Semester	**5**
Programme	**CHEMISTRY**
Course	**MAJOR (INORGANIC CHEMISTRY 4)**
Paper Code	**C3CH230522T/ C3CH230522P**
Credits	**4 (THEORY:3 + PRACTICAL: 1)**
Hours/week	**6 (THEORY:3 + PRACTICAL: 3)**
Category: Core/MDC/SEC/VEC	**CORE**
Theory/Practical/Composite	**COMPOSITE**
Number of Modules	**3**
Syllabus	**Module I: Main Group Chemistry- 1 (12 Lectures)** Concepts and explanation of variation in catenation properties along the period and down the group; variation in formulations of oxides, oxoacids, halides in Groups 13, 14, 15, 16 and 17; variation in structures and redox properties of hydrides, oxides and oxoacids. **Module II: Main Group Chemistry- 2 (12 Lectures)** Structure and Bonding in B_2H_6, Al_2Cl_6, $P_3N_3Cl_6$, O_2F_2, S_2N_2, S_4N_4, polythiazyl, XeF_2, XeF_4, XeF_6, Xenate and perxenate, Borazine, Boron nitride. **Module III: Organometallic Chemistry-1 (12 Lectures)** Definition and classification of organometallic compounds on the basis of bond type; Concept of hapticity of organic ligands. General methods of preparation of mono and binuclear carbonyls of 3d series. Structures of mononuclear and binuclear carbonyls. pi-acceptor behaviour of CO, synergic effect and use of IR data to explain extent of back bonding. **Practical: Redox Titrations** 1. Estimation of Fe(II) using standardized $KMnO_4$ solution 2. Estimation of Fe(III) and Ca(II) in a given mixture using standardized $KMnO_4$ solution 3. Estimation of Fe(II) and Fe(III) in a given mixture using $K_2Cr_2O_7$ solution. 4. Estimation of Fe(III) and Mn(II) in a mixture using standardized KMnO4 solution 5. Estimation of Fe(III) and Cu(II) in a mixture using $K_2Cr_2O_7$. 6. Estimation of Fe(III) and Cr(III) in a mixture using $K_2Cr_2O_7$.

Course Overview	**Theory:** 1. **Periodic Trends in Main Group Chemistry:** Analyze and rationalize the periodic variation in catenation, oxide/halide formulations, and redox properties across Groups 13-17, emphasizing the underlying electronic and structural factors. 2. **Structure-Property Correlations:** Develop a systematic understanding of how the structures of main group compounds (e.g., hydrides, oxides, oxoacids) dictate their chemical behavior and stability. 3. **Advanced Bonding Concepts:** Master the application of non-classical bonding models, including **3-center-2-electron (3c-2e) bonds** in diborane and coordinate bridges in Al_2Cl_6. 4. **Inorganic Ring Systems:** Explore the structure, bonding, and aromaticity of cyclic inorganic molecules like **borazine** and sulfur-nitrogen compounds (S_4N_4, polythiazyl), comparing them to their organic analogs. 5. **Noble Gas Chemistry:** Investigate the structures (using VSEPR theory) and hydrolysis products of xenon fluorides, including the formation of xenates and perxenates. 6. **Fundamentals of Organometallic Chemistry :** Define organometallic compounds, classify them by bond type (ionic, σ-bonded, π-bonded), and understand the concept of **hapticity (η)** in describing ligand-metal interactions. 7. **Metal Carbonyls: Synthesis & Structure:** Learn the general preparative methods and predict the structures of mononuclear and binuclear carbonyls of the 3d transition series. 8. **Synergic Bonding & Spectroscopic Analysis:** Explain the **synergic effect** (σ-donation and π-back-bonding) in metal-CO bonds and use **IR spectroscopy** data to quantitatively assess the extent of metal-to-ligand back-donation. **Practical:** 1. Quantitative Redox Analysis: Develop proficiency in performing accurate redox titrations using standardized $KMnO_4$ and $K_2Cr_2O_7$ as primary oxidizing agents, including endpoint detection (self-indicator vs. external indicator). 2. Sequential Estimation in Mixtures: Master the analytical techniques for the sequential estimation of metal ions (Fe^{2+}, Fe^{3+}, Ca^{2+}, Mn^{2+}, Cu^{2+}, Cr^{3+}) in binary mixtures using selective reduction, oxidation, or precipitation strategies followed by titration.

Course Outcomes (COs)	Upon successful completion of this course, students will be able to: **CO1:** Explain the periodic trends in catenation, oxide/halide formulations, and redox properties of p-block elements (Groups 13-17), rationalizing the variations based on electronic configurations, bond energies, and the inert pair effect. **CO2:** Analyze and predict the structures of main group compounds (hydrides, oxides, oxoacids, and halides) using VSEPR theory, and correlate structural changes with variations in their acidic/basic strength and redox behavior. **CO3:** Apply the concept of 3-center-2-electron (3c-2e) bonds and coordinate bridge bonding to explain the structure and stability of electron-deficient compounds such as B_2H_6 and Al_2Cl_6. **CO4:** Compare and contrast the structure, bonding, and aromaticity of inorganic ring systems (borazine, S_4N_4, polythiazyl) with their organic analogues, and evaluate the unique properties arising from delocalized bonding. **CO5:** Deduce the VSEPR structures of xenon fluorides (XeF_2, XeF_4, XeF_6) and their hydrolysis products (xenates and perxenates), and rationalize their chemical reactivity and redox behavior. **CO6:** Classify organometallic compounds based on the M-C bond type and hapticity, and explain the general synthetic routes and structural geometries of mononuclear and binuclear 3d metal carbonyls. **CO7:** Evaluate the synergic effect (σ-donation and π-back-bonding) in metal-carbonyls, and interpret IR spectroscopic data to assess the extent of metal-to-ligand back-donation and its influence **CO8:** Perform quantitative estimation of metal ions (Fe^{2+}, Fe^{3+}, Ca^{2+}, Mn^{2+}, Cu^{2+}, Cr^{3+}) in pure solutions and binary mixtures using standardized redox titrants ($KMnO_4$ and $K_2Cr_2O_7$), demonstrating proficiency in endpoint detection (self and external indicators) and accurate stoichiometric calculations.
Program Outcomes (POs)	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	**Explain periodic trends in catenation, oxide/halide formulations, and redox properties of p-block elements**	**K2 (Understand)**	**PO1, PO3**
CO2	**Analyze and predict structures of main group compounds using VSEPR theory and correlate with acidic/basic strength and redox behavior**	**K4 (Analyze)**	**PO1,PO3**
CO3	**Apply 3-center-2-electron (3c-2e) and coordinate bridge bonding concepts to explain structures of B_2H_6 and Al_2Cl_6**	**K3 (Apply)**	**PO1,PO3**
CO4	**Compare and contrast structure, bonding, and aromaticity of inorganic ring systems (borazine, S_4N_4, polythiazyl) with organic analogues**	**K4 (Analyze)**	**PO1,PO3**
CO5	**Deduce VSEPR structures of xenon fluorides and their**	**K4 (Analyze)**	**PO1, PO3**

	hydrolysis products, and rationalize their reactivity and redox behavior		
CO6	**Classify organometallic compounds by bond type and hapticity; explain synthesis and structures of 3d metal carbonyls**	**K2 (Understand)**	**PO1**
CO7	**Evaluate synergic effect in metal-carbonyls and interpret IR data to assess extent of back-bonding**	**K5 (Evaluate)**	**PO1, PO3**
CO8	**Perform quantitative redox titrations for metal ions in mixtures using $KMnO_4$ and $K_2Cr_2O_7$ with accurate endpoint detection and calculations**	**K3 (Apply)**	**PO1, PO2, PO3**

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. Winter, M. J., The Orbitron, http://winter.group.shef.ac.uk/orbitron/ (2002). An illustrated gallery of atomic and molecular orbitals. 6. Burgess, J., Ions in solution: basic principles of chemical interactions. Ellis Horwood (1999). 7. Pfennig, B. W. (2015), Principles of Inorganic Chemistry. John Wiley & Sons. 8. Housecraft, C. E.; Sharpe, A. G., (2018), Inorganic Chemistry, 5th Edition, Pearson. 9. Wulfsberg, G (2002), Inorganic Chemistry, Viva Books Private Limited.

	10. Magnetochemistry – A. Selwood 11. Introduction to Magnetochemistry Earnshaw 12. Elements of Magnetochemistry – R. L. Dutta & A. Shyamal **Practical:** 1. Mendham, J., A. I. Vogel’s Quantitative Chemical Analysis 6th Ed., Pearson, 2009. 2. Harris, D. C.; Lucy,C. A.(2016), Quantitative Chemical Analysis, 9th Edition, Freeman and Company Practical Workbook Chemistry (Honours), UGBS, Chemistry, University of Calcutta, 2015.	
	Theory: 60 Internal: 15 (CIA: 10; Other form of Assessment: 2; Attendance: 3) Semester Exam: 45	Practical: 40 CA: 38; Attendance:2
	Answer THREE out of FOUR questions, of 15 marks each.	