Seat No./Enrollment No.: _____

GUJARAT TECHNOLOGICAL UNIVERSITY
BACHELOR OF ENGINEERING – SEMESTER 6 – EXAMINATION – SUMMER 2026

Subject Code: 3160506 **Date: 22/05/2026**

Subject Name: Chemical Reactions Engineering I

Time: 10:30 AM TO 01:00 PM **Total Marks: 70**

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**
4. **Simple and non-programmable scientific calculators are allowed.**

Q.1	**(a)**	Define Elementary and non-elementary reactions with suitable example.	**03**
	(b)	Explain physical significance of activation energy. Also discuss temperature dependency of activation energy using Arrhenius theory.	**04**
	(c)	Milk is pasteurized if it is heated to 63°C for 30 min, but if it is heated to 74°C it only needs 15 s for the same result. Determine the activation energy of this sterilization process.	**07**
Q.2	**(a)**	On doubling the concentration of reactant, the rate of reaction triples. Find the reaction order.	**03**
	(b)	Derive the rate expression for Irreversible Unimolecular-Type First-Order Reactions.	**04**
	(c)	The first-order reversible liquid reaction takes place in a batch reactor. $A \rightleftarrows R, \quad C_{A0} = 0.5 \text{ mol/liter}, \quad C_{R0} = 0$ 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 re- action.	**07**

OR

Q.2	**(c)**	For a gas reaction at 400 K the rate is reported as $-\frac{dp_A}{dt} = 3.66p_A^2, \quad \text{atm/hr}$ (a) What are the units of the rate constant? (b) What is the value of the rate constant for this reaction if the rate equation is expressed as: $-r_A = -\frac{1}{V}\frac{dN_A}{dt} = kC_A^2, \quad \text{mol/m}^3\cdot\text{s}$	**07**
Q.3	**(a)**	Explain differential method of analysis for deriving the kinetics for homogeneous chemical reaction.	**03**
	(b)	Define: Space time, Space velocity, Holding time, Mean residence time.	**04**
	(c)	Derive the rate expression for Irreversible Reactions in Series.	**07**

OR

Q.3	**(a)**	Explain integral method of analysis for deriving the kinetics for homogeneous chemical reaction.	**03**

(b) Explain autocatalytic reaction with example. **04**

(c) Develop an expression that facilitates calculation of units of rate constant for any order. Give the unit of rate constant for first, second and third order reaction. **07**

Q.4 **(a)** Discuss selection criteria for CSTR. **03**

(b) Derive the performance equation for Mixed flow reactor. **04**

(c) An aqueous feed of A and B (400 literlmin, 100 mmol A per liter, 200 mmol B per liter) is to be converted to product in a plug flow reactor. The kinetics of the reaction **07**

$$A + B \rightarrow R, \qquad -r_A = 200\, C_A C_B \frac{\text{mol}}{\text{liter} \cdot \text{min}}$$

is represented by

Find the volume of reactor needed for 99.9% conversion of A to product.

OR

Q.4 **(a)** Write short note on recycle reactor. **03**

(b) Derive the performance equation plug flow reactor. **04**

(c) At 650°C phosphine vapor decomposes as follows: **07**

$$4PH_3 \rightarrow P_4(g) + 6H_2, \qquad -r_{phos} = (10\ hr^{-1})C_{phos}$$

Evaluate the size of plug flow reactor operating at 649°C and 11.4 atm which is needed for 75% conversion of 10 mol/hr of phosphine in a 2/3 phosphine-1/3 inert feed.

Q.5 **(a)** Define yield, selectivity and conversion. **03**

(b) Explain the procedure to determine the best system for a given conversion when two CSTR of different sizes are connected in series. **04**

(c) The concentration readings given in Table 1 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. **07**

Table 1

Time T, min	Tracer Output (C_{pulse}), gm/L of fluid
0	0
5	3
10	5
15	5
20	4
25	2
30	1
35	0

OR

Q.5 **(a)** Define optimum temperature progression. **03**

(b) Define Residence Time Distribution and explain E-Curve. **04**

(c) Explain qualitative discussion about the product distribution for reaction in parallel. **07**

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