09/06/2025 TE CHEMICAL SEM-V C-SCHEME CRE-I QP CODE: 10086757

Time: 3 Hours **Total Marks: 80**

N.B.: 1. Question No.1. is compulsory.
2. Attempt any three questions out of remaining five questions.
3. Assume suitable data and justify the same.
4. Figures to the right indicate full marks

Q 1 (a) Explain the Integral method of analysis of kinetic data. **05**

(b) Derive the performance equation for CSTR. **05**

(c) A common rule of temperature is that the rate of a reaction doubles for each 10°C rise in temperature. What activation energy would this suggest at a temperature of 25°C **05**

(d) Short note on Optimum temperature Progression **05**

Q 2 (a) Experiment shows that the homogeneous decomposition of ozone proceeds at a rate **10**

$$-r_{O3}=k\,[O_3]\,[O_2]^{-1}$$

(a) What is the overall order of reaction?

(b) Suggest a two-step mechanism to explain this rate.

(b) A 10-minute experimental run shows that 75% of the liquid reactant is converted to product by a ½ order rate. What would be the fraction converted in a half-hour run? **10**

Q 3 (a) Liquid reactant A decomposes as follows: **10**

$A \rightarrow R \quad r_R = k_1 C_A^2 \qquad k_1 = 0.35\ m^3/mol.min$

$A \rightarrow S \quad r_S = k_2 C_A \qquad k_2 = 2.5\ min^{-1}$

A feed of aqueous A (C_{A0} = 50 mol/m^3) enters a reactor, decomposes and a mixture of A, R, and S leaves the reactor. Find C_R, C_S and τ for X_A =0.8 in a mixed flow reactor

(b) For the irreversible first-order series reaction A→ R→ S, the values of rate constants k1 and k2 are 0.17 min-1 and 0.11 min-1, respectively, for reactions 1 and 2. i) Calculate the time at which the concentration of R is maximum, and ii) the maximum concentration of R. **10**

Q4 (a) A first-order reaction is carried out in a single CSTR, resulting in an 80% conversion of reactant A. It is proposed to put another similar CSTR in series with the first one. How will this addition affect the conversion of the reactant? **10**

(b) What is an autocatalytic reaction? Discuss the types of reactors/reactor combinations used to carry out this type of reaction. **10**

Q 5 (a) The first-order homogeneous gaseous reaction A → 2.5 R is carried out in an isothermal variable volume batch reactor at 2 atm pressure with 20 mole % inert present, and the volume increases by 60 % in 20 minutes. In the case of a constant volume reactor, determine the time required for the pressure to reach 8 atm if the initial pressure is 5 atm, 2 atm of which consists of inerts. **10**

(b) From the steady-state kinetic runs in a mixed flow reactor, we obtained the following data on the reaction. **10**

$$A \rightarrow R$$

Find the space time needed to treat a feed with an initial concentration of 100 mol/m^3 to 80% conversion in a) Plug flow reactor, b) Mixed flow reactor.

Space time (min)	60	35	11	20	11
C_{AO} (mol/m^3)	50	100	100	200	200
C_A(mol/m^3)	20	40	60	80	100

Q 6 (a) The standard heat of gas phase reaction at 25 ^{0}C **10**

A+ B → 2R is ΔH_R^0 = - 45000 J. This indicates the reaction is strongly exothermic. It is planned to run this reaction at 1000 ^{0}C. What is the value of heat of reaction at that temperature? Is the reaction still exothermic at 1000 ^{0}C?

Data: Cp_A = 35.5 J/mol.k Cp_B = 45.5 J/mol.k Cp_R = 70.5 J/mol.k

(b) An irreversible isomerisation reaction carried out in the liquid phase in a mixed reactor A→R is a first-order reaction. Rate constant at 165 ^{0}C = 0.7 h^{-1}, Activation energy = 120000 J/mol, Heat of reaction = - 350 KJ/kg, Heat capacity of reactants and products = 1.95 kJ/kg.K, volumetric flow rate = 0.33 m^3/h Feed temp = 20^0 C, conversion expected = 95 % Calculate the reactor size and temperature of the reaction mixture if the reactor is operated adiabatically. **10**