1T00535 - T.E.(Chemical Engineering)(SEM-V)(Choice Base Credit Grading System) (R- 19) (C Scheme) / 31723 - Chemical Reaction Engineering-I QP CODE: 10039862 DATE: 29/11/2023

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

N.B.:

(i) Question No.1. Is compulsory.
(ii) Attempt any three questions out of the remaining five questions.
(iii) Assume suitable data and justify the same.
(iv) Figures to the right indicate full marks

Q 1

(a) Difference between elementary and nonelementary reaction with example. **05**

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

(c) Derive performance equation of constant stirred tank reactor. **05**

(d) Explain the fractional life method of analysis of experimental data **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 and further test this mechanism

(b) 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 % inerts 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**

Q 3 **(a)** Sucrose is hydrolysed at room temperature by the catalytic action of enzyme sucrase as follows. **12**

Sucrose → Products

Following kinetic data are obtained in a batch reactor by starting a run with a sucrose concentration C_{A0} = 1 mmol/lt and an enzyme concentration C_{E0} = 0.01 mmol/lt

Time, hr	1	2	3	4	5	6	7	8	9	10	11
C_A, (mmol/lt)	0.84	0.68	0.53	0.38	0.27	0.16	0.09	0.04	0.018	0.006	0.0025

Check whether these data can reasonably fit a kinetic equation of type.

$$-r_A = \frac{kC_AC_{E0}}{C_A + M}$$

If so, evaluate constant k and M (Michaelis Menten constant)

(b) It is proposed to replace our present mixed-flow reactor with one having double the volume. Find the conversion in a new mixed-flow reactor for the same aqueous feed (C_{A0}= 10 mol A/lt) and the same feed rate. The stoichiometry and kinetics of the reaction are given by **08**

$A \rightarrow R \quad -r_A = kC_A^{1.5}$

Q4 **(a)** For the irreversible first-order series reaction A→ R →S, the values of rate constants k_1 and k_2 are 0.34 $(min)^{-1}$ and 0.22 $(min)^{-1}$, respectively. Calculate (i) the time at which the concentration of R is maximum and (ii) the maximum concentration of R. **10**

Take C_{A0} = 1.25 mol/l.

(b) 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**

Q 5 **(a)** The homogeneous gas phase reaction A→3R is a second-order reaction. In an experimental reactor (size: 25 mm ID pipe x 2 m length), 60% conversion of A is achieved for a feed rate of $4m^3/h$ of pure A at 350℃ and 5 atm. A commercial plant is to handle 320 m^3/h of feed containing 50 mole% A and 50 mole% inerts at 350 ℃ and 25 atm for obtaining 80% conversion of A. **12**

i) How many 2 m lengths of 25 mm ID pipes are needed to achieve 80% conversion?

ii) Should the pipes be arranged in parallel or series?

(b) What is autocatalytic reaction? Discuss the types of reactor /reactor combinations used to carry out this type of reaction. **08**

Q 6 **(a)** Between 0^0 C and 100^0 C determine the equilibrium conversion for the elementary aqueous reaction. Plot conversion versus temperature chart **15**

$A \rightleftharpoons R$ ΔG^0_{298} = -14130 J/mol ΔH^0_{298} = -75300 J/mol

$C_{pA} = C_{pR}$ = constant

What restrictions should be placed on the reactor operating isothermally if we are to obtain a conversion of 75% or higher?

(b) Explain optimum temperature progression wrt reversible exothermic reaction? **05**

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