298} = -18,000 \text{ cal/mol}$$

- (b) For the following liquid phase reactions in parallel, product R is desired out of two products R & S , 07

i. Desired reaction



ii. Undesired reaction



90% conversion of A is desired. Feed comprises of pure A & pure B in equal proportion with density of 20 mol/lit of each. Assuming that B is introduced into reactor in such a way that $C_B = 1$ moles/lit, throughout the reactor. Find the Overall fractional yield.

OR

- Q.5 (a) Discuss performance equations for Recycle reactors. 07

- (b) An exothermic reaction is carried out in an adiabatic batch reactor. Show how fractional conversion X , is related to temperature. 07
