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SAINTGITS COLLEGE OF ENGINEERING (AUTONOMOUS)

(AFFILIATED TO APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY, THIRUVANANTHAPURAM)

FIFTH SEMESTER B. TECH DEGREE EXAMINATION (S), FEBRUARY 2023
CHEMICAL ENGINEERING
(2020 SCHEME)

Course Code : **20CHT305**

Course Name: **Chemical Reaction Engineering**

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

Graph sheets will be provided

PART A

(Answer all questions. Each question carries 3 marks)

1. Differentiate elementary and non-elementary reactions with an example of each.
2. On doubling the concentration of reactant, the rate of reaction triples at constant temperature. Then what will be the order of reaction?
3. Differentiate CSTR & PFR.
4. Define the space time and space velocity with its units.
5. Explain auto-catalytic reaction with a conversion graph.
6. How can we connect two CSTR in series according to the order of reaction so as to get maximum conversion?
7. Distinguish endothermic reactions and exothermic reactions.
8. Give the conversion equation for non-adiabatic operation and mention its significance.
9. State the reasons for reactors showing non-ideal behavior.
10. List the important properties of a tracer should have.

PART B

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

MODULE I

11. a) Consider the given series reaction with rate constants as k_1 and k_2 (11)

$$A \xrightarrow{k1} R \xrightarrow{k2} S$$

Derive an expression for the maximum concentration of R and concentration of S in terms of initial concentration. Also make an expression for the time at which the concentration of R is maximum.

b) Consider a gaseous feed C_{A0}=100 mol/L and C_{B0}=200 mol/L to a steady flow reactor operated at constant temperature and pressure. The reaction is given below: (3)

A+B → R+S and the conversion of B is 80%. Find C_A, C_B and X_B.

OR

12. a) Find the conversion after 1 hr in a batch reactor (A → R), where C_{A0}= 1 mol/L and the rate equation is given by (4)
$-r_A = 3\ C_A^{0.5}$ mol/L · hr

b) Derive the rate equation for first order reversible reactions and graphically represent the concentration – time curve. (10)

MODULE II

13. a) Derive the performance equation of a PFR for constant volume and variable volume system with a graph. (8)

b) A liquid phase reaction, A → B is carried out isothermally in a CSTR having a residence time of 2 seconds. The inlet concentration of species A is 2 mol/L, and the outlet concentration is 1 mol/L. The rate law for the reaction is $-r_A = \frac{kC_A}{P + C_A}$, where k = 5 mol/L · sec (6)
Find the value of constant P and the rate of reaction.

OR

14. a) Derive the performance equation of a CSTR for constant volume and variable volume system with a graph. (7)

b) A gaseous feed of pure A (having molar flow rate of 2 mol/min and an initial concentration of 2 mol/L) decomposes to give a variety of products in a PFR. Kinetics of the reaction is as follows: (7)

A → 2.5R $\qquad -r_A = 10\ \text{min}^{-1}\ C_A$

Find the expected conversion in 22 L reactor.

MODULE III

15. The elementary irreversible liquid phase reaction A + B → R + S takes place in a PFR using equimolar amount of A and B, C_{A0}=C_{B0}=1 mol/L and conversion is 96%. If a CSTR 10 times as large as PFR is placed in series with the existing PFR, what will be the overall conversion? (14)
Also compare the conversion with the same reactors place in the reverse order (In this case the conversion in PFR will not be 96 %).

OR

16. a) A liquid reactant C_{A0}= 1 mol/L pass through two steady CSTR in series. The concentration of A in the exit stream from the first reactor is 0.5 mol/L. The kinetics given below: (8)

A → R $\qquad -r_A = kC_A^2$

The ratio of volume of second reactor to the volume of first reactor is 2. Calculate the concentration leaving the second reactor.

b) Derive the design equation for recycle reactor with a graph. (6)

MODULE IV

17. a) Derive an expression for conversion in an adiabatic operation. Clearly mention its significance. (10)

b) Derive an expression relating equilibrium conversion and equilibrium constant. (4)

OR

18. a) Explain the effect of temperature on equilibrium conversion for exothermic reaction and endothermic reaction. (6)

b) Explain the multiple steady state in a mixed flow reactor for exothermic reversible and irreversible reactions using graph. (8)

MODULE V

19. a) Distinguish between C curve and E curve. Explain the transformation of C curve to E curve. (7)

b) Compare the RTD of PFR and CSTR with the help of a graph. (7)

OR

20. a) Discuss any two experimental methods to determine E curve and mention the relation between E and F curves. (10)

b) Explain the tank in series model. (4)

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