भारतीय प्रौद्योगिकी संस्थान तिरुपति
TIRUPATI
INDIAN INSTITUTE OF TECHNOLOGY TIRUPATI
भारतीय प्रौद्योगिकी संस्थान तिरुपति
Yerpedu - Venkatagiri Road, Yerpedu Post, Yerpedu – 517619 , Dist. - Tirupati

Syllabus for the Level-I/ Level-II/ Level-III for the post of Junior Technician (JT) in Chemistry

Section 1: Physical Chemistry

Kinetic Theory of Gases and Real gases: Concept of pressure and temperature; Collision theory of gas molecules; Nature of distribution of velocities, Maxwell's distribution of speed and kinetic energy; Principle of equipartition of energy and its application. Deviation of gases from ideal behavior; compressibility factor; Boyle temperature; Andrew's and Amagat's plots; van der Waals equation; Existence of critical state, Critical constants in terms of van der Waals constants; Law of corresponding states.

Liquids: Surface tension; Viscosity; Effect of temperature on surface tension and coefficient of viscosity of a liquid.

Solids: Forms of solids, crystal systems, unit cells, Bravais lattice types, Symmetry elements; Laws of Crystallography - Law of constancy of interfacial angles, Law of rational indices; Miller indices of different planes and interplanar distance, Bragg's law; Structures of NaCl, KCl and CsCl (qualitative treatment only); Defects in crystals; Glasses and liquid crystals.

Solutions: Ideal solutions and Raoult's law, deviations from Raoult's law – non-ideal solutions; Vapour pressure-composition and temperature-composition curves of ideal and non-ideal solutions; Distillation of solutions; Critical solution temperature; effect of impurity on partial miscibility of liquids; Immiscibility of liquids- Principle of steam distillation; Nernst distribution law and its applications, solvent extraction.

Chemical Bonding: Valence bond theory and molecular orbital theory (MOT), LCAO- MO theory. Hybrid orbitals. Applications of LCAO-MOT to $H2^{+}$, H2 and other homonuclear diatomic molecules, heteronuclear diatomic molecules like HF, CO, NO, and to simple delocalized π-electron systems.

Equilibrium: Laws of thermodynamics. Standard states. Thermochemistry. Thermodynamic functions and their relationships: Gibbs-Helmholtz and Maxwell relations, van't Hoff equation. Criteria of spontaneity and equilibrium. Absolute entropy. Partial molar quantities. Thermodynamics of mixing. Chemical potential. Fugacity, activity and activity coefficients. Chemical equilibria. Dependence of equilibrium constant on temperature and pressure. Non-ideal solutions. Phase rule. Clausius-Clapeyron equation. Phase diagram of one component systems: CO2, H2O.

Kinetics: Introduction of rate law, Order and molecularity; Extent of reaction; rate constants; Rates of First, second and nth order reactions; Pseudo first order reactions; Determination of order of a reaction by half-life and differential method; Opposing reactions, consecutive reactions and parallel reactions. Temperature dependence of rate constant; Arrhenius equation, energy of activation; Kinetics of photochemical and photophysical processes.

Surfaces and Interfaces: Physisorption and chemisorption. Langmuir, Freundlich and BET isotherms. Surface catalysis: Langmuir-Hinshelwood mechanism. Surface tension, viscosity. Self-assembly. Physical chemistry of colloids, micelles and macromolecules.

Electrochemistry: Ionic mobility and conductivity. Standard electrode potentials and electrochemical cells. Nernst Equation, Double Layers, Zeta and Over Potentials, Conductivity and Conductance. Potentiometric and conductometric titrations.

Section 2: Inorganic Chemistry

Main Group Elements: Hydrides, halides, oxides, oxoacids, nitrides, sulfides – shapes and reactivity. Structure and bonding of boranes, carboranes, silicones, silicates, boron nitride, borazines and phosphazenes. Allotropes of carbon. Chemistry of noble gases, pseudohalogens, and interhalogen compounds. Acid-base concepts.

Transition Elements: Coordination chemistry – structure and isomerism, theories of bonding (VBT, CFT, and MOT). Energy level diagrams in various crystal fields, CFSE, applications of CFT, Jahn-Teller distortion. Electronic spectra of transition metal complexes: spectroscopic term symbols, selection rules, Orgel diagrams, charge- transfer spectra. Magnetic properties of transition metal complexes. Reaction mechanisms: kinetic and thermodynamic stability, substitution and redox reactions.

Lanthanides and Actinides: Recovery. Periodic properties, spectra and magnetic properties.

Organometallics: 18-Electron rule; metal-alkyl, metal-carbonyl, metal-olefin and metal-carbene complexes and metallocenes. Fluxionality in organometallic complexes. Types of organometallic reactions. Homogeneous catalysis - Hydrogenation, hydroformylation, acetic acid synthesis, metathesis and olefin oxidation. Heterogeneous catalysis - Fischer-Tropsch reaction, Ziegler-Natta polymerization.

Radioactivity: Decay processes, half-life of radioactive elements, fission and fusion processes.

Bioinorganic Chemistry: Ion (Na^+ and K^+) transport, oxygen binding, transport and utilization, electron transfer reactions, nitrogen fixation, general introduction to. metalloenzymes..

Solids: Crystal systems and lattices, Miller planes, crystal packing, crystal defects, Bragg's law, ionic crystals, structures of AX, AX_2, ABX_3 type compounds, spinels, band theory, metals and semiconductors.

Section 3: Organic Chemistry

Aromatic compounds: Structure of benzene, spectroscopic properties; criteria for aromaticity-Huckel's rule; other aromatic compounds, heterocyclic aromatic compounds; anti aromatic and non-aromatic compounds.

Stereochemistry: Chirality of organic molecules with or without chiral centres and determination of their absolute configurations. Relative stereochemistry in compounds having more than one stereogenic centre. Homotopic, enantiotopic and diastereotopic atoms, groups and faces. Conformational analysis of acyclic and cyclic compounds. Geometrical isomerism.

Reaction Mechanisms: Basic mechanistic concepts – kinetic *versus* thermodynamic control, Hammond's postulate and Curtin-Hammett principle. Methods of determining reaction mechanisms through identification of products, intermediates and isotopic labelling. Nucleophilic and electrophilic substitution reactions (both aromatic and aliphatic). Addition reactions to carbon-carbon and carbon-heteroatom (N, O) multiple bonds. Elimination reactions.

Oxidation and Reduction: Reducing agents; reduction of alkenes, alkynes, and carbon-heteroatom multiple bonds; Oxidizing agents, epoxidation, dihydroxylation, oxidative cleavage of alkenes and alkynes, oxidation of alcohols.

Organic Synthesis: Synthesis, reactions, mechanisms and selectivity involving the following classes of compounds – alkenes, alkynes, arenes, alcohols, phenols, aldehydes, ketones, carboxylic acids, esters, nitriles, halides, nitro compounds, amines and amides. Carbon-carbon bond formation through coupling reactions - Heck, Suzuki, Stille and Sonogoshira. Condensation and conjugate addition reactions of carbonyl compounds.

Pericyclic Reactions and Photochemistry: Electrocyclic, cycloaddition and sigmatropic reactions.

Heterocyclic Compounds: Structure, preparation, properties and reactions of furan, pyrrole, thiophene, pyridine, indole, quinoline and isoquinoline.

Biomolecules: Structure, properties and reactions of mono- and di-saccharides, physicochemical properties of amino acids, chemical synthesis of peptides, structural features of proteins, nucleic acids, steroids, terpenoids, carotenoids, and alkaloids.

Spectroscopy: Applications of UV-visible, IR, NMR and Mass spectrometry in the structural determination of organic molecules.

Section 4: Laboratory Experiments

Quantitative Analysis: Volumetric (acid-base, redox and complexometric titrations), Colorimetric (e.g., estimating Cu content in brass) and Gravimetric (e.g., estimation of Ni).

Kinetics Study: Examining the order of chemical reactions (such as acid/base catalysed ester hydrolysis).

Viscometry Study: Determine the intrinsic viscosity and the molecular weight of a polymer.

Qualitative Analysis: Determine different radicals (both cations and anions) present in unknown salt.

Functional Group Analysis: Identify different functional groups present in organic compounds using chemical methods and spectroscopic techniques.

Synthesis and Characterization: Synthetic procedures for some commonly used compounds: Urea, Paracetamol, Aspirin and their derivatives and their characterization.

Extraction and Identification: DNA from green peas, caffeine from tea leaves, glucosamine from crab shell.

Selection Criteria
1) Level-I: Objective based Test
2) Level-II: Descriptive Test
3) Level- III: Skill/Trade Test (Qualifying Nature: minimum 50% score is required to qualify)

Note: All the above test will be based on the above mentioned syllabus. Equal weightage will be given to the Level-I and Level-II for the purpose of merit list.

*****