Register No.: .... Name: ....

SAINTGITS COLLEGE OF ENGINEERING (AUTONOMOUS)

(AFFILIATED TO APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY, THIRUVANANTHAPURAM)

FIFTH SEMESTER B.TECH DEGREE EXAMINATION (S), FEBRUARY 2024
CHEMICAL ENGINEERING
(2020 SCHEME)

Course Code : **20CHT305**

Course Name: **Chemical Reaction Engineering**

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

PART A

(Answer all questions. Each question carries 3 marks)

1. Find the rate constant of a first order reaction, if the half-life period of the reaction is 10 min.
2. Differentiate between constant and variable volume systems.
3. Show how CSTR's in series approximate a PFR graphically.
4. Liquid A decomposes by first order kinetics and in a batch reactor 60% of A is converted in 8 min run. Calculate the time required for it to reach 72% conversion.
5. Compare selectivity and yield in multiple reactions.
6. Differentiate instantaneous and overall yield.
7. Relate Gibbs free energy change and equilibrium constant.
8. Differentiate non-isothermal reactor and adiabatic reactor.
9. Sketch the exit age distribution curve for an ideal and non-ideal flow.
10. List the models used to characterize non-ideal flow.

PART B

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

MODULE I

11. a) A reaction proceeds 40% in 7.5 min. How much time will be required for 75% degradation if the reaction follows (i) first order and (ii) second order. (6)

b) A first order reaction undergoes 30% completion at a temperature of 298 K in 40 min. At an elevated temperature of 400 K, how much percentage completion will be achieved in the same time duration. The activation energy is 10000 J/mol. (8)

OR

12. a) Determine the order and rate constant of a reaction through differential method of analysis. The kinetics of the reaction are given below. (14)

t (hr)	0	0.2	0.4	0.6	0.8	1.0
C_{A0} (mol/l)	100	50	33.33	25	20	16.67

MODULE II

13. a) Derive the performance equation for an ideal plug flow reactor with a neat sketch and explain the graphical method of determining the volume of the reactor. (10)

b) Explain the concept of an ideal flow reactor and list the assumptions taken for such reactors. (4)

OR

14. a) Compare and contrast ideal batch reactors, steady-state mixed flow reactors, and steady-state plug flow reactors in terms of their key characteristics and applications. (7)

b) Consider a mixed flow reactor with a stoichiometry of $A \rightarrow R$. The rate of reaction is given in the table given below. What size of mixed flow reactor is needed for 75% conversion of a feed stream of 1000 mol/hr at C_{A0} = 1.2 mol/l? (7)

C_A (mol/l)	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	1.0	1.3
$-r_A$ (mol/l.min)	0.1	0.3	0.5	0.6	0.5	0.25	0.1	0.06	0.05	0.045

MODULE III

15. a) Find an equation representing the concentration within the N_{th} reactor when N identical continuous stirred tank reactors are connected in a sequential series, assuming a first-order reaction. (7)

b) Examine the optimal arrangement of two CSTRs with unequal volumes to achieve a specific conversion level and reaction order. Justify. (7)

OR

16. a) Consider the reaction $A \rightarrow R, -r_A = kC_A^{1.5}$ in an mixed flow reactor with conversion of 70%. For the same aqueous feed (10 mol/l), estimate the new conversion of the mixed flow reactor with one having double the volume. (10)

b) Comment on the arrangement of a stirred tank reactor and plug flow reactor for a N_{th} order reaction. (4)

MODULE IV

17. Explain the concept of optimum temperature progression and graphical design procedure to design the reactor. (14)

OR

18. a) Calculate the equilibrium constant at 298 K and 700 K for a reversible reaction A⇌R. (10)

Given data:

ΔG^0 = -2500 J/mol

ΔH_f^o for A = -55000 J/mol

ΔH_f^o for R = -47400 J/mol

$C_{pA} = C_{pR}$ = constant

b) Draw the rate-concentration curve for autocatalytic reactions. (4)

MODULE V

19. For a non-ideal reactor described by N Tanks in series model, derive an expression for Exit age distribution, E(t) and E(θ). (14)

OR

20. Following results were obtained for a pulse test on a piece of reaction equipment. The output concentration rose linearly from zero to 0.5 µmol/dm^3 in 5 min, and then fell linearly to zero in 10 min after reaching a maximum value of 0.5 µmol/dm^3. (14)

(i) Calculate the mean residence time.

(ii) Calculate the total reactor volume, if the flow rate is 570 l/min.

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