Home

CHE-302-MJ-T: INORGANIC CHEMISTRY II

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

A. Course Objectives:

1. To provide fundamental knowledge of molecular orbital theory for covalent and coordination compounds.
2. To familiarize students with bonding concepts and electronic structure of inorganic systems.
3. To develop understanding of properties and chemistry of d- and f-block elements.
4. To introduce concepts of organometallic chemistry and homogeneous catalysis.
5. To promote insight into structure–property relationships and catalytic processes in inorganic chemistry.

B. Course Outcomes (COs):

CO No.	**Course Outcome Statement (COs)** *After learning the course, the students are able to -*
CO-1	Recall concepts of MOT, coordination complexes, d- and f-block elements, and organometallic chemistry.
CO-2	Explain bonding, structure, and properties of inorganic systems.
CO-3	Apply concepts to determine bond order, stability, and reactivity.
CO-4	Analyze trends in coordination complexes and d- and f-block elements.
CO-5	Evaluate catalytic behavior and applications of organometallic systems.
CO-6	Illustrate bonding models and structure–property relationships.

C. Contents:

Prerequisites	
Students should have basic knowledge of atomic structure, periodic table, and chemical bonding (VBT and CFT). Familiarity with electronic configuration, basic inorganic reactions, and elementary coordination chemistry is required.	
Chapter 1: Molecular Orbital Theory of Covalent Compounds	**05 Hours**
Limitations of Valence Bond Theory(VBT), Concept of molecular orbitals, Linear Combination of Atomic Orbitals (LCAO) principle and rules, Bonding combinations of AOs: s-s, s-p, p-p and d-d, Types of molecular orbitals: Bonding, antibonding, non-bonding. MO Energy level diagrams for homonuclear diatomic molecules, Bond order, existence, energy (β) and magnetic behaviour of molecules or ions: H_2, H^{2+}, He^{2+}, Li_2, Be_2, B_2, C_2, N_2, O_2, O_2^+,	

O_2^-, O_2^{2-}, F_2 and Ne_2. MO energy level diagrams for heteronuclear diatomic molecules: CO and HF. **[Ref-1 to 3:** Relevant Pages**]**	
Chapter 2: Molecular Orbital Theory for Coordination Complexes	**05 Hours**
Electroneutrality principle, Nephelauxetic effect and need of MOT over VBT and CFT for explaining M-L bonding, Assumptions of MOT for coordination complexes and formation of MOs w.r.t. bonding, antibonding, and non-bonding MOs, MO energy level diagrams for octahedral complexes with σ-bond: $[Ti(H_2O)_6]^3$, $[Co(NH_3)_6]^3$, $[Fe(H_2O)_6]^2$, $[CoF_6]^{4-}$ & $[Co(CN)_6]^{4-}$ and $[Fe(F)_6]^{3-}$ & $[Fe(CN)_6]^3$, H.S. and L.S. complexes, and effect of π bonding on MO diagram and charge transfer transitions. **[Ref-1 to 4:** Relevant Pages**]**	
Chapter 3: Chemistry of d and f-block Elements	**10 Hours**
d-Block elements: [03 Hours] Position in periodic table, occurrence, electronic configuration. Trends in properties w.r.t.(a) size of atoms and ions (b) reactivity (c) catalytic activity (d) oxidation state (e) complex formation ability (f) colour (g) magnetic property (h) non-stoichiometry (i) density, melting & boiling points. **f-Block elements:** Introduction on the basis of electronic configurations, occurrence and reactivity, f-block elements as Lanthanide and Actinide series **I. Lanthanides: [04 Hours]** Position in periodic table, Name and electronic configuration of lanthanides and Oxidation States. Atomic and ionic radii, Lanthanide contraction: its causes and consequences. Occurrence and separation: Bulk separation, Individual separation by modern methods *viz.,* Ion exchange method and solvent extraction method, and applications of lanthanides. **II. Actinides: [03 Hours]** Position in periodic table, names and their electronic configurations. Oxidation States, Occurrence and general methods of preparation of transuranic elements *viz.,* Neutron Bombardment, Accelerated projectile bombardment and Heavy ion bombardment. Nuclear Fuels-Nuclear fission and fusion fuels in brief, comparison between Lanthanides and Actinides. [**Ref-1:** Pages: 859-863, 865-866; **Ref-5:** Pages: 639-685]	
Chapter-4: Organometallic Chemistry and Homogeneous Catalysis	**10 Hours**
Definition of Organometallic compounds and Organometallic chemistry, CO as a *π*-acid donor ligand, binary metal carbonyls, synthesis of metal carbonyls; (a) Direct reaction (b)	

Reductive carbonylation (c) Photolysis and thermolysis. Hepticity, Molecular and electronic structures of binary metal carbonyls, Electron count in complexes (18 electron rule). Chemistry of ferrocene; Introduction, synthesis and physical properties of ferrocene. Reactions of ferrocene such as Friedel-Craft Acylation, Friedel-Craft Alkylation, Mannich reaction, Nitration and Halogenation

Applications of organometallic compounds in industrial catalysis (list of examples). Introduction to Catalysis, basic principles, activity and selectivity in catalysis, Types of catalysis, Homogeneous catalysis: importance of catalysis in the synthesis of high value chemicals. Catalytic cycles for: a) Hydrogenation of olefins using Wilkinson's complex, b) Hydroformylation of olefins using Co and Rh complexes, c) Carbonylation of methanol - Monsanto processes and d) C-C coupling reaction: Heck reaction.

[Ref-1: Pages: 534-542,553-564, 690-721; **Ref-2:** Pages: 534-542,553-564, 690-721; **Ref-7**; Pages: 13-23, 55-61,85-102, 161-16**]**

References:

1. Concise Inorganic Chemistry, J. D. Lee, Blackwell Science, 5th Edition, 1996.
2. Inorganic Chemistry, D. F. Shriver, P. W. Atkins, C. H. Langford, ELBS, 2nd Edition, 1994.
3. Concepts and Models of Inorganic Chemistry, B. E. Douglas, D. H. McDaniel, J. J. Alexander, Wiley, 3rd Edition, 1994.
4. Inorganic Chemistry, G. L. Miessler, D. A. Tarr, Pearson, 3rd Edition, 2010.
5. Principles of Inorganic Chemistry, B. R. Puri, L. R. Sharma, K. C. Kalia, Milestone Publications.
6. Homogeneous Catalysis: The Applications and Chemistry of Catalysis by Soluble Transition Metal Complexes, G. W. Parshall, S. D. Ittel, Wiley, 1992.
7. Homogeneous Catalysis: Mechanisms and Industrial Applications, S. Bhaduri, D. Mukesh, Wiley, 2000.