CHE-352-MJ-T: INORGANIC CHEMISTRY III

Course Type: Major Theory **Credits: 2**

A. Course Objectives:

1. To develop a comprehensive understanding of reaction mechanisms and catalytic processes in inorganic chemistry.
2. To explore the significance of metal ions in biological and environmental systems.
3. To introduce the principles governing electrical, structural, and functional properties of solid-state materials.
4. To provide exposure to emerging areas such as nanomaterials and metal–organic frameworks.
5. To cultivate problem-solving skills related to modern inorganic chemistry concepts.

B. Course Outcomes (COs):

CO No.	Course Outcome Statement (COs) *After learning the course, the students are able to -*
CO-1	Define mechanisms, catalysis, bioinorganic systems, solids, nanomaterials, and MOFs.
CO-2	Explain reactions, catalysis, biological metals, electronic properties, and materials.
CO-3	Solve problems on mechanisms, catalysis, bioinorganic systems, and solids.
CO-4	Analyze reactions, catalytic processes, biological roles, and material behavior.
CO-5	Justify properties and applications of inorganic systems and materials.
CO-6	Derive theoretical explanations of inorganic processes.

C. Contents:

Prerequisites	
Basic understanding of coordination chemistry, chemical bonding, and periodic properties is required. Knowledge of thermodynamics, electronic structure, and introductory solid-state chemistry will support comprehension of reaction mechanisms, catalysis, and advanced inorganic topics.	
Chapter 1: Inorganic Reaction Mechanism	**04 Hours**
Introduction of stability and lability, stability or formation constant, factors affecting lability, chelate effect. Types of inorganic reactions, ligand substitution reactions and mechanisms in brief, Substitution Reactions in square planar complexes: Trans effect, Trans effect series and	

its applications. [**Ref. 1:** Pages 537-576; **Ref. 2:** Relevant Pages; **Ref. 3:** Pages 507-517; **Ref. 4:** Pages 412-420, 434-440]	
Chapter 2: Heterogeneous catalysis	**05 Hours**
Introduction, Classification of heterogeneous catalysts, supported metal catalyst, Role of support, Promoters and Poisons. Catalytic processes *viz.,* a) Hydrogenation of Olefins using Raney Nickel catalyst, b) Zeolites in catalysis: Catalytic Cracking, c) Biodiesel Synthesis using Heteropolyacids(HPAs) and d) Automotive Exhaust Catalysts: The catalytic converters. [**Ref. 5:** Pages 1-16, 87-112, 203-205, 222-224; **Ref. 6:** Relevant Pages]	
Chapter 3: Bioinorganic Chemistry	**06 Hours**
Introduction, definition, scope and importance of metal ions in biological systems. Classification of biological metals: a) Enzymatic and non-enzymatic metals and b) Redox-active and non-redox-active metals. Role of non-enzymatic metals with one example (Na, K, Ca, and Mg). Metals in enzymatic processes in brief: a) Enzymatic redox metals (Cu in superoxide dismutase), b) Enzymatic non-redox metals (Zn in hydrolases), and c) Redox-active transition-metal enzymes (catalase, peroxidase, nitrogenase). Metalloproteins: a) Iron–Sulphur proteins and electron-transfer systems, b) Iron transport and storage proteins: transferrin and ferritin. c) Bioinorganic chemistry of iron: hemoglobin and myoglobin and d) Bioinorganic chemistry of cobalt: Vitamin B_{12} (cobalamin). [**Ref. 3:** Relevant Pages; **Ref. 7:** Pages 353,775,779,796-797; **Ref. 8:** Pages 1-13,24,285-290]	
Chapter 4: Metals, Semiconductors and Superconductors	**08 Hours**
Metals: Introduction, Metallic bonding, Band theory in metals with respect to Na along with n(E) and N(E) curves/diagrams, Electrical conductivity of metals (Na, Mg, Al), Valence electrons and conductivity of metals, Effect of temperature and impurity on electrical conductivity of metals and insulators. **Semiconductors:** Types of Semiconductors: a) Intrinsic and Extrinsic, b) n and p type semiconductors and c) Non-stoichiometry and semiconductivity w.r.t. ZnO and NiO/FeO. **Superconductivity:** Discovery, property, models, structure and superconductivity, low and high temperature superconductors, applications of superconductors. [**Ref. 9 :** Pages 359-391; **Ref. 10:** Pages 394-411; **Ref. 11:** Relevant Pages; **Ref. 12:** Pages 394-411]	
Chapter 5: Introduction to Advanced topics in Inorganic Chemistry	**07 Hours**
A. Introduction to Nanomaterials [4 Hours]	

Definition and concept of nanomaterials, Difference between bulk and nanomaterials, Size scale and surface-to-volume ratio.

Classification of Nanomaterials: A) Based on dimensions: 1) 0D: nanoparticles and quantum dots, 2) 1D: nanowires and nanotubes, 3) 2D: graphene and thin films, and 4) 3D: nanocomposites and B) Based on composition: 1) Metals, 2) Metal oxides, 3) Semiconductors and 4) Carbon-based nanomaterials.

Methods for Synthesis of Nanomaterials: a) Top-Down Methods, b) Bottom-Up Methods, c) Sol–gel method, d) Chemical vapor deposition (CVD), e) Hydrothermal and f) Solvothermal methods. Properties and Applications of Nanomaterials.

[**Ref. 13 :** Pages 1-30; **Ref. 14:** Relevant Pages]

B. Introduction to Metal–Organic Frameworks [3 Hours]

Definition and basic concept of MOFs, Comparison of MOFs with coordination polymers, zeolites, and porous materials, Building Blocks of MOFs, Synthesis of MOFs: Solvothermal and hydrothermal methods, Advantages and significance of MOFs, Applications of MOFs in Gas storage (H_2, CO_2, CH_4), Gas separation and capture (CO_2 capture, air purification), MOFs in catalysis (heterogeneous catalysis concept).

[**Ref. 15 :** Pages 1-35; **Ref. 16:** Relevant Pages]

References:

1. Inorganic Chemistry – Principles of Structure and Reactivity, J. E. Huheey, E. A. Keiter & R. L. Keiter, 4th Edn. Harper Collins College Publ. New York, 1993.
2. Martin L. Tobe and John Burgess, Inorganic Reaction Mechanisms, Addison Wesley Longman Inc., 1999.
3. Inorganic Chemistry, D.F. Shriver, P.W. Atkins, C.H. Lamgford, Oxoford, 5th Edn., 1994.
4. Inorganic Chemistry - Messler and Tarr - Pearson Publishers.
5. Heterogeneous catalysis in industrial practice, Chaerls N. Shatterfield, second edition, Krieger Publishing Company, Florida USA.
6. Heterogeneous catalysis by B. Vishwanathan and D. K. Chakrabarty , New Age International Private Limited, 2007.
7. Concise Inorganic Chemistry by J.D. Lee - 5th Edn.
8. Principles of Bioinorganic Chemistry by S. J. Lippard and J. M. Berg, Panima Publishing Corporation, 1st Edn.
9. Solid State Chemistry and its Applications, Anthony R. West, Second Edition, Wiley

2014.

10. Solid State Chemistry: An Introduction, Lesley E. Smart, Elaine A. Moore, 3rd Edn.
11. Chemistry by Raymond Chang - 5th Edn.
12. New Guide to Modern Valence Theory by G.I. Brown - 3rd Edn.
13. The Chemistry of Nanomaterials, C. N. R. Rao, A. Müller, A. K. Cheetham, Wiley-VCH.
14. Nanotechnology: Principles and Practices by Sulabha K. Kulkarni, Springer Publisher
15. Introduction to Reticular Chemistry: Metal–Organic Frameworks and Covalent Organic Frameworks by Omar M. Yaghi, Markus J. Kalmutzki, and Christian S. Diercks, Wiley-VCH, 2019.
16. Review Article: a) H. Furukawa Kyle E. Cordova, Michael O'Keeffe, Omar M. Yaghi, "The Chemistry and Applications of Metal–Organic Frameworks," Science, 2013, 341, 1230444, b) G. Férey, "Hybrid porous solids: past, present, future," Chemical Society Reviews, 2008, 37, 191-214.