Semester	**5**
Programme	**CHEMISTRY**
Course	**MAJOR (INORGANIC CHEMISTRY 5)**
Paper Code	**C3CH230541T**
Credits	**4 (THEORY: 4)**
Hours/week	**4 (THEORY: 4)**
Category: Core/MDC/SEC/VEC	**CORE**
Theory/Practical/Composite	**THEORY**
Number of Modules	**4**
Syllabus	**Module I: Bonding in Coordination Complexes-1 (12 Lectures)** Concept of Effective Atomic Number (EAN) and EAN rule for stability of complexes; concept of 18electron and 16- electron rules and their applications to organometallic complexes; VBT in simple coordination complexes: examples and major drawbacks; **Module II: Bonding in Coordination Complexes-2 (12 Lectures)** Crystal Field Theory: Splitting of d-orbitals in octahedral, tetrahedral, and square planar complexes; factors affecting the splitting of d-orbitals; spectrochemical series of ligands; concept of CFSE/ LFSE and calculations; concept of high-spin, low-spin, and spin state crossover in transition metal complexes; **Module III: Applications of Crystal Field Theory (12 Lectures)** Jahn Teller (JT) theorem and its application in coordination complexes; static and dynamic JT-effect with explanations and illustrations; Application of CFT in lattice enthalpy, hydration enthalpy, redox potential, and prediction of spinel/ inverse spinel structure of transition metal and mixed metal oxides. **Module IV: Molecular Orbital Theory in Coordination Complexes (12 Lectures)** Major drawbacks of CFT; Nephelauxetic Effect and Nephelauxetic parameter, MOT for octahedral complexes: construction of LGOs (qualitative) and energy level diagram explanation of – bonding (Ligand to Metal donation and Metal to Ligand donation) by MOT; explanation of spectrochemical series.

Course Overview	**Theory:** 1. Builds upon foundational knowledge of coordination chemistry to explore advanced theoretical models of bonding. 2. Provides a rigorous, step-by-step analysis of four key bonding theories: EAN/18-electron rule, VBT, CFT, and MOT. 3. Develops critical problem-solving skills through the quantitative calculation of CFSE, lattice enthalpy, and hydration enthalpy for transition metal complexes. 4. Applies theoretical concepts to explain real-world chemical phenomena, such as the magnetic behavior, color, and stability of coordination compounds. 5. Connects microscopic bonding theories to macroscopic material properties, including the prediction of spinel and inverse spinel structures in mixed metal oxides 6. Trains students to rationalize and predict the spectrochemical series and the nephelauxetic effect using molecular orbital theory. 7. Emphasizes the interpretation of electronic configurations to explain structural distortions, such as the Jahn-Teller effect in octahedral complexes. 8. Integrates concepts from inorganic chemistry with principles of physics and materials science, highlighting interdisciplinary applications. 9. Strengthens analytical thinking by comparing the strengths and limitations of different bonding models (VBT, CFT, and MOT) for coordination complexes. 10. Prepares students for advanced research and industry roles by providing the theoretical foundation necessary to design and understand transition metal-based catalysts and functional materials.
Course Outcomes	Upon successful completion of this course, students will be able to: **CO1:** Apply the Effective Atomic Number (EAN), 18-electron, and 16-electron rules to predict and justify the stability of coordination and organometallic complexes. **CO2:** Critically evaluate the strengths and limitations of Valence Bond Theory (VBT) in explaining the geometry, magnetic properties, and hybridization of simple coordination complexes. **CO3:** Illustrate the splitting of d-orbitals in octahedral, tetrahedral, and square planar geometries and correlate the magnitude of splitting (Δ) with the nature of the metal ion and the position of ligands in the spectrochemical series. **CO4:** Calculate the Crystal Field Stabilization Energy (CFSE) for various d-electron configurations and differentiate between high-spin, low-spin, and spin-crossover behavior in transition metal complexes. **CO5:** Apply the Jahn-Teller theorem to predict structural distortions in coordination complexes and distinguish between static and dynamic Jahn-Teller effects with suitable examples. **CO6:** Utilize Crystal Field Theory to explain and interpret the trends in lattice enthalpy, hydration enthalpy, and redox potentials of

	transition metal ions and oxides. **CO7:** Predict the normal or inverse spinel structure of mixed metal oxides by analyzing the CFSE preferences of metal ions in tetrahedral and octahedral sites. **CO8:** Identify the major limitations of CFT and explain the nephelauxetic effect and its parameter (β) as evidence of covalent character in metal-ligand bonding. **CO9:** Construct qualitative molecular orbital (MO) energy level diagrams for octahedral complexes, illustrating the formation of ligand group orbitals (LGOs) and the role of σ-donation and π-bonding (metal-to-ligand back-donation). **CO10:** Rationalize the entire spectrochemical series of ligands using Molecular Orbital Theory by distinguishing between π-donor, σ-donor only, and π-acceptor ligands and their effect on the Δo splitting.
Program Outcomes	PO1: Fundamental Knowledge: Demonstrate a comprehensive understanding of core concepts in chemistry, including organic, inorganic, physical, analytical, and biochemistry. PO2: Laboratory Skills: Acquire hands-on experience in laboratory techniques and instrumentation, applying safety protocols and proper methodologies to conduct experiments and analyse results. PO3: Problem Solving: Develop critical thinking and problem-solving skills by applying chemical principles to real-world scenarios, including the ability to design experiments and interpret data. PO4: Research Competency: Engage in independent and collaborative research projects, employing scientific methods to formulate hypotheses, conduct experiments, and communicate findings effectively. PO5: Interdisciplinary Applications: Understand the interdisciplinary nature of chemistry, exploring its applications in fields such as medicine, environmental science, materials science, and nanotechnology. PO6: Communication Skills: Effectively communicate scientific information, both verbally and in written form, to diverse audiences, demonstrating the ability to present complex ideas clearly and concisely. PO7: Ethics and Sustainability: Recognize the ethical implications and responsibilities of scientific research and practice in chemistry, emphasizing the importance of sustainability and environmental stewardship in chemical practices.

CO #	Course Outcome Summary	Bloom’s Taxonomy (K-Level)	Mapped POs
CO1	**Stability Rules Application**	**K3 (Applying)**	**PO1, PO3**
CO2	**VBT Critique**	**K5 (Evaluating)**	**PO1, PO3**

CO3	**d-orbital Splitting**	**K4 (Analyzing)**	**PO1, PO3**
CO4	**CFSE & Spin States**	**K4 (Analyzing)**	**PO1, PO3**
CO5	**Jahn-Teller Distortion**	**K3 (Applying)**	**PO3, PO5**
CO6	**Thermochemical Trends**	**K3 (Applying)**	**PO3, PO5**
CO7	**Spinel Prediction**	**K4 (Analyzing)**	**PO3, PO5**
CO8	**Nephelauxetic Effect**	**K2 (Understanding)**	**PO1, PO3**
CO9	**MO Diagram Construction**	**K4 (Analyzing)**	**PO1, PO3**
CO10	**Spectrochemical Rationalization**	**K5 (Evaluating)**	**PO1, PO3, PO5**

Reading/Reference Lists	**Theory:** 1. Douglas, B.E. and McDaniel, D.H. Concepts & Models of Inorganic Chemistry Oxford, 1970. 2. Atkin, P. Shriver & Atkins' Inorganic Chemistry, 5th Ed., Oxford University Press (2010). 2. Cotton, F.A., Wilkinson, G. and Gaus, P.L., Basic Inorganic Chemistry 3rd Ed.; Wiley India. 4. Sharpe, A.G., Inorganic Chemistry, 4th Indian Reprint (Pearson Education) 2005. 3. Huheey, J. E.; Keiter, E.A. & Keiter, R.L. Inorganic Chemistry, Principles of Structure and Reactivity 4th Ed., Harper Collins 1993, Pearson,2006. 4. Mingos, D.M.P., Essential trends in inorganic chemistry. Oxford University Press (1998). 5. Housecraft, C. E.; Sharpe, A. G., (2018), Inorganic Chemistry, 5th Edition, Pearson. 6. Wulfsberg, G (2002), Inorganic Chemistry, Viva Books Private Limited.
Evaluation	Theory: 100 Internal: 30 (CIA:20, Other mode of Assesment:5, Attendance: 5) Semester Exam:70
Paper Structure for Theory Semester Exam	Answer SEVEN out of NINE questions, of 10 marks each.