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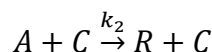
GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER-VII(OLD) • EXAMINATION – WINTER 2017

Subject Code: 173601
Date: 10/11/2017
Subject Name: Basics of Catalysis
Time: 10.30 AM TO 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.

- 1 (a) What are the differential and integral analysis for kinetic data? Which one is more accurate? 07
- (b) Classify the catalyst based on the reactions, explain any two in detail. 07
- 2 (a) Derive an expression for concentration and time for a first order homogeneous catalytic reaction with respect to A by an integral method. The equation is in the form as: 07



- (b) Show that the decomposition of N_2O_5 at 340 K is a first order reaction. Calculate the value of the rate constant. 07

| | | | | | |
|----------------------|------|-------|------|-------|------|
| Time (min) | 0 | 1 | 2 | 3 | 4 |
| $C_{N_2O_5}$, mol/l | 0.16 | 0.113 | 0.08 | 0.056 | 0.04 |

OR

- (b) How the deactivation of a catalyst takes place? How it is prevented and regenerated? 07
- 3 (a) How the deactivation of a catalyst takes place by sintering? Derive the expression for the catalyst decay due to sintering. 07
- (b) Reactant A is adsorbed on the surface of a catalyst and reacts with another component B in the gas phase. The products of the reaction are: C adsorbed on the surface and D in the gas phase. The product C is then desorbed from the surface. The proposed mechanism is 07

 Adsorption: $A(g) + S \leftrightarrow A.S$

 Surface reaction: $B(g) + A.S \leftrightarrow C.S + D(g)$

$$r_s = k_s \left(P_B C_{A.S} - \frac{C_{C.S} P_D}{K_s} \right)$$

 Desorption: $C.S \leftrightarrow C(g) + S$

$$r_D = k_D \left(C_{C.S} - \frac{C_V P_C}{K'_C} \right)$$

For surface reaction control, show that

$$-r'_A = r_s = \frac{C_t k_s K_A (P_A P_B - P_C P_D / K_P)}{1 + P_A K_A + P_C / K'_C}$$

OR

- 3 (a) How the deactivation of a catalyst takes place by poisoning? Derive the expression for catalyst decay due to poisoning. 07
- (b) Toluene is adsorbed on the surface of a catalyst and reacts with hydrogen in the gas phase to produce benzene adsorbed on the surface and methane in gas phase. Benzene is then desorbed from the surface. The proposed mechanism is:

Adsorption: $T(g) + S \leftrightarrow A.S$

$$r_{AD} = k_A \left(P_T C_V - \frac{C_{T.S}}{K_T} \right)$$

Surface reaction: $H_2(g) + T.S \leftrightarrow B.S + M(g)$

$$r_s = k_s \left(P_{H_2} C_{T.S} - \frac{C_{B.S} P_M}{K_S} \right)$$

Desorption: $B.S \leftrightarrow B(g) + S$

$$r_D = k_D \left(C_{B.S} - \frac{C_V P_B}{K'_B} \right)$$

When surface reaction controls show that

$$-r'_T = r_s = \frac{C_t K_S K_t (P_{H_2} P_T - P_B P_M / K_P)}{1 + P_T K_T + P_B / K'_B}$$

- 4 (a) Derive a performance equation for a catalytic batch reactor containing a batch of gas. 07
- (b) What is temperature time trajectory for a catalytic reaction? 07

OR

- 4 (a) Derive an expression of concentration at the surface and at any time for the pore diffusion resistance combined with surface kinetics for a cylindrical particle. Consider the reaction is of first order. 07
- (b) Derive a performance equation for a catalytic plug flow reactor for a first order reaction. 07
- 5 (a) Write the expression for the different catalyst particle shapes effectiveness factor. Also make a graph between effectiveness factor and the Thiele modulus for different particle shapes. 07

- (b) For the first order reaction the following rate concentration data is available

07

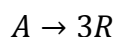
| | | | | |
|-------------------------|-------|--------|-------|-------|
| C_A , mol/l | 0.039 | 0.0575 | 0.075 | 0.092 |
| $-r_A$, mol A/h.kg cat | 3.4 | 5.4 | 7.6 | 9.1 |

Without using a rate equation, find the size of packed bed needed to treat 2000 mol/hr of pure A at 117°C ($C_{A0}=0.1$ mol/l, $\epsilon_A=3$) to 35% conversion at 3.2 atm.

OR

- 5 (a) A homogeneous gas reaction

07



has a reported rate at 215°C

$$-r_A = 10^{-2} C_A^{\frac{1}{2}}, \text{mol/l. sec}$$

Find the space time needed for 80% conversion of a 50% A-50% inert feed to a plug flow reactor operating at 215°C and 5 atm ($C_{A0}=0.0625$ mol/l).

- (b) Explain the mechanism for the enzyme-substrate reaction of Michaelis-Menton. Derive the expression for the rate.

07

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