

(Time : 3 Hours)**[Total Marks: 80]**

- N.B.** (i) Question number 1 is compulsory.
(ii) Answer any three questions from rest.
(iii) Assume suitable data wherever necessary.

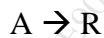
- Q. 1 (A) The rate constant of a certain reaction are 1.6×10^{-3} and 1.625×10^{-2} $(s)^{-1}$ at $10^\circ C$ and $30^\circ C$. Calculate the activation energy. [05]
- (B) Derive integrated rate expressions in terms of concentration and conversion for first order reaction. [05]
- (C) Explain differential method of analysis. [05]
- (D) Derive design equation of batch reactor. [05]
- Q. 2 (A) The decomposition of phosphine is irreversible and first order at $650^\circ C$. [10]
- $$4PH_3(g) \rightarrow P_4(g) + 6H_2(g)$$
- The rate constant in $(s)^{-1}$ is reported as
- $$\log K = (-18963/T) + 2 \log T + 12.13$$
- where T is in Kelvin (K). In a closed vessel (constant volume) initially containing pure phosphine, the pressure is 1 atm. What will be the pressure after 50, 100 and 500 seconds? The temperature is maintained at $650^\circ C$.
- (B) An aqueous solution of ethyl acetate is to be saponified with NaOH. The initial concentration of ethyl acetate is 5 gm/lit and that of caustic is 0.1 normal. The values of second order rate constant at $0^\circ C$ and $20^\circ C$ are $k = 0.235$ and 0.924 $(lit/mol) \min^{-1}$ respectively. The reaction is irreversible. Calculate the time required to saponify 95% of ester at $40^\circ C$. [10]
- Q. 3 (A) A homogeneous gas phase reaction $A \rightarrow 3R$, proceeds with $(-r_A) = 10^{-1} C_A$, $[mol/l.s]$ at $200^\circ C$. [10]
- Find the space time required to achieve 80% conversion of a 50 mole % A and 50 mole % inerts feed to a plug flow reactor operating at $200^\circ C$ and 5 atm pressure. The initial concentration of A is 0.0625 mol/lit.
- (B) A gaseous feed of pure A with $C_{A0} = 2$ mol/lit and $F_{A0} = 100$ mol/min decomposes to give variety of products in a plug flow reactor (22 lit). [10]
- The kinetics and stoichiometry of reaction are given by
 $A \rightarrow 2.5$ (products), $(-r_A) = (10 \min^{-1}) C_A$
Find the conversion of A in the reactor.
- Q. 4 (A) 100 lit/hr of radioactive fluid having a half life of 20 hr is to be processed by passing it through two mixed flow reactors in series. The [10]
- volume of each MFR in series is 40000 lit. Find the decay in activity in passing the fluid through this reactor system. The reaction follows first order kinetics.

- (B) A liquid phase reaction $A + B \rightarrow P + Q$ with $k_1 = 7 \text{ lit}/(\text{mol}\cdot\text{min})$ and $k_2 = 3 \text{ lit}/(\text{mol}\cdot\text{min})$ takes place in a steady state mixed flow reactor ($V = 120 \text{ lit}$). Two feed streams, one containing 1.4 mol A/lit and the other containing 0.8 mol B/lit are fed in equal volumes into the reactor. 75% conversion of the limiting component is achieved. Find the flow rate of each stream assuming a constant density throughout. [10]

- Q. 5 (A) The saponification reaction $\text{NaOH} + \text{CH}_3\text{COOC}_2\text{H}_5 \rightarrow \text{CH}_3\text{COONa} + \text{C}_2\text{H}_5\text{OH}$ follows second order kinetics. A laboratory well stirred tank reactor is charged with an aqueous solution containing NaOH and ethyl acetate, both at an initial concentration of 0.1 molar. 18% conversion of ethyl acetate is obtained in 15 min. For an initial charge containing NaOH and ethyl acetate in equal concentration of 0.2 molar, find the time required to achieve a conversion of 30% in a commercial batch reactor? [10]

- (B) One gaseous feed stream, containing A with $C_{A0}' = 0.01 \text{ mol/lit}$, at a rate of 1 lit/min and a second gaseous stream, containing B with $C_{B0}' = 0.02 \text{ mol/lit}$, at a rate of 3 lit/min enter a mixed flow reactor of volume 1 lit and react in it to form a number of products R, S, T.... Analysis of the exit stream of 6 lit/min shows that $C_A = 0.0005 \text{ mol/lit}$ and $C_R = 0.001 \text{ mol/lit}$. The measurements of flow rates and concentrations are done at the uniform temperature and pressure of the reactor. Estimate the rate of reaction of A in the reactor. [10]

- Q. 6 (A) Determine the equilibrium conversion for the following elementary reaction between 273 K and 373 K. [15]



$$\text{At } 298 \text{ K: } \Delta G^\circ = -14130 \text{ J/mol, } \Delta H_R^\circ = \Delta H_{RT=298} = -75300 \text{ J/mol}$$

$$C_{PA} = C_{PR} = \text{constant}$$

(i) Construct a plot of temperature v/s conversion

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

- (B) Write short note on Optimum Temperature Progression [05]
