(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 activation energy of a bimolecular reaction is about 9150 cal/mol. How much faster is this reaction takes place at 500 K than at 400 K? [05]

(B) After 8 minutes in batch reactor, reactant is 80% converted and after 18 minutes conversion is 90%. Find the rate expression to represent this reaction if CA0 = 1 mol/lit. [05]

(C) Explain Differential method of analysis of kinetic data. [05]

(D) Derive design equation of continuous stirred tank reactor. [05]

Q. 2 (A) Show that the following scheme: [10]

$$N_2O_5 \rightleftharpoons NO_2 + NO_3^*$$

$$NO_2 + NO_3^* \rightarrow NO_2 + O_2 + NO^*$$

$$NO^* + NO_3^* \rightarrow 2NO_2$$

Is consistent with, and can explain, the observed first order decomposition of N_2O_5

(B) The first order reversible liquid phase reaction $A \leftrightarrow R$ takes place in a batch reactor. After 8 minutes, conversion of A is 33.33% while equilibrium conversion is 66.7%. Find the rate expression for this reaction taking CA0 = 0.5 mol/lit and CR0 = 0. [10]

Q. 3 (A) The gases reaction $2A \rightarrow R + 2S$ is approximately second order with respect to A. when pure A is introduced at 1 atm into a constant volume batch reactor the pressure rises by 40% in 3 minutes. For a constant pressure batch reactor find- [10]

a) Time required for the same conversion,
b) The fractional increase in volume at that time.

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

Q. 4 (A) 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 the reactant with 2 mol A/lit and enzyme. The kinetics of fermentation is represented as – [10]

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

(B) For the gas phase reaction 4A → 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]

Q. 5 (A) It is desired to produce 4000 kmol/day of Ethylene Glycol as per reaction – [20]

$$C_2H4O + H_2O \rightarrow CH_2OH\text{-}CH_2OH$$

The reactor is operated isothermally. A 16.05 kmol/m^3 solution of Ethylene oxide is fed to the CSTR together with an equal volumetric solution of water containing 90% by wt H_2SO_4. If 80% conversion is to be achieved, find the volume of reactor. How many CSTRs of volume 3 m^3 each would be required if they are arranged in parallel and what would be the corresponding conversion. How many CSTRs of volume 3 m^3 each would be required if they are arranged in series and what would be the conversion.

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

(B) At 1000K and 1 atm substance A is 2 mol% dissociates according to gas phase reaction $2A \leftrightarrow 2B + C$. Using the following data calculate – [15]

i) mole% dissociated at 200K and 1 atm
ii) mole% dissociated at 200K and 80.1 atm.

Data –

$C_{pAavg} = 12\ Cal/mol.K$, $C_{pBavg} = 9\ Cal/mol.K$, $C_{pCavg} = 6\ Cal/mol.K$ $\Delta H_R^\circ = 2000\ Cal/mol$

At 25C and 1 atm, 2000 Cal are released when mole of A is formed from the reactants B and C.