**16117**

**3 Hours / 100 Marks**   Seat No. ⬜⬜⬜⬜⬜⬜⬜

*Instructions* : (1)  All Questions are *compulsory*.

(2)  Illustrate your answers with neat sketches wherever necessary.

(3)  Figures to the right indicate full marks.

(4)  Assume suitable data, if necessary.

(5)  Use of Non-programmable Electronic Pocket Calculator is permissible.

**Marks**

1.  (A)  **Attempt any THREE of the following :**                                     **12**

(a)  Write any four differences between molecularity and order of reaction.

(b)  Derive the relation between $K_p$ and $K_c$.

(c)  Define autocatalytic reaction. Give example.

(d)  Draw a sketch of graphical representation of the design equation for MFR and PFR.

(B)  **Attempt any ONE of the following :**                                     **06**

(a)  Write the steps for differential method of analysis data.

(b)  After 8 minutes in a batch reactor, reactant A ($C_{Ao}$ = 1 mol/lit) is 80% converted. After 18 minutes conversion is 90%. Find the rate of reaction (K and order both).

**2. Attempt any TWO of the following :** **16**

(a) The rule of thumb that the rate of reaction doubles for a 10 °C increase in temperature occurs only at a specific temperature for a given activation energy (i.e., for specific combination of temperature and activation energy). Show that the relationship between activation energy and temperature for which the rule holds is

$$T = \left[ \frac{10 \ (K) \ E}{R \ ln \ 2} \right]^{1/2}$$

(b) Compare the size of MFR v/s PFR for first order reaction.

(c) What is catalyst poison ? Describe the method of catalyst preparations.

**3. Attempt any FOUR of the following :** **16**

(a) How the feasibility of chemical reaction is determined from Gibb's free energy change ?

(b) Derive an integrated rate expression for first order reaction $(A \rightarrow R)$ in term of concentration.

(c) Calculate the ratio of $K_p$ to $K_c$ at 300 K for the following reactions :

    (I)    $N_2 \ (g) + O_2 \ (g) \rightleftharpoons 2 \ NO \ (g)$

    (II)   $NH_4 \ Cl \ (S) \rightleftharpoons HCl \ (g) + NH_3 \ (g)$

(d) Derive the temperature dependency of rate constant from Arrhenius theory.

(e) Differentiate between fixed – bed and fluidized – bed reactors. (any four points)

**4. (A) Attempt any THREE of the following :** **12**

(a) Show that the decomposition of $N_2O_5$ at 67 °C is a first order reaction.

Calculate the value of the rate constant.

Data :

| Time, Min | 0 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| $C_{N_2O_5}$, Mol / $l$ | 0.16 | 0.113 | 0.08 | 0.056 | 0.040 |

(b)   State the desired properties of Catalyst.

(c)   Derive an integrated rate expression for a zero order reaction.

(d)   Derive the relationship between $\Delta G°$ and $K_P$.

**(B)   Attempt any ONE of the following :**                                     **06**

(a)   At 500 K the rate of bimolecular reaction is ten times the rate at 400 K. Find the activation energy for this reaction.

   (I)    From Arrhenius law.

   (II)   From collision theory

   (III)  What is the percentage difference in rate of reaction at 600 K predicted by these two methods ?

(b)   Derive the Van't Hoff equation.

**5.   Attempt any TWO of the following :**                                      **16**

(a)   Derive the relation for constant volume irreversible second order reaction $A + B \rightarrow$ product using integral method of analysis.

(b)   The laboratory measurements of rate v/s conversion for reactant A are given below. Compare the volume of a mixed flow reactor. (CSTR) and a plug flow reactor require to achieve 60% conversion. The feed conditions are the same in both the cases and molar flow rate of A entering the reactor is 10 mol/s.

| $X_A$ | 0 | 0.20 | 0.4 | 0.60 | 0.80 |
|---|---|---|---|---|---|
| $-V_{A,\ Mol\ /\ (l.\ s)}$ | 0.182 | 0.143 | 0.10 | 0.0667 | 0.0357 |

(c)   Derive the performance equation for plug flow reactor in terms of concentration and conversion. Give the graphical representation also.

6. **Attempt any FOUR of the following :** 16

(a) Define the term space time and space velocity with their units and mathematical expression.

(b) Derive the expression for entropy change of an ideal gas process.

(c) State the factors affecting the rate of reaction.

(d) Show the relation $C_A = C_{A_o} (1 - X_A)$

(e) Derive the relationship between $C_A$ and $X_A$ for constant density batch and flow systems.

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