GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Engineering

Level: Under Graduate

Branch: Chemical Engineering (Green Technology and Sustainability Engineering)

Course/Subject Code: BE05044021

Subject Name: Reaction Engineering & Kinetics – I

W. E. F. Academic Year:	2024-25
Semester:	5
Category of the Course:	Professional Core Course

Prerequisite:	Basics of Physical chemistry, material and energy balance, and principles of thermodynamics.
Rationale:	The objective of this course is to introduce students to the fundamental ideas related to reaction rates. This includes comprehending the process of deriving rate equations from reaction mechanisms, understanding different types of ideal reactors, grasping both integral and differential approaches to analyzing reactions, and becoming familiar with the principles governing the analysis and design of chemical reactors. The course will also cover practical aspects such as experimentally determining rate equations, designing batch and continuous reactors, selecting the suitable reactor type for specific feeds, enhancing selectivity in reactions involving multiple steps, and considering the impacts of temperature and pressure variations, among other relevant topics.

Course Outcome:

After Completion of the Course, Student will able to:

Sr. No.	CO statement	Marks % weightage
CO-1	Apply principles of reaction kinetics and stoichiometry to analyze homogeneous reaction systems and determine temperature dependence of reaction rates.	16
CO-2	Evaluate batch reactor kinetic data using integral and differential methods to determine reaction rate parameters.	14
CO-3	Design and analyze ideal reactors such as batch reactors, plug flow reactors (PFR), and mixed flow reactors (CSTR).	14
CO-4	Compare the performance of single and multiple reactor systems, including recycle and autocatalytic reactors.	12
CO-5	Analyze and design reactors for complex reactions such as parallel, series, and series–parallel reactions.	16
CO-6	Apply material and energy balances to evaluate reactor performance and determine optimum operating conditions.	12
CO-7	Analyze non-ideal reactor behavior using Residence Time Distribution (RTD) and develop reactor models based on RTD data.	16

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Teaching and Examination Scheme:

Teaching /Learning Scheme in Hours Per Semester					Total Credits = TH/30	Examination Marks					Total Marks
L	T	P	PBL	TH	03	Theory Marks		Practical Marks			
						ESE (E)	PA (M)	PA (I)	PBL	ESE (V)	
45	0	30	15	90		70	30	20	30	50	200

Course Content:

Sr. No.	Content	Total Hrs
1	Kinetics of Homogeneous Reactions, Kinetic Model and Temperature Dependency, Introduction and Stoichiometry for the Batch System, Stoichiometry for Constant Volume Flow and Variable Volume Batch Systems, Stoichiometry for Variable Volume Flow System	6
2	Analysis of Batch Reactor Kinetic Data, Integral Method of Analysis of Batch Reactor Data, Differential Method of Analysis and Variable Volume Batch Reactor Data	6
3	Introduction and Ideal Batch Reactor Design, Ideal Mixed Flow Reactor Design, Ideal Plug Flow Reactor Design	5
4	Size Comparison of Single and Multiple Reactors, Size Comparison, Multiple Reactors, Recycle and Autocatalytic Reactors, Recycle and Autocatalytic Reactors	5
5	Design for Parallel Reactions, Design for Series Reactions, Design for Series Reactions, Design for Series-Parallel Reactions, Denbigh Reactions and Their Special Cases	5
6	Heats of Reaction and Equilibrium Conversion from Thermodynamics, General Graphical Reactor Design Procedure, Material and Energy, Balances in Batch Reactor, Optimum Temperature Progression in Batch Reactor	7
7	Material and Energy Balances in Plug Flow and Mixed Flow Reactors, Ideal and Non-Ideal Mixed Flow Reactor Design and Multiple Steady States	5
8	Non-Ideal Reactors and Residence Time Distribution, RTD Measurement and Moments of RTD, RTD in Ideal Reactors, Reactor Modeling using the RTD	6

Sustainability alignment:

This course addresses SDG 7 (Affordable and Clean Energy), SDG 9 (Industry, Innovation and Infrastructure), SDG 12 (Responsible Consumption and Production), and SDG 13 (Climate Action) by developing knowledge of reactor design, reaction kinetics, process optimization, and sustainable chemical processing techniques essential for efficient and environmentally responsible industrial operations.

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
15	20	25	10	10	0

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Reference Books:

1. Chemical Reaction Engineering by K. A. Gavhane
2. Elements of Chemical Reaction Engineering by H. S. Fogler
3. Chemical Reaction Engineering by Octave Levenspiel

Suggested list of experiments

1. To study the operation of Isothermal Batch Reactor
2. To study the operation of Isothermal Plug Flow Reactor
3. To study the operation and principle of Isothermal CSTR
4. To study the operation and principle of Packed Bed Reactor
5. To study and analyze residence time distribution (RTD) in a Packed Bed Reactor
6. To study and analyze residence time distribution (RTD) in CSTR
7. To study and analyze residence time distribution (RTD)in PFR
8. To study the operation of Combined Flow Reactor
9. To study the reactions involved in UV Photo Reactor
10. To determine the activation energy for reaction between ethyl acetate and sodium hydroxide at different temperature
11. To determine the Kinetics of chemical reactions
12. To study and interpret Kinetics of Bio-diesel synthesis from vegetable oils by Transesterification

Open source software and website:

Students can refer to video lectures available on the websites including NPTEL.

Activities suggested under self learning:

Sl. No.	Name of the activity	No. of hours	Total Hours
1.	Industry/Research laboratory visit	Visit = 5h, Report preparation = 5h	10
2.	Assignment writing. Numerical based assignment is preferable.	5 assignments of 2h each.	10
3.	Self learning on-line course	Minimum duration of the course should be 10h.	10
4.	Complex problem solving	Maximum 2 problems. Study of the problem and solution finding.	10
5.	Poster/chart/power point preparation on technical topics		6

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