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) Explain the temperature dependency of reaction rates on the basis of Arrhenius theory. **[05]**

(B) Liquid A decomposes by second-order kinetics, and in a batch reactor 50% of A is converted in 5 minutes. How long will it take to reach 75% conversion? **[05]**

(C) Differentiate between the integral and differential methods of analysis of kinetic data. **[05]**

(D) Derive the design equation of a plug flow reactor. **[05]**

Q. 2 (A) The reaction between nitric oxide and oxygen **[10]**

$2\ NO + O_2 \rightarrow 2\ NO_2$

Follows the rate law

$-d[O_2] / dt = k\ [NO]^2\ [O_2]$

Suggest a reaction mechanism which is consistent with this rate law.

(B) The decomposition of Phosphine is irreversible and first order at 650°C **[10]**

$$4PH_{3(g)} \rightarrow P_{4(g)} + 6H_{2(g)}$$

The rate constant in sec^{-1} is reported as –

$$\log k = \frac{-18963}{T} + 2\log T + 12.130$$

Where T is in K. In a closed vessel (constant volume) initially containing PH_3 at 1 atm pressure, what will be pressure after 50, 100 and 500 seconds. The temperature is maintained at 650°C.

Q. 3 (A) The first order homogenous gaseous decomposition $A \rightarrow 2.5R$ is carried out in an isothermal batch reactor at 2 atm pressure with 20 mol% inert present and the volume increases by 60% in 20 minutes. In case of 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 inert. **[10]**

(B) Write short notes on- i) Auto catalytic reactions ii) Shifting order reactions. **[10]**

Q. 4 (A) For the gas phase reaction $4A \rightarrow R + 6S$, what size of PFR , operating at 650C and 5 atm pressure, produce 75% conversion of a feed consisting of 5 mol of pure A / hr. The rate of reaction is $-r_A = 10\ hr^{-1}.C_A$ **[10]**

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(B) Enzyme e catalyses the fermentation of substrate A (reactant) to product R. estimate the size of MFR needed for 95% conversion of a reactant in a feed stream of 25 lit/min of reactant with 2 mol A/lit and enzyme. The kinetics of fermentation is represented as – **[10]**

$$A \xrightarrow{enzyme} R, \qquad -r_A = \frac{0.1C_A}{1 + 0.5C_A}, \frac{mol}{lit.min}$$

Q. 5 (A) The liquid reactant stream [1 mol/lit] passes through 2 MFRs in series. The concentration of A in the exit of first reactor is 0.5 mol/ lit. find the concentration of A in tne exit stream of second reactor. The reaction follows second order kinetics with respect ot A and $V_2/V_1 = 2$. **[10]**

(B) The hydrolysis of Acetic Anhydride with $-r_A = 0.06$ CA gmol/cc.min is being carried out in flow reactors at 1 atm and 15°C. the feed concentration is **[10]**

2×10^{-4} gmol/cc and feed rate is 10 cc/s. Find conversion –

i] if the reaction is carried out in CSTR of 10 liter capacity.

ii] if the reaction is carried out in two CSTRs each of 5 liter volume connected in series.

Iii] if the reaction is carried out in two CSTRs each of 5 liter volume connected in parallel.

Q. 6 (A) Write short note on Optimum Temperature Progression. **[05]**

(B) Determine the equilibrium conversion for the following elementary reaction between 0C and 100C. **[15]**

$$A \leftrightarrow R$$

$$At\ 298K, \Delta G° = -14130\frac{J}{mol}, \Delta H_R^\circ = -75300\frac{J}{mol},$$
$$C_{pA} = C_{pR} = constant$$

i) Construct a plot of temperature vs conversion.

ii) What restrictions should be placed on the reactor operating isothermally if conversion of 75% or more is desired?

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