(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 ^oC and 30 ^oC. 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^{o}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^{o}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^{o}C and 20^{o}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^{o}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^{o}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^{o}C and 5 atm pressure. The initial concentration of A is 0.0625 mol/lit.

(B) A gaseous feed of pure A with C_{Ao} = 2 mol/lit and F_{Ao} = 100 mol/min decomposes to give variety of products in a plug flow reactor (22 lit). The kinetics and stoichiometry of reaction are given by [10]
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 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. [10]

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(B) A liquid phase reaction A + B → P + Q with k_1 = 7 lit/(mol.min) and k_2 = 3 lit/(mol.min) takes place in a steady state mixed flow reactor (V = 120 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 NaOH + $CH_3COOC_2H_5$ → CH_3COONa + C2H5OH 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. [10]
For an initial charge containing NaOH and ethyl acetate in equal concentration of 0.2molar, find the time required to achieve a conversion of 30% in a commercial batch reactor?

(B) One gaseous feed stream, containing A with C_{Ao}' = 0.01 mol/lit, at a rate of 1 lit/min and a second gaseous stream, containing B with C_{Bo}' = 0.02 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 mol/lit and C_R = 0.001 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]
A → R
At 298 K: $\Delta G^o = -14130$ *J/mol,* $\Delta H_R^o = \Delta H_{RT=298} = -75300$ *J/mol*
$C_{PA} = C_{PR}$ = *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]

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