Semester	**2**
Programme	**CHEMISTRY**
Course	**MAJOR (INORGANIC CHEMISTRY)**
Paper Code	**C1CH230212T/C1CH230212P**
Credits	**4 (THEORY : 3 PRACTICALS : 1)**
Hours/week	**6 (THEORY: 3 PRACTICALS : 3)**
Category: Core/MDC/SEC/VEC	**CORE**
Theory/Practical/Composite	**COMPOSITE**
Number of Modules	**4 (THEORY: 3 PRACTICALS: 1)**
Syllabus	**Theory:**

Module 1: Acid-Base theories (12 Lectures)

Acid-Base concept: Arrhenius concept, theory of solvent system (H_2O, NH_3, SO_2 and HF), Bronsted- Lowry's concept, relative strength of acids, Pauling's rules. Lux-Flood concept, Lewis concept, characteristics of Lewis acids, solvent levelling and differentiating effects; Thermodynamic acidity parameters, Drago-Wayland equation; superacids, Gas phase acidity and proton affinity; HSAB principle.

Module 2: Ionic bonding (12 Lectures)

General characteristics, types of ions, unit cell, lattice and basis, crystal plane, Weiss and Miller indices, diffraction; size effects, radius ratio rule and its application and limitations. Packing of ions in crystals. Born-Landé equation with derivation and importance of Kapustinskii expression for lattice energy. Madelung constant, Born-Haber cycle and its application, Solvation energy. Defects in solids (elemementary idea). Solubility energetics of dissolution process;

Module 3: Covalent Bonding-II (12 Lectures)

Molecular orbital concept of bonding (The approximations of the theory, Linear combination of atomic orbitals (LCAO)) (elementary pictorial approach): sigma and pi-bonds and delta interaction, multiple bonding. Orbital designations: gerade, ungerade, HOMO, LUMO. Orbital mixing; MO diagrams of H_2, Li_2, Be_2, B_2, C_2, N_2, O_2, F_2, and their ions wherever possible; Heteronuclear molecular orbitals: CO, NO, NO^+, CN□, HF, HF □, BeH , CO and H O. Bond properties: bond orders, bond lengths.

Practicals:

Acid and Base Titrations:

1. Standardization of NaOH using oxalic acid.
2. Standardization of HCl/acetic acid using standardized NaOH.
3. Estimation of carbonate and hydroxide present together in mixture.
4. Estimation of carbonate and bicarbonate present together in a mixture.

	5. Estimation of free alkali present in different soaps/detergents. 6. Determination of the amount of acid neutralized by antacid tablets. 7. Determination of the amount of acetic acid in vinegar. 8. Determination of the amount of citric acid in fruit juices. Estimation of NH_4^+ by formol titration.
Course Overview	Theory: 1. This composite course offers an advanced exploration of chemical bonding and reactivity principles. 2. The theoretical component focuses on diverse **Acid-Base theories**, ranging from classical Arrhenius and Brønsted-Lowry to advanced concepts like the Drago-Wayland equation, superacids, and the **HSAB principle**. 3. It provides an in-depth study of **Ionic Bonding**, covering lattice structures, Miller indices, and the quantitative derivation of lattice energy through Born-Landé and Kapustinskii equations. 4. To understand the idea of lattice and to be able to find out the lattice energy by several methods. 5. To develop the basic idea of defects in lattices and the principles of solubility. 6. The course also introduces **Molecular Orbital Theory (MOT)** for hetero- and homo-nuclear diatomic and triatomic molecules, alongside a qualitative understanding of metallic bonding. 7. To have a grasp of the MOT of simple hetero and homo-nuclear diatomic molecules as well as some tri-atomic molecules (non- mathematical approach); understanding metallic bonding in a qualitative way Practical: 1. The practical module is dedicated to mastering **acid-base titrimetric analysis**, including the estimation of commercial samples like soaps, antacids, and fruit juices. To develop the concepts of several theories of acids and bases. 2. To develop skills and to understand the underlying principles in acid-base titrimetric analysis.
Course Outcome	Upon successful completion of this course, students will be able to: CO1: Differentiate between classical and modern acid-base theories (Arrhenius, Solvent System, Brønsted-Lowry, Lux-Flood, Lewis) and quantify acid-base interactions using advanced parameters like the Drago-Wayland equation, proton affinity, and gas-phase acidity to predict reactivity and strength. CO2: Apply thermodynamic cycles (Born-Haber) and equations (Born-Landé, Kapustinskii) to calculate lattice energies, solvation energies, and interpret the thermodynamic stability of ionic compounds. CO3: Correlate the physical properties of ionic solids (density, conductivity, solubility) with their structural features by interpreting Miller indices, applying the radius ratio rule (and its limitations), and identifying Schottky and Frenkel defects. CO4: Construct molecular orbital (MO) energy diagrams for homo- and hetero-nuclear diatomic and simple triatomic molecules using LCAO, orbital mixing, and symmetry principles, and predict bond orders, magnetic behavior (e.g., O_2 paramagnetism), and HOMO-LUMO based

	reactivity. CO5: Execute precise acid-base titrations to standardize solutions (NaOH, HCl) and estimate the concentration of pure analytes (acetic acid, citric acid) and complex mixtures (carbonate-hydroxide, carbonate-bicarbonate) using appropriate indicators. CO6: Formulate and apply specialized titrimetric techniques, including back-titration (for antacids) and formol titration (for NH_4^+), to determine the composition of real-world commercial and biological samples like soaps, detergents, and fruit juices. CO7: Analyze experimental titration data to calculate unknown concentrations, critique sources of procedural error, and justify the selection of specific indicators based on pH equivalence points and the nature of the analyte. CO8: Synthesize knowledge from all three theory modules (e.g., linking HSAB principles to lattice energetics and dissolution) and communicate the findings of practical analysis effectively, demonstrating the application of inorganic chemistry in industrial and environmental contexts.
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	**Differentiate acid-base theories & quantify using Drago-Wayland/HSAB.**	**K4 (Analyze)**	**PO1, PO3**
CO2	**Apply Born-Haber/Landé equations for lattice energy calculations.**	**K3 (Apply)**	**PO1, PO3**
CO3	**Correlate properties of ionic solids with crystal geometry & defects.**	**K4 (Analyze)**	**PO1, PO3**
CO4	**Construct MO diagrams and predict bond orders/magnetic properties.**	**K5 (Synthesize/Evaluate)**	**PO1**
CO5	**Execute standardization & estimation of single/mixture analytes.**	**K3 (Apply)**	**PO2, PO3**
CO6	**Formulate & apply back-titration & formol titration techniques.**	**K5 (Synthesize)**	**PO2, PO3, PO5**
CO7	**Analyze titration data, critique errors, and justify indicator choice.**	**K5 (Evaluate)**	**PO3, PO6**
CO8	**Synthesize theory modules and communicate practical findings.**	**K6 (Create)**	**PO5, PO6**

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). 3. 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. 5. Huheey, J. E.; Keiter, E.A. &Keiter, R.L. Inorganic Chemistry, Principles of Structure and Reactivity 4th Ed., Harper Collins 1993, Pearson,2006. 6. Mingos, D.M.P., Essential trends in inorganic chemistry. Oxford University Press (1998). 7. Winter, M. J., The Orbitron, http://winter.group.shef.ac.uk/orbitron/ (2002). An illustrated gallery of atomic and molecular orbitals. 8. Burgess, J., Ions in solution: basic principles of chemical interactions. Ellis Horwood (1999). 9. Pfennig, B. W. (2015), Principles of Inorganic Chemistry. John Wiley & Sons. 10. Housecraft, C. E.; Sharpe, A. G., (2018), Inorganic Chemistry, 5th Edition, Pearson. 11. Wulfsberg, G (2002), Inorganic Chemistry, Viva Books Private Limited. Practical: 12. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009. 13. Harris, D. C.; Lucy,C. A.(2016), Quantitative Chemical Analysis, 9th Edition, Freeman and Company	
Evaluation	Theory: 60 Internal: 15 (CIA: 10; Other form of Assessment: 2; Attendance: 3) Semester Exam: 45	Practical: 40 CA: 30 ; Attendance:2 Semester Exam: 8
Paper Structure for Theory Semester Exam	Answer Three out of FOUR, 15 marks for each question.	