Seat No.: ________ *Enrolment No.*______________

GUJARAT TECHNOLOGICAL UNIVERSITY

BE- VIIth SEMESTER–EXAMINATION – MAY/JUNE- 2012

Subject code: 170501 **Date: 24/05/2012**

Subject Name: Chemical Reaction Engineering – I

Time: 02:30 pm – 05:00 pm **Total Marks: 70**

Instructions:

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

Q – 1 Answer the following in brief.

(i) Give an example of zero order reaction. [01]

(ii) Name the method used to determination order of nuclear reaction. The decay constant of radium is 1620 yr^{-1}, calculate half life of radium in sec. [02]

(iii) The gas mixture contains 50 mole % A, 25 mole % B and remaining inert in close vessel at a pressure of 15 atmosphere and temperature 150 ^{0}C. Calculate the concentration of A and B in k-mol / m^3. [02]

(iv) The gas phase reaction between A and B is written as: A + 3B →C is second order with respect to both reacting components. Suddenly the volume of reacting mixture reduced to one third of the initial volume. Find the change in rate of reaction. [03]

(v) On doubling the concentration of the reactants, the rate of reaction increase four times. Find the order of reaction. [03]

(vi) Distinguish between elementary and nonelementary. [03]

Q – 2

(a) Write a short note on temperature dependency of reaction rate constant from Arrhenius law. Compare the same with transition state and collision theories. [07]

(b) Discuss the kinetic models for nonelementary reactions and mechanisms of different type with suitable example. [07]

OR

(b) Explain the effect of temperature on rate of endothermic and exothermic reactions. The rule of thumb that the rate of reaction doubles for a 10 ^{0}C increase in temperature occurs only at a specific temperature for given activation energy. Show that the relationship between activation energy and temperature in terms of Kelvin for which the rule holds is: $T = \left[\frac{10\,E}{R\,\ln 2}\right]^{\frac{1}{2}}$ [07]

Q – 3

(a) Discuss the analysis of total pressure data obtained in a constant volume system and also establish the relation use to calculate the partial pressure of gaseous component in reaction mixture. [07]

(b) Discuss the integral method of analysis of rate data. Establish the relation between conversion – time and reaction rate constant – half life of reaction for irreversible unimolecular type first order reactions using integral method of analysis. [07]

OR

Q – 3

(a) For the reaction A + B → products with equal concentration of A and B, establish the relation between conversion and time. Also discuss the half-life of the reaction. [07]

(b) Show that $\ln \frac{M - X_A}{M\,(1 - X_A)} = C_{A0}\,(M - 1)\,k\,t,\, M \pm 1$ for second order irreversible bimolecular type reaction A + B → products with different concentration of reactants A and B. [07]

Q – 4

(a) Consider a unimolecular type first order in series reaction A → R → S. Derive an expression for concentration of intermediate R as a function of time. [07]

(b) Show that conversion at the outlet of N^{th} reactor is $X_N = 1 - \frac{1}{(1 + \tau\,k)^N}$ for N equal size continuous stirred tank reactor connected in series and operating at the same temperature. [07]

OR

Q – 4

(a) Assuming a stoichiometry: A → R for a first order gas phase reaction, the volume of a plug flow reactor to achieve 99 % conversion of pure A is calculated to be 32 liters. In fact, however, the stoichiometry of the reaction is: A → 3R. For this corrected stoichiometry of reaction, find the volume of reactor required to achieve the same conversion. [07]

(b) Discuss the size comparison of mixed flow reactor with plug flow reactor for first order reaction. Also discuss the general graphical comparison of performance of mixed flow reactor with that of plug flow reactor for any reaction kinetics. [07]

Q – 5

(a) It is proposed to operate a batch reactor for converting A into B. This is a liquid phase reaction with the stoichiometry: A → B. Determine the time required to reduce the initial concentration 1.3 mol / liter to final concentration 0.30 mol / liter. Also determine the volume of plug flow reactor required to achieve 80 % conversion of a feed stream of 1500 mol A / hr with initial concentration 1.5 mol / liter to final concentration 0.30 mol / liter. The rate versus concentration data are as given below: [10]

C_A, mol / liter	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	1.0	1.3	2.0
$-r_A$ mol / liter min.	0.10	0.30	0.50	0.60	0.50	0.25	0.10	0.06	0.05	0.045	0.042

(b) An aqueous reactant stream with initial concentration 4 mol / liter passes through mixed flow reactor followed by a plug flow reactor. If concentration of reactant A in mixed flow reactor is 1 mol / liter, reaction is second order with respect to A and volume of plug flow reactor double than mixed flow reactor. Find the concentration at the exit of the plug flow reactor. [04]

OR

Q – 5

(a) The data of decomposition of gaseous reactant A in a constant volume batch reactor at 100 ^{0}C is given below. The stoichiometry of the decomposition reaction is: 2A → R + S. Find the size of plug flow reactor operating at 100 ^{0}C and 1 atmosphere that can process 100 mol A / hr feed containing 20 mole % inert necessary to achieve 95 % conversion of A. If mixed flow reactor of volume 208 liters is used in same reaction with identical feed and operating conditions. Find the conversion of A achieved in mixed flow reactor. [10]

Time (t, Sec.)	0	20	40	60	80	100	140	200	260	330	420
Partial pressure of A, (p_A, atm)	1.0	0.80	0.68	0.56	0.45	0.37	0.25	0.14	0.08	0.04	0.02

(b) The elementary liquid phase reaction: A + B → C with $-r_A = 500\, C_A C_B$ is carried out in plug flow reactor. The reaction is second order with equal initial concentration 0.01 mol / liter of both the reactant. The volume of reactor is 0.1 liter and volumetric flow rate is 0.05 liter / min. Find the fractional conversion of reactants that can be achieved in plug flow reactor and the volume of continuous stirred tank reactor to achieve same fraction conversion that achieved in plug flow reactor. [04]

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