(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) Explain the following terms [05]
i. Rate of reaction
ii. Order of reaction
iii. Rate constant

(B) Differentiate between Elementary & Non-elementary reactions. [05]

(C) Derive design equation of Continuous Stirred Tank reactor (CSTR) [05]

(D) A certain reaction has a rate given by [05]
$-r_A = 0.005\ C_A^2$, mol/(cm^3.min)
If the concentration is expressed in mol/lit and time in hours, what would be the value and units of rate constant?

Q. 2 (A) Experimental analysis shows that the homogeneous decomposition of $(2O_3 \rightarrow 3O_2)$ proceeds with a rate [10]
$-r_{O3} = k\,[O_2]^2\,[O_2]^{-1}$
(i) Suggest a two-step mechanism to explain this rate
(ii) What is the overall order of reaction?

(B) The following table shows how the concentration of reactant A varied with time in a particular experiment. [10]

Time (min)	Concentration of A (mol/lit)
0	2.77×10^{-4}
10	2.32×10^{-4}
31	2.05×10^{-4}
55	1.59×10^{-4}
79	1.26×10^{-4}
157	0.58×10^{-4}
∞	0

(a) Plot a graph of concentration of A against time
(b) Draw tangents to the curve at 10, 50, 100 & 150 minutes and calculate their slopes.
(c) Plot a graph of rate of reaction against concentration of A
(d) Find if the line passes through origin.
(e) With the help of graph, state the relationship between the rate of reaction and concentration of reactant both in words and mathematically.
(f) Find the value of rate constant from graph
(g) What is the order of reaction?

Q. 3 (A) 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°C and 20°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°C. [10]

(B) A zero order homogeneous gas phase reaction with the stoichiometry A → rR proceeds in a constant volume bomb, 80 mole % A & 20 mole % inerts. Due to this the pressure rises from 1 to 1.3 atm in 2 min. If the same reaction is carried out in a constant pressure batch reactor. Find the fractional volume change in 4 minutes if the feed contains 60 mole % A & 40 mole % inerts & is at 3 atm. [10]

Q. 4 (A) 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 MFR 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_{Af} = 0.0005 mol/lit and C_{Rf} = 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 and rate of formation of R in the reactor. [10]

(B) Assuming a stoichiometry A → R for a first order gas phase reaction, the size (volume) of plug flow reactor required to achieve 99% conversion of a pure A is 32 lit. In fact, however, the stoichiometry of the reaction is A → 3R. For this corrected stoichiometry, find the required size of the same type reactor. [10]

Q. 5 (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]

(B) An industrial unit has two mixed flow reactors of unequal size for producing a specified products according to first order kinetics. How should these reactors be connected to obtain a maximum production rate? [10]

Q. 6 (A) For the reversible first order aqueous reaction [10]

A ⟷ R starting with pure A, kinetic experiments in a batch reactor give 58.1 % conversion in 1 min at 65oC and 60% conversion in 10.1 min at 25°C. Find the rate expression for this reaction.

Data: Equilibrium conversion at 65°C = 0.89

Equilibrium conversion at 25°C = 0.993

At 298 K, $\Delta G = -14130$ J/mol, $\Delta H_R^o = -75300$ J/mol

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

(B) 400 lit/min of an aqueous feed of A & B with C_{Ao} = 100 mmol/lit and C_{Bo} = 200 mmol/lit is to be converted into product in a mixed flow reactor. The kinetics and stoichiometry of the reaction are given by [10]

A + B → R, $-r_A = 200\ C_A C_B$, mol/lit.min

Estimate the volume of reactor required to achieve 99% conversion of A to product.

END