Screening test syllabus for the post of Assistant Professor

Subject: Chemistry

Unit I

Basic principles of quantum mechanics: Postulates; Operators and 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; quantum mechanical tunneling.

Atomic structure and spectroscopy; term symbols; many-electron systems and antisymmetry principle.

Chemical bonding in diatomics; MO and VB theories. Structure and bonding in homo- and heteronuclear molecules, including shapes of molecules (VSEPR Theory).

Approximate methods of quantum mechanics: Variational principle; perturbation theory up to second order in energy; applications; Huckel theory for conjugated π-electron systems.

Unit II

Group theory, Chemical applications of group theory; symmetry elements; point groups; character tables; selection rules.

Solid state: Crystal structures; Bragg's law and applications; band structure of solids. Colloids and surfaces: Stability and properties of colloids; isotherms and surface area; heterogeneous catalysis

Catalysis and green chemistry.

Environmental chemistry.

Unit III

Analytical chemistry- separation, spectroscopic, electro- and thermo-analytical methods. Data analysis: Mean and standard deviation; absolute and relative errors; linear regression; covariance and correlation coefficient.

Polymer chemistry: Molar masses, determination; kinetics of polymerization.
Concepts of acids and bases, Hard-Soft acid base concept, Non-aqueous solvents.

Nuclear chemistry: nuclear reactions, fission and fusion, radio-analytical techniques and activation analysis

Chemistry in nanoscience and technology.

Unit IV

Chemical periodicity

Main group elements and their compounds: Allotropy, synthesis, structure and bonding, industrial importance of the compounds.

Transition elements and coordination compounds: structure, bonding theories, spectral and magnetic properties, reaction mechanisms.

Inner transition elements: spectral and magnetic properties, redox chemistry, analytical applications.

Unit V

Organometallic compounds: synthesis, bonding and structure, and reactivity. Organometallics in homogeneous catalysis.

Bioinorganic chemistry: photosystems, porphyrins, metalloenzymes, oxygen transport, electron- transfer reactions; nitrogen fixation, metal complexes in medicine.

Supramolecular chemistry. Cages and metal complexes

Unit VI

Molecular spectroscopy: Interaction of radiation with matter, peak position, peak intensity and peak width.

Rotational , vibrational, electronic spectra; selection rules.

Principles of ^{1}H & ^{13}C NMR and Mass spectroscopic techniques.

Characterisation of inorganic and organic compounds by IR, Raman, NMR, EPR, Mössbauer, UV-vis, NQR, MS, electron spectroscopy and microscopic techniques.

Principle of thermal techniques : TGA, DTA & DSC

Unit VII

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.

Statistical thermodynamics: Boltzmann distribution; kinetic theory of gases; partition functions and their relation to thermodynamic quantities – calculations for model systems.

UNIT VIII

Electrochemistry: Nernst equation, redox systems, electrochemical cells; Debye- Huckel theory; electrolytic conductance – Kohlrausch's law and its applications; ionic equilibria; conductometric and potentiometric titrations.

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.

Unit IX

IUPAC nomenclature of organic molecules including regio- and stereoisomers. Aromaticity: Benzenoid and non-benzenoid compounds. Organic reactive intermediates: Generation, stability and reactivity of carbocations, carbanions, free radicals, carbenes, benzynes and nitrenes.

Organic reaction mechanisms involving addition, elimination, substitution and rearrangements reactions with electrophilic, nucleophilic or radical species, Determination of reaction pathways.

Principles of stereochemistry: Configurational and conformational isomerism in acyclic and cyclic compounds; stereogenicity, stereoselectivity, enantioselectivity, diastereoselectivity and asymmetric induction.

Unit X

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.

Concepts in organic synthesis: Retrosynthesis, disconnection, synthons, linear and convergent synthesis, umpolung of reactivity and protecting groups.

Synthesis and reactivity of common heterocyclic compounds containing one or two heteroatoms (O, N, S).

Pericyclic reactions – electrocyclisation, cycloaddition, sigmatropic rearrangements and other related concerted reactions. Principles and applications of photochemical reactions in organic chemistry.

Chemistry of natural products: Carbohydrates, proteins and peptides, fatty acids, nucleic acids, terpenes, steroids and alkaloids. Biogenesis of terpenoids and alkaloids.