Course Code	Course Name	Credits
26CH607	CATALYSIS	04

Course Objectives

- To develop an understanding of the fundamental principles and mechanisms of catalysis.
- To explain the influence of solvent effects on reaction rates and reaction mechanisms.
- To introduce the basics of catalysis along with methods of correlation analysis in chemical kinetics.

Learning Outcomes

Upon successful completion of this course it is intended that a student will be able to:

- Understand the fundamental principles of catalysis, including homogeneous, heterogeneous, enzyme, and surface catalysis.
- Apply catalytic concepts to molecular systems such as acid–base, enzyme, micellar, and phase transfer catalysis.
- Analyze catalytic mechanisms in zeolites, electrocatalysis, and industrial chemical processes.
- Evaluate surface and industrial catalysis including adsorption, reaction mechanisms, and applications in fuel, polymer, and petrochemical industries.

Unit 1 - Catalysis phenomenon (12 Hrs.)

Mode of action of catalysts; types of catalysts; comparison of homogeneous and heterogeneous catalysis; homogeneous catalysis—general mechanisms; acid–base catalysis—mechanism, catalytic activity, and salt effects; enzyme catalysis—effect of substrate concentration, pH, and temperature; transient-phase kinetics and enzyme mechanisms; kinetics of inhibition; chain reactions; mechanisms of enzyme-catalyzed reactions.

Unit 2 – Catalysis in molecular-scale cavities (10 Hrs.)

Structure of crystalline solids; zeolites and families of zeolites; adsorption and diffusion in zeolites; catalysis by zeolites containing metal complexes and clusters; non-zeolite molecular sieves; clays and other layered materials.

Unit 3 - Advanced Catalysis (13 Hrs.)

Catalysts for phase transfer catalysis (PTC); mechanism and benefits of PTC; PTC reactions; selected industrial processes involving PTC; micellar catalysis—effects of micelles on chemical reactions; characteristics of enzyme-like behavior; micelle-catalyzed reactions and inhibition in micellar solutions; reverse micelles and microemulsions; catalysis in thermal and photochemical reactions.

Unit 4 – Electrocatalysis (13 Hrs.)

Introduction to electrocatalysis and fuel cells; industrial applications of catalysis; petroleum refining—distillation, cracking, reforming, hydrotreating, alkylation, and isomerization; steam cracking; ethylene-based processes—ethylene oxide, ethylene glycol, polyethylene, vinyl chloride, and PVC; propylene-based processes—acrylic acid, acrylonitrile, and Ziegler–Natta catalysis; carbon-based processes—butadiene and isobutylene.

Unit 5 - Surface catalysis (12 Hrs.)

Introduction; mechanisms of surface reactions—Langmuir–Hinshelwood and Eley–Rideal mechanisms; surface structures—single-crystal metal surfaces and high surface area amorphous solids; adsorption; functionalized surfaces; catalysis on functionalized surfaces and its connection to molecular catalysis; catalysis on metal surfaces, metal oxide surfaces, supported metals, mixed metal oxides, and metal sulfides (with at least one example for each).

Reference Books:

1. B. C. Gates, Catalytic Chemistry, 1992, John Wiley & Sons, Inc.
2. J. C. Kuriacose, Catalysis, 1991, Macmillan India Ltd, New Delhi.
3. M. Gratzel, K. Kalyan Sundaram, Kinetics and Catalysis in Micro heterogeneous Systems, 1991, Marcel Dekker, New York.
4. K. Kalyan Sundaram, Photochemistry in Micro heterogeneous Systems, 1987, Academic Press, Orlando.
5. K. J. Laidler, Chemical Kinetics, 3 rd Edition, 2005, Pearson Education Pte., Ltd.
6. P. H. Emmett, Catalysis, Vol. I and II, 1954, Reinhold Corp., New York.
7. J. M. Smith, Chemical Engineering Kinetics, 1971, McGraw Hill.

Websites and eLearning Sources:

1. https://archive.nptel.ac.in/content/storage2/courses/103103026/module4/lec41/1.html
2. https://archive.nptel.ac.in/content/storage2/courses/122101001/Slide/lect36/36_18.htm

COs and Bloom's Taxonomy Mapping – 26CH607		
Course Outcomes	**On completing P.G. program the students will be able to**	**BTL**
CO1	Recall and understand the fundamental concepts of catalysis, zeolite structures, micellar effects, electrocatalysis, and surface catalysis mechanisms.	K1, K2
CO2	Apply principles of catalysis to compare mechanisms, analyze zeolite and micellar catalysis, and industrial catalytic processes.	K3
CO3	Analyze catalytic mechanisms, molecular sieves, micellar effects, industrial olefin processes, and surface adsorption phenomena.	K4
CO4	Evaluate enzyme mechanisms, compare catalytic methods, and assess the role of mixed metal oxides and sulfides in catalysis.	K5
CO5	Develop analyses of enzyme kinetics and design explanations for diverse catalytic processes at molecular and surface levels.	K6

BTL K1 and K2 – remembering and understanding, K3- Applying, K4 – Analyse, K5- Evaluate and K6- Create

Relationship Matrix – 26CH607												
Course Outcomes	**Programme Outcomes (POs)**						**Programme Specific Outcomes (PSOs)**					**Mean Score of Cos**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	
CO1	1	1	3	2	3	1	3	1	2	2	1	2.0
CO2	1	3	3	2	1	3	1	2	1	1	3	2.1
CO3	1	2	1	2	2	3	2	3	2	2	2	2.2
CO4	2	1	3	1	2	3	1	2	3	2	1	2.1
CO5	1	2	1	2	2	2	2	3	3	3	3	2.4
											Total	2.1

Mean Score: 3- High, 2- Medium/Moderate, 1-Low