INDIAN INSTITUTE OF TECHNOLOGY MADRAS, CHENNAI-600036.

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Syllabus & Scheme of Examination for the post of SENIOR TECHNICAL OFFICER

LEVEL-1 OBJECTIVE / DESCRIPTIVE TEST

Stream: Chemistry

(Candidate should attempt questions from any THREE of the following modules)

Module I: Physical Chemistry

Quantum Chemistry: Postulates of quantum mechanics. Operators. Schrödinger equation. Born interpretation, Particle in a box – applications; Harmonic oscillator and Rigid rotor, Angular momentum operators. Hydrogen and hydrogen-like atoms; atomic orbitals, physical significance of quantum numbers; radial distribution function; electron spin; Pauli exclusion principle.

Chemical Kinetics: Elementary, parallel, opposing and consecutive reactions. Steady state approximation. Unimolecular reactions. Transition state theory: Eyring equation, thermodynamic aspects. Kinetics of polymerization. Catalysis concepts and enzyme catalysis.

Thermodynamics: Laws of thermodynamics. Standard states. Thermochemistry. Thermodynamic functions and their relationships: Gibbs-Helmholtz and Maxwell relations, Gibbs-Duhem equation, van't Hoff equation. Criteria of spontaneity and equilibrium. Dependence of equilibrium constant on temperature and pressure. Absolute entropy. Partial molar quantities. Thermodynamics of mixing. Chemical potential. Fugacity, activity and activity coefficients. Ideal and Non-ideal solutions, Raoult's Law and Henry's Law. Clausius-Clapeyron equation, Phase rule, Phase diagrams of CO_2 and H_2O; two-components system – solid-liquid, eutectics.

Microcanonical, canonical and grand canonical ensembles, Boltzmann distribution, partition functions and thermodynamic properties.

Electrochemistry: Ionic mobility and conductivity. Debye-Hückel limiting law. Debye-Hückel-Onsager equation. Standard electrode potentials and electrochemical cells. Nernst Equation – application, relationship between electrode potential and thermodynamic quantities.

Solid state and surface chemistry: Crystal lattices, unit cells, Miller indices, X-ray diffraction and powder method, bonding in solids, crystal structures, defects in solids. Physisorption and chemisorption. Langmuir, Freundlich and Brunauer–Emmett–Teller (BET) isotherms. Langmuir-Hinshelwood mechanism. Surface tension, viscosity. Self-assembly. Colloids, micelles and macromolecules.

Module II: Inorganic Chemistry

Molecular structure and symmetry: Lewis structure, VSEPR model, valence bond theory, molecular orbital theory; symmetry elements, point groups and applications.

Main group chemistry: Structure, bonding, synthesis and reactivities of boranes, carboranes, silicones, silicates, boron nitride, borazines and phosphazenes. Allotropes of carbon, phosphorus and sulphur. Chemistry of halogen, interhalogen and noble gas compounds.

Coordination and bioinorganic chemistry of d-block elements: Variety of ligands and complexes, isomerism, crystal field theory, CFSE, Jahn-Teller distortion, magnetic properties. Ligand field theory, Orgel and Tanabe-Sugano diagrams. Reaction mechanisms – kinetic and thermodynamic stability, substitution and redox reactions. Oxygen binding, transport, storage and utilization in biosystems.

Organometallic chemistry of d-block elements: 18-Electron rule, concept of hapticity; synthesis, structure and bonding of metal-carbonyls, nitrosyls, alkyls, alkenes, cyclic polyenes and carbenes. Variety of reactions – Substitution, oxidative addition, reductive elimination, insertion and de-insertion. Terminology in catalysis – turnover number, turnover frequency. Catalytic reactions including mechanistic aspects for hydrogenation, hydroformylation, Monsanto process, Wacker process, Ziegler-Natta polymerization, and olefin metathesis.

Lanthanides and actinides: Periodic properties, spectral and magnetic properties.

Module III: Organic Chemistry

Basic concepts: IUPAC nomenclature of organic molecules. Regio-, and stereo, and atropisomerism. Configurational and conformational isomerism in acyclic and cyclic compounds; stereoselectivity, enantioselectivity, diastereoselectivity and asymmetric induction. Topicity – homotopic, enantiotopic and diastereotopic atoms, groups and faces. Configurational and conformational effects, neighbouring group participation on reactivity and selectivity/specificity.

Reactive intermediates and mechanisms: Generation, stability and reactivity of carbocations, carbanions, free radicals, carbenes, arynes and nitrenes. Organic reaction mechanisms involving addition, elimination and substitution reactions with electrophilic, nucleophilic or radical species. Determination of reaction pathways.

Synthesis: Aromatic, anti-aromatic and non-aromatic compounds. Reactions of aromatic compounds. Synthesis, reactions and mechanisms involving alkenes, alkynes, arenes, alcohols, phenols, aldehydes, ketones, carboxylic acids, esters, nitriles, halides, nitro compounds, amines and amides. Common named reactions and rearrangements. Organic transformations and reagents – Functional group interconversion. Carbon-carbon bond formation including cross-coupling reactions, Tsuji-Trost, olefin/enyne metathesis and McMurry. Umpolung reactivity – formyl and acyl anion equivalents. Chemo-, regio- and stereoselectivity in organic synthesis. Synthetic applications of enolates, including boron enolates, enamines and silyl enol ethers. Stereoselective addition to C=O groups (Cram, Prelog and Felkin-Anh models).

Pericyclic and photochemical reactions: Electrocyclic, cycloaddition and sigmatropic reactions. FMO treatment, Woodward-Hoffmann rule. Photochemistry of alkenes, arenes and carbonyl compounds, Norrish type-I and II cleavages. Photooxidation and photoreduction. Di-π-methane rearrangement, Barton-McCombie reaction.

Biomolecules: Structure, properties and reactions of mono- and di-saccharides, physicochemical properties of amino acids, chemical synthesis and identification of C- and *N*-terminals of peptides. Structural features of proteins and nucleic acids.

Module IV: Analytical Techniques

Applications of techniques like HPLC, GC and polarimetry (optical rotation).

Emission and absorption spectra, Beer-Lambert law; Atomic and molecular spectroscopy – rotational, vibrational, electronic and Raman spectroscopy of diatomic and polyatomic molecules; selection rules.

Line broadening. Basic principles of nuclear magnetic resonance: gyromagnetic ratio; chemical shift, nuclear coupling.
Applications of UV-visible, IR, NMR, ESR spectroscopy and mass spectrometry in the structural determination of inorganic and organic molecules.
Mössbauer spectroscopy (Fe and Sn), X-ray crystallography, basics of photoelectron spectroscopy.
Electroanalytical methods – polarography, cyclic voltammetry, ion-selective electrodes. Thermo-analytical methods.

Module V: Laboratory Techniques

Separation techniques – chromatography (thin-layer and column), distillation and extraction.
Purification techniques – crystallization, recrystallization and sublimation.
Qualitative analysis – detection of organic functional groups and nitrogen, sulphur, halogen in organic compounds; inorganic anions and cations.
Quantitative estimation – acid/base (pH), redox, iodo/iodimetry, complexometric (including EDTA), potentiometric and conductometric titrations, and gravimetry.

LEVEL-2 PRESENTATION & PERSONAL INTERVIEW

The Candidates should make a brief presentation, approximately 6 slides, to the Selection Committee covering a brief profile of the applicant, contributions to research project(s) / Academic activities, Future Plans, & Contributions for IIT Madras as a Senior Technical Officer. The candidate should complete the presentation within 6 minutes.

Scheme of Examination:

Level	Type of Test	Weightage for final result
Level-1	Objective / Descriptive Test	50%
Level-2	Presentation & Personal Interview	50%

Based on the performance in the Level-1 Objective / Descriptive Test, the candidate will be shortlisted for the Level-2 Presentation & Personal Interview.

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Date: 13.01.2026

Sd/-
Registrar