Indus Institute of Sciences, Humanities & Liberal Studies

Department of Chemistry

Syllabus for IURAT-2021

Unit-I Inorganic Chemistry

1. Chemical periodicity, Concepts of acids and bases, Hard-Soft acid base concept, Nonaqueous solvents.
2. Atomic Structure:Concept of proton, neutron, electron, atom and molecule. Bohr's theory and its limitation, Heisenberg Uncertainty principle,Madelung Constant, atomic orbitals and their variations for 1s, 2s, 2p, 3s, 3p and 3d orbitals (only graphical representation). Quantum numbers(n,l,mands) and its significance. Stability of half-filled and fully-filled orbitals. Electronic Configuration, Hund's rule, Pauli exclusion principle. Aufbau principle.
3. Main group elements and their compounds: Allotropy, synthesis, structure and bonding,industrial importance of the compounds.
4. Transition elements and coordination compounds: structure, bonding theories, spectral and magnetic properties, reaction mechanisms.
5. Inner transition elements: spectral and magnetic properties, redox chemistry, analytical applications.
6. Organometallic compounds: synthesis, bonding and structure, and reactivity. Organometallics in homogeneous catalysis.
7. Bioinorganic chemistry: photosystems, porphyrins, metalloenzymes, oxygen transport, electron- transfer reactions; nitrogen fixation, metal complexes in medicine.
8. Coordination compounds in biology and medicines, redox chemistry of Iron porphyrins, cytochromes, therapeutic uses of coordination compounds as anticancer, anti arthritis drugs.
9. Ring, Cages and metal clusters: Structure and synthesis.
10. Characterisation of inorganic compounds by IR, Raman, NMR, EPR, Mössbauer, UV-vis, NQR, MS, electron spectroscopy and microscopic techniques.

Unit-II Organic Chemistry

1. Principles of stereochemistry: Configurational and conformational isomerism in acyclic and cyclic compounds; stereogenicity, stereoselectivity, enantioselectivity, diastereoselectivity and asymmetric induction.
2. Aromaticity: Benzenoid and non benzenoid compounds – generation and reactions. IUPAC nomenclature of organic molecules including regio- and stereoisomers.
3. Organic reactive intermediates: Generation, stability and reactivity of carbocations, carbanions, free radicals, carbenes, benzynes and nitrenes. Common named reactions and rearrangements – applications in organic synthesis.

4. Organic reaction mechanisms involving addition, elimination and substitution reactions with electrophilic, nucleophilic or radical species. Determination of reaction pathways.
5. Concepts in organic synthesis: Retrosynthesis, disconnection, synthons, linear and convergent synthesis, umpolung of reactivity and protecting groups.
6. Pericyclic reactions – electrocyclization, cycloaddition, sigmatropic rearrangements and other related concerted reactions.
7. Principles and applications of photochemical reactions in organic chemistry.
8. Synthesis and reactivity of common heterocyclic compounds containing one or two heteroatoms (O, N, S).
9. Chemistry of natural products: Carbohydrates, proteins and peptides, fatty acids, nucleic acids, terpenes, steroids and alkaloids. Biogenesis of terpenoids and alkaloids.
10. Structure determination of organic compounds by IR, UV-Vis, 1H & 13C NMR and Mass spectroscopic techniques.
11. Organic transformations and reagents: Functional group interconversion including oxidations and reductions; common catalysts and reagents (organic, inorganic, organometallic and enzymatic). Chemo, regio and stereoselective transformations.
12. Asymmetric synthesis: Chiral auxiliaries, methods of asymmetric induction – substrate, reagent and catalyst controlled reactions; determination of enantiomeric and diastereomeric excess; enantio-discrimination. Resolution – optical and kinetic.

Unit-III Physical Chemistry

1. Chemical bonding in diatomics; elementary concepts of MO and VB theories; Huckel theory for conjugated π-electron systems. Chemical applications of group theory; symmetry elements; point groups; character tables; selection rules.
2. Atomic structure and spectroscopy; term symbols; many-electron systems and antisymmetry principle.
3. Approximate methods of quantum mechanics: Variational principle; perturbation theory up to second order in energy; applications.
4. Basic principles of quantum mechanics: Postulates; operator algebra; exactly solvable systems: particle-in-a-box, harmonic oscillator and the hydrogen atom, including shapes of atomic orbitals; orbital and spin angular momenta; tunneling.
5. Electrochemistry: Nernst equation, redox systems, electrochemical cells; DebyeHuckel theory; electrolytic conductance – Kohlrausch's law and its applications; ionic equilibria; conductometric and potentiometric titrations.
6. Polymer chemistry: Molar masses; kinetics of polymerization.
7. Chemical thermodynamics: Laws, state and path functions and their applications; thermodynamic description of various types of processes; Maxwell's relations; spontaneity and equilibria; temperature and pressure dependence of thermodynamic quantities; Le Chatelier principle; elementary description of phase transitions; phase equilibria and phase rule; thermodynamics of ideal and non-ideal gases, and solutions.
8. Statistical thermodynamics: Boltzmann distribution; kinetic theory of gases; partition functions and their relation to thermodynamic quantities – calculations for model systems.
9. Nuclear chemistry: nuclear reactions, fission and fusion, radio-analytical techniques and activation analysis, Cages and metal clusters.

10. Colloids and surfaces: Stability and properties of colloids; isotherms and surface area; heterogeneous catalysis.
11. Chemical kinetics: Empirical rate laws and temperature dependence; complex reactions; steady state approximation; determination of reaction mechanisms; collision and transition state theories of rate constants; unimolecular reactions; enzyme kinetics; salt effects; homogeneous catalysis; photochemical reactions.
12. Solid state: Crystal structures; Bragg's law and applications; band structure of solids.

Unit-IV Analytical Chemistry

1. Data analysis: Mean and standard deviation; absolute and relative errors; linear regression; covariance and correlation coefficient.
2. Molecular spectroscopy: Rotational and vibrational spectra of diatomic molecules; electronic spectra; IR and Raman activities – selection rules; basic principles of magnetic resonance.
3. Separation, spectroscopic, thermal and electro-analytical methods.
4. Principle and instrumentation of IR, NMR, Raman, UV-Vis, Mass, X-ray Spectroscopy.
5. Chromatography: Classification of stationary and mobile phase, Column Chromatography, Normal and Reverse Phase Chromatography, Paper Chromatography, Thin Layer Chromatography (TLC), Preparative TLC, Principle and examples of detection methods, Electrophoresis and electrochromatography, Radio Chromatography
6. Principle and instrumentation of GC, HPLC, HPTLC, LCMS and UPLC

Unit-V Interdisciplinary Topics

1. Basic principles and applications of Nanotechnology
2. Green Chemistry
3. Dyes
5. Medicinal Chemistry
6. Supramolecular Chemistry

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