Subject Code: ICH402	Roll No.:

B.TECH.
(SEM IV) EVEN SEMESTER EXAMINATION 2025-26
CHEMICAL REACTION ENGINEERING-I

[Time: 3Hrs] [Max Marks: 70]

Note: Attempt All Questions. All Question carry equal marks.

Q1. Answer **ALL** parts. **Marks**

a Differentiate between differential and Integral analysis 3.5

b Derive the performance equation for ideal Plug Flow Reactor and state the assumption used. 3.5

c A reaction is 50% complete in 20 min. How much time will be taken to complete 75% reaction? 3.5

OR

A first order reaction is 25% complete in 50 min. What would be concentration at the end of another 50 min if the initial concentration of the reactant is 5.0×10^3 mol dm^{-3}?

d A 1100-K n-nonane thermally cracks (breaks down into smaller molecules) 20 times as rapidly as at 1000 K. Find the activation energy for this decomposition. 3.5

OR

For an elementary reaction A+B → Product , the reaction rate at 500 K is 10 times the reaction rate at 400 K. Calculate the activation energy for this reaction.

Q2. Answer **ALL** parts.

(a) The first-order reversible liquid reaction. 7

$A \leftrightarrow R$, $C_{A0} = 0.5$ mol / liter, $C_{R0} = 0$; takes place in a batch reactor.

After 8 minutes, conversion of A is 33.3% while equilibrium conversion is 66.7%. Find the rate equation for this reaction.

OR

The following data are obtained at 0°C in a constant-volume batch reactor using pure gaseous A:

Time, min	0	2	4	6	8	10	12	14	∞
Partial pressure of A, mm	760	600	475	390	320	275	240	215	150

The stoichiometry of the decomposition is $A \rightarrow 2.5R$. Find a rate equation which satisfactorily represents this decomposition.

(b) The half-life of a radioactive substance 91X is 20 years. Calculate the decay constant. In how many years three quarters of the given amount of substance will disappear? 7

Q3. Answer **ALL** parts.

(a) A liquid reactant stream (1mol/liter) passes through two mixed flow reactors in a series. The concentration of A in the exit of the first reactor is 0.5 mol/liter. Find the concentration in the exit stream of the second reactor. The reaction is second-order with respect to A and $V_2/V_1 = 2$. 7

(b) Derive the performance equation of recycle plug flow reactor. 7

OR

An aqueous feed containing A (1 mol/liter) enters a 2-liter plug flow reactor and reacts away ($2A \rightarrow R$, $-r_A = 0.05C^2$, mol/liter.s). Find the outlet concentration of A for a feed rate of 0.5 liter/min.

Q4. Answer **ALL** parts.

(a) For the reaction $A \xrightarrow{k1} R \xrightarrow{k2} S$ in a plug flow reactor, derive that 7

$$\frac{C_{R,\max}}{C_{A0}} = \left(\frac{k1}{k2}\right)^{k2/(k2-k1)}$$

OR

For the reaction $A \xrightarrow{k1} R \xrightarrow{k2} S$ in a mixed flow reactor, derive that

$$\frac{C_{R,\max}}{C_{A0}} = 1/[(k_2/k_1)^{1/2}+1]^2$$

(b) Derive the performance equation of recycle plug flow reactor. 7

Q5. Answer **ALL** parts.

(a) Explain RTD, C curve and E curve with proper sketches 7

(b) 100 liters/hr of radioactive fluid having a half-life of 20 hr is to be treated by passing it through two ideal stirred tanks in series, V = 40000 liters each. In passing through this system, calculate how much will the activity decay? 7

OR

For an irreversible first-order liquid-phase reaction (C_{A0} = 10 mol/liter) conversion is 90% in a plug flow reactor. If two-thirds of the stream leaving the reactor is recycled to the reactor entrance, and if the throughput to the whole reactor-recycle system is kept unchanged, what does this do to the concentration of reactant leaving the system?

CO-BL Mapping			
Subject Code: ICH402			
Subject Name: Chemical Reaction Engineering I			
Q. No.	**Marks**	**CO**	**BL**
1(a)	3.5	1	1
1(b)	3.5	1	2
1(c)	3.5	1	2
1(d)	3.5	1	1
2(a)	7	2	4
2(b)	7	1	2
3(a)	7	3	3
3(b)	7	3	5
4(a)	7	1	2
4(b)	7	2	2
5(a)	7	2	3
5(b)	7	3	3

Class Test (2025-26).
Chemical Reaction Engineering- I

Time: 60 min

Max. Marks :30

Note : All questions are compulsory and carry equal marks

1. A 1100-K n-nonane thermally cracks (breaks down into smaller molecules) 20 times as rapidly as at 1000 K. Find the activation energy for this decomposition.

2. Hydrolysis of ester, in presence of NaOH, was followed keeping their concentration same at 0.02 mol dm^{-3}. The specific rate constant at 35°C was found to be 5.55 $mol^{-1} dm^{3} min^{-1}$. What proportion of ester will be hydrolysed in 30 min? Also calculate the time for 30% decomposition of ester.

3. The first-order reversible liquid reaction:

$A \leftrightarrow R$, $C_{A0} = 0.5$ mol / liter, $C_{R0} = 0$,

takes place in a batch reactor. After 8 minutes, conversion of A is 33.3% while equilibrium conversion is 66.7%. Find the rate equation for this reaction.

4. A gaseous feed of pure A (1 mol/liter) enters a mixed flow reactor (2 liters) and reacts as follows:

$2A \rightarrow R$, $-r_A = 0.05\ C_A^2$ mol/liter.sec

Find what feed rate (liter/min) will give an outlet concentration $C_A = 0.5$ mol/liter.

5. An aqueous feed containing A (1 mol/liter) enters a 2-liter plug flow reactor and reacts away ($2A \rightarrow R$, $-r_A = 0.05\ C_A^2$, mol/liter.s). Find the outlet concentration of A for a feed rate of 0.5 liter/min.

1. For the reaction A → R, second-order kinetics and C_{A0} = 1 mol/liter, we get 50% conversion after 1 hour in a batch reactor. What will be the conversion and concentration of A after 1 hour if C_{A0} = 10 mol/liter?

2. For the reaction $A \overset{k1}{\rightarrow} R \overset{k2}{\rightarrow} S$ in a mixed flow reactor, derive that

$$\frac{C_{R,max}}{C_{A0}} = 1/[(k_2/k_1)^{1/2}+1]^2$$

3. An aqueous feed of A and B (400 liter/min, 100 mmolA/liter, 200 mmolB/liter) is to be converted to product in a plug flow reactor. The kinetics of the reaction is represented by
$A+B \rightarrow R$, $-r_A=200\, C_A\, C_B$ mol/liter.min
Find the volume of reactor needed for 99.9% conversion of A to product.

4. Derive the performance equation for CSTR with proper assumption.

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Subject Code: ICH 402 Roll No.:

B.Tech.

(SEM IV) EVEN SEMESTER EXAMINATION 2024-25

CHEMICAL REACTION ENGINEERING I

[TIME: 3 hrs.] [Max. Marks: 70]

Note: *Attempt All Questions. All Question carry equal marks.*

Q1. Answer **ALL** parts. Marks

(a) A reaction 2A → 3 B occurs in batch reactor with equimolar feed of A & B which enters in reactor at 500K and 2atm. Calculate the time required to achieved 75% conversion, if k= 1lit/min.mol. 3.5

(b) Write the kinetics for second order system non-equimolar feed. 3.5

(c) What is specific reaction rate. For particular reaction A → B , T_1 = 400 K, T_2 = 500 K, E_A = 9150 Cal/mol. What is the change in K for collision theory. 3.5

OR

For an elementary reaction A + B → P, reaction rate at 500K is just 10times at 400K. calculate the activation energy for given reaction.

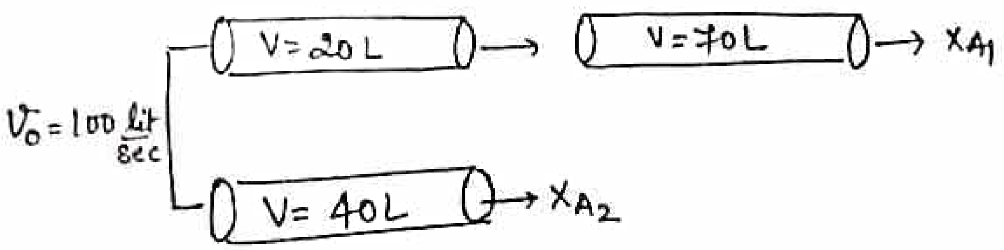
(d) A liquid phase reaction A+ B → R is occurs in a bath reactor feed enters the reactor at a rate of 15kmol/m³ at 30°C. find the conversion in a batch reactor in 3 min. 3.5

Given data n=0, k=1 kmol/m³.sec. A= 30% and B= 70% in a feed

Q2. Answer **ALL** parts.

(a) For a liquid phase second order reaction, operating in a PFR, conversion obtained in 50%. If the existing PFR is replaced by 5 times larger than PFR. Then what will be the conversion for new reactor. 7

OR



The reactor setup shown in figure consist of three PFR in two parallel branches. Then find out the volumetric flow rate of both stream when X_{A1}=X_{A2}.

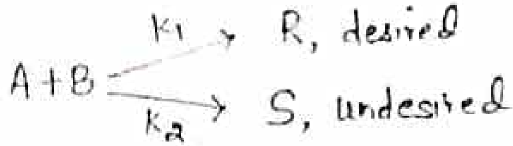
(b) Pure gasesous reactant A(C_{Ao} = 100 millimol/lit) is fed at a steady rate into a mixed flow reactor (V =0.1 lit) where it dimerizes (2A→ R). For different gas feed rates the following data are obtained. Find the rate equation for this reaction. 7

Run number	1	2	3	4
v_o , lit/hr	30	9	3.6	1.5
C_{Af} millimole/lit	85.7	66.7	50	33.4

Q3. Answer **ALL** parts.

(a) For an elementary reaction $A \xrightarrow{K1} R \xrightarrow{K2} S$. find the value of C_{Rmax} and t_{opt} , if K_1=K_2 assume n=1. 7

(b) Consider the aqueous reactions.



$$\frac{dC_R}{dt} = 1.0\, C_A^{1.5}\, C_B^{0.3}, \frac{mol}{lit}.min$$
$$\frac{dC_s}{dt} = 1.0\, C_A^{0.5}\, C_B^{1.8}, \frac{mol}{lit}.min$$

For 90% conversion of A find the concentration of R in the product stream. Equal volumetric flow frates of the A and B streams are fed to the reactor, and each stream has a concentration of 20 mol/lit of reactant for plug flow reactor.

OR

Write the conversion and concentration for multiple reaction system in series with all three cases.

Q4. Answer ALL parts.

(a) Liquid A decompose as R and S whose order 2 and 1 respectively, K_1 = m^3/mol.min K_2 = 2 min^{-1} Pure aqueous feed enters at a rate of 40 mol/m^3 produces R &S . Find out the space time and composition of A, R & S. When X_A =90% For both MFR & PFR. 7

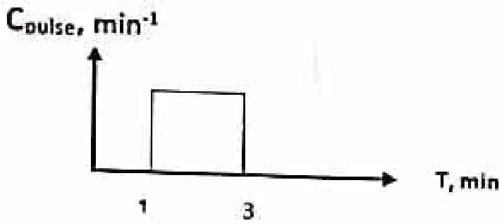
(b) In a adiabatic CSTR operated at 520C, a reaction A→ B occurs with 100mol/sec of feed rate reaction follows the CVRS. If 40% of A is present in feed. Calculate the feed temperature for 75% concentration. If Cp mix = 120 J/mol K .ΔHr = -25 KJ/mol. 7

OR

An irreversible aqueous phase reaction A + B → P is carried ouot in an adiabatic mixed flow reactor. a feed containing 4 kmol/m^3 of each A & B enters the reactors at 8 m3/hr. if the temperature of the exit stream is never to exceed 390 K. what is the maximum feed inlet temperature allowed. ΔHr= -50kJ/mol. ρ_{mix} = 1000 kg/m^3., Cpmix = 2KJ/Kg K

Q5. Answer ALL parts.

(a) Dispersed non coalescing droplet (C_{AO} =2mol/l) react as they pass through a contacter. Find the average concentration of A remaining in droplet leaving the contactor. If their RTD is given by the below curve. 7



OR

The exit age distribution for a reactor is given by E(t) = δ(t-4), where t is in seconds. A first order liquid phase reaction (K = 0.25) is carried in this reactor under steady state isothermal conditions. Calculate the mean conversion of the reactant at the exit of the reactor.

(b) The concentration reading in table represent a continuous response to a pulse input into a closed vessel which is to be used as a chemical reactor. Calculate the mean residence time of fluid in the vessel t, and tabulate and plot the exit age distribution E. 7

Time t.min	0	5	10	15	20	25	30	35
Tracer output conc. Cpulse gm/lit fluid	0	3	5	5	4	2	1	0