C **581A2** Total Pages: **3**

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SAINTGITS COLLEGE OF ENGINEERING (AUTONOMOUS)

(AFFILIATED TO APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY, THIRUVANANTHAPURAM)

FIFTH SEMESTER B.TECH DEGREE EXAMINATION (Regular), DECEMBER 2022

CHEMICAL ENGINEERING

(2020 SCHEME)

Course Code : **20CHT305**

Course Name: **Chemical Reaction Engineering**

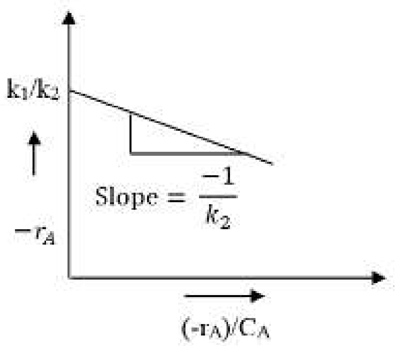
Max. Marks : **100** **Duration: 3 Hours**

Graph sheets may be provided.

PART A

(Answer all questions. Each question carries 3 marks)

1. For the figure below, write a suitable rate expression.



2. The half-life period for a certain first order reaction is 2.5×10^3 s. Determine the time taken for 1/3rd of the reactant to be left behind.
3. Define space time and space velocity.
4. State the performance equation of a mixed flow reactor with its significance.
5. Explain a recycle reactor with recycle ratio.
6. Describe autocatalytic reaction with a suitable example.
7. Differentiate between equilibrium conversion and adiabatic equilibrium conversion.
8. Highlight the relation between equilibrium conversion and equilibrium constant.
9. Outline the significance of dispersion coefficient in non-ideal flow.
10. Mention the reasons for non-ideality in reactors.

PART B

(Answer one full question from each module, each question carries 14 marks)

MODULE I

11. a) Variation of the rate constant with temperature for the reaction is given in the following table. (8)

$$2N_2O_5 \rightarrow 2\ N_2O_4 + O_2$$

Temp. (K)	298	308	318	328	338
k (s^{-1})	1.74×10^{-5}	6.61×10^{-5}	2.51×10^{-4}	7.59×10^{-4}	2.40×10^{-3}

Determine graphically, the activation energy for the reaction and frequency factor.

b) In a batch reactor, the conversion of A → R, C_{A0} = 1 mol/L is 75% after 1 hour. The reaction got completed after 2 hours. Find rate equation to represent this kinetics. (6)

OR

12. a) Liquid A decomposes by second - order kinetics in a batch reactor and 50% of A is converted in a 5-minute. How much longer would it take to reach 75% conversion? (6)

b) Derive the performance equation for a batch reactor for constant density and variable density systems for a first order reversible reaction. (8)

MODULE II

13. a) A homogeneous gas phase decomposition reaction 4A → B + 7S takes place in an isothermal ideal plug flow reactor. The reaction rate is, $-r_A = k_1C_A$ with k_1 = 0.17 s^{-1}; feed concentration of A (C_{Ao}) = 0.1 mol/m^3; feed flow rate (F_{Ao}) = 0.17 mol/s. Determine the size of the reactor to achieve 50% conversion (7)

b) Derive the performance of plug flow reactor for constant and variable volume systems. (7)

OR

14 Consider a feed C_{AO} = 100 mol/L, C_{BO} = 200 mol/L which enters a reactor at 1000 K and 5 atm. The gas phase reaction is $A + B \rightarrow 5R$. The stream leaves the reactor at 400 K, 4 atm and C_A = 20 mol/L. Calculate the X_A, X_B and concentration of B. (14)

MODULE III

15. a) Explain the graphical method of determining the conversion in the case of unequal size mixed flow reactors connected in series. (8)

b) Show that the performance of N equal sized CSTRs in series is equivalent to a plug flow reactor. (6)

OR

16. a) A CSTR and a PFR of equal volume V each are given for the conduct of a second order, isothermal, liquid phase reaction, A→B. The reactors are to be arranged in series. Find the overall conversion for the two possible reactor arrangements. (8)
Data given: $k = 1\ m^3/(kmol \cdot s)$, $C_{Ao} = 0.1\ kmol/m^3$ and $\tau = 5$ s (for volume V).

b) Derive the expression of recycle ratio for a first order reaction in recycle reactor. (6)

MODULE IV

17. Determine the equilibrium conversion for the elementary aqueous reaction between 0 to 100 ˚C. (14)

$$A \leftrightarrow R$$
$$\Delta G^0_{298} = -14130\ J/mol$$
$$\Delta H^0_{298} = -75300\ J/mol$$
$$C_{PA} = C_{PR} = \text{Constant}$$

Express the results in the form of a plot of temperature vs equilibrium conversion. What restriction should be placed on the reactor operating isothermally to reach a conversion greater than 75%.

OR

18. a) Explain optimum temperature progression for irreversible reactions, reversible exothermic and endothermic reactions. (6)

b) Derive the expression for finding out the conversion of adiabatic and non-adiabatic reactor. (8)

MODULE V

19. An RTD analysis was carried out in a liquid phase reactor using step input. Analyze the following data (14)

Time (s)	1	150	175	200	225	250	275	300	325	350	375	400	450
$C \times 10^3$ (g/dm^3)	0	0	1	3	7.4	9.7	8.2	5	2.5	1.2	0.5	0.2	0

i) Tabulate and plot E(t) values. (7 marks)
ii) What fraction of material spends between 230 s and 270 s in the reactor? (3 marks)
iii) Tabulate F(t) values. (4 marks)

OR

20. a) Derive the expression for number of tanks using the tanks in series model for CSTRs in series (10)

b) Write short notes on (i) mean residence time and (ii) cumulative distribution function (4)

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