GUJARAT TECHNOLOGICAL UNIVERSITY

Master of Engineering
Subject Code: 3721613

Semester – II
Subject Name: Advanced Reaction Engineering and Kinetics

Type of course: Core course IV

Prerequisite: Knowledge of Chemical Reaction Engineering.

Rationale: The subject deals with the heterogeneous reactions. This Subject is essential for design of reactors especially heterogeneous reactors. Students will learn concentration profile in different reactors and advance design aspects of multiphase reactors. Students will also focus on Temperature and pressure effects on reactions. The course also covers catalytic reactions and biochemical reaction systems.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	4	5	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs
1	HETEROGENEOUS REACTIONS: Introduction, Classification, Examples of Heterogeneous reaction, Rate expressions Fluid-Particle Reactions, Different Types of Models, Stoke's Regime, Determination of Rate controlling steps Fluid-Fluid Reactions, Rate equation, Kinetic regimes for mass transfer and reaction, Rate equation for Different Kinetic regimes	08
2	FLUIDIZED BED REACTORS: Design of catalytic Reactors, Fluidized bed reactor Reaction kinetics, Performance equation, Design equation for fluidized bed reactor, Different Models for fluidized bed reactor, Hydrodynamic flow model, Bubbling Fluidized bed reactor, Flow patterns, Performance equation	08
3	MULTIPHASE REACTORS: Design of Multiphase Reactor, Slurry Reactor-Slurry Reaction kinetics, Performance equation, Applications. Loop Reactor- Introduction, and Field Applications, Practical limitation of Stirred Tank and Loop Reactor, Design Methods, Reactor Modeling. Moving bed reactor- performance equation, characteristics, application etc.	08

4	BUBBLE COLUMN REACTOR: Bubble column Reactor-Introduction, Various factors affecting the performance of Bubble column Reactor, Industrial Applications, Advantages and disadvantages of Bubble column reactor, Criteria of selection of different types of gas-liquid reactors, Process design of Bubble column reactor, Example of Bubble column reactor	**06**
5	CATALYTIC REACTIONS: Catalyst, steps in catalytic reactions and its kinetics, Adsorption Kinetics: rate of adsorption and desorption, Reaction mechanism: Power law model, LHHW model, Eley Rideal model; Diffusion: Bulk, Knudsen, Surface diffusion, Effective diffusivity, Estimation of diffusion and reaction limited regimes: Weisz Prater criterion and Mear's criterion, Effectiveness factor; Catalyst Characterization: Surface analysis (BET), Chemisorption technique; Catalyst deactivation: aging, Poisoning, Sintering, Catalyst Regeneration	**12**
6	BIOCHEMICAL REACTION ENGINEERING: Types of Bio reactors, Selection of reactor, Design, Scale up, Operation and Control of Bio Reactors, Kinetics of Bio-Chemical reactions	**05**
7	TEMPERATURE AND PRESSURE EFFECTS ON REACTIONS: Single reactions: Heats of reaction from thermodynamic, Equilibrium constant from thermodynamic, optimum temperature progression, heat effects, Adiabatic and Non adiabatic operations, Exothermic reaction in MFR, Multiple reactions: Product distribution and Temperature	**07**

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
10	**25**	**10**	**10**	**10**	**05**

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

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1) Smith J M, Chemical Engineering Kinetics, McGraw Hill, Third Edition, 1981
2) Levenspiel O, Chemical Reaction Engineering, Wiley, 1998
3) Fogler,H.S., Elements of Chemical Reaction Engineering, Prentice Hall of India, 2008

4) Schmidt L D., The Engineering of Chemical Reaction, 2nd Edition, Oxford University Press, 2005
5) Inamdar S T A., Biochemical Engineering- Principles and Concepts, Prentice Hall of India, New Delhi, 2007.
6) Shuler M L. and Kargi F., Bioprocess Engineering- Basic concepts, Prentice Hall of India, New Delhi, 2006
7) Liu S., Bioprocess Engineering: Kinetics, Sustainability, and Reactor Design, Elsevier, 2013

Course Outcomes:

Sr. No.	CO statement	Marks % weightage
CO-1	Understanding of heterogeneous reaction system.	20
CO-2	Design of heterogeneous and multiphase reactors.	40
CO-3	Knowledge of catalytic reactions and biochemical reactions.	30
CO-4	Understanding of Temperature and Pressure effects on the single and multiple reactions.	10

List of Experiments:

1) To study catalytic activity of the reaction.

2) To study biochemical reaction using enzymes.

3) To study heterogeneous reaction system using rate equation.

4) To study the fermentor.

Major Equipment: Fermentor

List of Open Source Software/learning website:

- www.irisa.fr/s4/download/papers/ltta-emsoft-2004.pdf
- www.academia.edu/.../A_NOVEL_DESIGN_OF_HETEROGENEOUS_C.
- *opus4.kobv.de/opus4-tuberlin/files/3541/jaso_stanislav.pdf*
- www.industchem.com/content/4/1/20
- www.nptel.ac.in