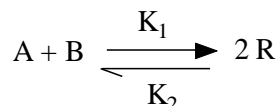




- Notes :
1. All questions carry equal marks.
 2. Answer **any five** questions.
 3. Assume suitable data wherever necessary.

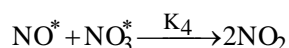
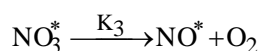
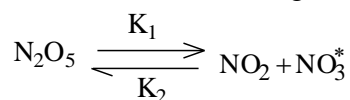
1. For second order reversible reaction 16



Show that

$$\ln \frac{X_{Ae} - (Z X_{Ae} - 1) X_A}{X_{Ae} - X_A} = Z K_1 \left(\frac{1}{X_{Ae}} - 1 \right) C_{A0} t$$

2. a) Show that the following scheme 6



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

- b) In the mid-nineteenth century the entomologist Henri Fabre noted that French ants busily 4
bustled about their business on hot days but were rather sluggish on cool days. Checking
his results with Oregon ants, I find.

Running Speed, M/hr	150	160	230	295	370
Temperature, °C	13	16	22	24	28

What activation energy represents this change in bustliness ?

- c) Derive performance equation for a plug flow reactor. 6

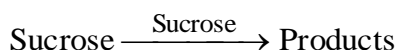
3. a) Hellin and Jungers, Bull. Soc. Chim. France, 386 (1957), present the data in following table 10
on the reaction of sulfuric acid with diethyl sulfate in aqueous solution at 22.9°C



Initial concentrations of H_2SO_4 and $(C_2H_5)_2SO_4$ are each 5.5 mol/liter. Find a rate
equation for this reaction.

t (min)	$C_2H_5SO_4H$ mol/lit	t (min)	$C_2H_5SO_4H$ mol/lit
0	0	180	4.11
41	1.18	194	4.31
48	1.38	212	4.45
55	1.63	267	4.86
75	2.24	318	5.15
96	2.75	368	5.32
127	3.31	379	5.35
146	3.76	410	5.42
162	3.81	00	(5.80)

- b) At room temperature sucrose is hydrolyzed by the catalytic action of the enzyme sucrose as follows. 6



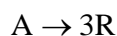
Starting with a sucrose concentration $C_{A0} = 1.0$ millimol/liter and an enzyme concentration $C_{E0} = 0.01$ millimol/liter, the following kinetic data are obtained in a batch reactor.

CA millimol/lit	0.84	0.68	0.53	0.38	0.27	0.16	0.09	0.04	0.018	0.006	0.0025
T (hr)	1	2	3	4	5	6	7	8	9	10	11

Determine whether these data can be reasonably fitted by a kinetic equation of the Michaelis-Menten type $-r_A = \frac{k_3 C_A C_{E0}}{C_A + C_M}$ where C_M = Michaelis constant. If the fit is reasonable, evaluate the constants K_3 and C_M . Solve by the integral method.

4. a) Pure gaseous A at about 3 atm and 30°C (120 mmol/lit) is fed into a 1-lit mixed flow reactor at various flow rates. There it decomposes, and the exit concentration of A is measured for each flow rate. From the following data find a rate equation to represent the kinetics of the decomposition of A. Assume that reactant A alone affects the rate. 10

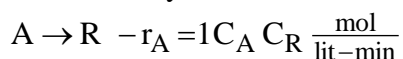
V_0 (lit/min)	0.06	0.48	1.5	8.1
C_A mmol/lit	30	60	80	105



- b) For second order reaction carried out in a variable volume batch reactor show that. 6
- $$\frac{(1+\epsilon_A)\Delta V}{V_0\epsilon_A - \Delta V} + \epsilon_A \ln\left(1 - \frac{\Delta V}{V_0\epsilon_A}\right) = kt$$

5. a) At present conversion is 2/3 for our elementary second order liquid reaction $2A \rightarrow 2R$ when operating in an isothermal plug-flow reactor with a recycle ratio of unity. What will be the conversion if the recycle stream is shut off? 6

- b) Aqueous feed containing reactant A ($C_{A0} = 2 \frac{\text{mol}}{\text{lit}}$) enters a plug flow reactor (10 lit) which has a provision for recycling a portion of the flowing stream. The reaction kinetics and stoichiometry are. 10



and we wish to get 96% conversion. Should we use the recycle stream? If so, at what value should we set the recycle flow rate so as to obtain the highest production rate, and what volumetric feed rate can we process to this conversion in the reactor.

6. a) Reactant A decomposes in an isothermal batch reactor ($C_{A0} = 100$) to produce wanted R and unwanted S, and the following progressive concentration readings are recorded. 10

C_A	(100)	90	80	70	60	50	40	30	20	10	(0)
C_R	(0)	1	4	9	16	25	35	45	55	64	(71)

Additional runs show that adding R or S does not affect the distribution of products formed and that only A does. Also it is noted that the total number of moles of A, R and S is constant.

- Find the Q versus C_A curve for this reaction with feed of $C_{A0} = 100$ and $C_{Af} = 10$, find C_R .
- From a mixed flow reactor
- From a plug flow reactor

- b) For first order followed by zero order reaction carried out in plug flow reactor, Derive expressions for $C_{R_{\max}}$ and $\bar{C}_{R, \max}$. 6
7. a) Explain the concept of resistance time distribution (RTD) and discuss the relationship between F and E curves. 8
- b) What is optimum temperature progression ? Explain the concept in details. 8
8. Write short note on **any four**. 16
- i) Catalyst deactivation.
 - ii) Catalyst poisoning and regeneration.
 - iii) Product distribution in multiple reactions.
 - iv) Catalyst classification.
 - v) Integral method for determination of rate law.
