

Syllabus for the post of Assistant Professor- Chemistry, Government Engineering College, Maharashtra Engineering College Teachers Service, Group - A

Steps of Exam: Written Exam - 200 Marks

Interview - 50 Marks

Level: - Degree

No. of Questions: - 100

Medium: English

No. of Marks: - 200

Nature of Paper - Objective Type

Duration: - 1 hour

Final merit list will be prepared by considering the marks obtained in Written test & Interview.

SYLLABUS

- 1 Quantum Chemistry, Planck's quantum theory, wave-particle duality, Uncertainty Principle, operators and commutation relations, postulates of quantum mechanics and Schrodinger equation, free particle, particle in a box, degeneracy, harmonic oscillator, rigid rotator and the hydrogen atom. Angular momentum including spin coupling of angular momenta including spin-orbit coupling.
- 2 **The variation method and perturbation theory** : Application to the helium, atom, antisymmetry and Exclusion Principle, Slater determinantal wave functions. Term symbols and spectroscopic states.
- 3 **Born-Oppenheimer approximation, Hydrogen molecule ion** : LCAO-MO and VB treatments of the hydrogen molecule, electron density, forces and their role in chemical binding. Hybridisation and valence MO, of H_2O , NH_3 and CH_4 . Huckel pi-electron theory and its applications to ethylene, butadiene and benzene, idea of self-consistent fields.
- 4 **Group theoretical representations and quantum mechanics** : Vanishing of integrals, spectroscopic selection rules for vibrational, electronic, vibronic and Raman spectroscopy. MO treatment of large molecules with symmetry.
- 5 **Spectroscopy** : Theoretical treatment of rotational, vibrational and electronic spectroscopy. Principles of magnetic resonance, Mossbauer and Photoelectron spectroscopy.
- 6 **Thermodynamics** : First law of thermodynamics, relation between C_p and C_v ; enthalpies of physical and chemical changes, temperature dependence of enthalpies. Second law of thermodynamics, entropy, Gibbs-Helmholtz equation. Third law of thermodynamics and calculation of entropy.
- 7 **Chemical Equilibrium** : Free energy and entropy of mixing, partial molar quantities, Gibbs-Duhem equation. Equilibrium constant, temperature dependence of equilibrium constant, phase diagram of one and two-component systems, phase rule.

- 8 **Ideal and Non-ideal Solutions** : Excess functions, activities, concept of hydration number, activities in electrolytic solutions, mean ionic activity coefficient. Debye-Huckel treatment of dilute electrolyte solutions.
- 9 **Equilibria in Electrochemical Cells** : Cell reactions, Nernst equation, application of cell EMF measurements.
- 10 **Surface Phenomena** : Surface tension, adsorption on solids, electrical phenomena at interfaces including electrokinetic micelles and reverse micelles; solutions. Applications of photoelectron spectroscopy, ESCA and Auger spectroscopy to the study of surfaces.
- 11 **Statistical Thermodynamic probability and entropy** : Maxwell-Boltzmann distribution of velocities, average, most probable and root-mean-square velocities. Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac statistics. Partition function, rotational, translational, vibrational and electronic partition functions for diatomic molecules, calculations of thermodynamic functions and equilibrium constants. Theories of specific heat for solids.
- 12 **Non-equilibrium Thermodynamics** : Postulates and methodologies, linear laws, Gibbs equation, Onsager reciprocal theory.
- 13 **Reaction Kinetics** : Methods of determining rate laws, Mechanisms of photo-chemical, chain and oscillatory reactions. Collision theory of reaction rates, steric factor, treatment of unimolecular reactions. Theory of absolute reaction rates, comparison of result with Eyring and Arrhenius equations, ionic reactions, salt effect. Homogeneous catalysis and Michaelis-Menten Kinetics; heterogeneous catalysis.
- 14 **Fast Reactions** : Study of kinetics by stop-flow technique, relaxation method, flash photolysis and magnetic resonance method.
- 15 **Macromolecules** : Number-average and weight-average molecular weights. Determination of molecular weights. Kinetics of polymerisation. Stereochemistry and mechanism of polymerisation.
- 16 **Solids** : Dislocations in solids, Schottky and Frenkel defects. Electrical properties. Insulators and semiconductors, band theory of solids, solid-state reactions.
- 17 **Nuclear Chemistry** : Radioactive decay and equilibrium. Nuclear reactions, Q value, cross-sections, types of reactions. Chemical effects of nuclear transformations, fission and fusion, fission products and fission yields. Radioactive techniques, tracer techniques, neutron activation analysis, counting techniques such as G.M., ionization and proportional counters.
- 18 **Chemistry of Non-transition Elements** : General discussion on the properties of the non-transition elements, special features of individual elements, synthesis, properties and structure of their halides and oxides, polymorphism of carbon, phosphorus and sulphur. Synthesis, properties and structure of boranes, carboranes, borazines, silicates, carbides, silicones, phosphazenes, sulphur, oxyacids of nitrogen, phosphorus, sulphur and halogens. Interhalogens, pseudohalides and noble gas compounds.

- 19 **Chemistry of Transition Elements** : Coordination chemistry of transition metal ions. Stability constants of complexes and their determination, stabilization of unusual oxidation states. Stereochemistry of coordination compounds. Ligand field theory, splitting of d-orbitals in low symmetry environments. Jahn-Teller effect, interpretation of electronic spectra including charge transfer spectra, spectrochemical series, nephelauxetic series. Dia-para-ferro and antiferromagnetism, quenching of orbital angular moments, spin orbit coupling. Inorganic reaction mechanisms, substitution reactions, trans-effect and electron transfer reactions, photochemical reactions of chromium and ruthenium complexes. Fluxional molecules. Iso and heteropolyacids, metal clusters. Spin crossover in coordination compounds.
- 20 **Chemistry of Lanthanides and Actinides** : Spectral and magnetic properties, use of lanthanide compounds as shift reagents.
- 21 **Organometallic Chemistry of Transition Elements** : Synthesis, structure and bonding, organometallic reagents in organic synthesis and in homogeneous catalytic reactions (hydrogenation, hydroformylation, isomerisation and polymerisation), pi-metal complexes, activation of small molecules by coordination.
- 22 **Topics in Analytical Chemistry** : Adsorption, partition, exclusion, electrochromatography. Solvent extraction and ion exchange methods. Application of atomic and molecular absorption and emission spectroscopy in quantitative analysis. Light scattering techniques including nephelometry and Raman spectroscopy. Electroanalytical techniques, voltammetry, cyclic voltammetry, polarography, amperometry, coulometry and conductometry. Ion-selective electrodes. Anodic stripping voltammetry, TGA, DTA, DSC and on-line analysers.
- 23 **Bioinorganic Chemistry** : Molecular mechanism of ion transport across membranes, ionophores. Photosynthesis-PS-I, PS-II, nitrogen fixation, oxygen uptake proteins, cytochromes and ferredoxins.
- 24 **Aromaticity** : Huckel's rule and concept of aromaticity : annulenes and heteroannulenes, fullerenes. (C_{60})
- 25 **Stereochemistry and Conformational Analysis** : Newer methods of asymmetric synthesis (including enzymatic and catalytic), enantio- and diastereoselective synthesis. Effects of conformation on reactivity in acyclic compounds and cyclohexanes.
- 26 **Selective Organic Name Reactions** : Favorskii reaction, Stork enamine reaction, Michael addition, Mannich reaction, Sharpless asymmetric epoxidation, ene reaction, Barton reaction, Hofmann-Löffler-Freytag reaction, Shapiro reaction, Baeyer-Villiger reaction, Chichibabin reaction.
- 27 **Mechanisms of Organic Reactions** : Labelling and kinetic isotope effects, Hammett equation, σ - ρ (sigma-rho) relationship, non-classical carbonium ions, neighbouring group participation.
- 28 **Pericyclic Reactions** : Selection rules and stereochemistry of electrocyclic reactions,

cycloaddition and sigmatropic shifts, Sommelet-Hauser, Cope and Claisen rearrangements.

- 29 **Heterocycles** : Synthesis and reactivity of furan, thiophene, pyrrole, pyridine, quinoline, isoquinoline and indole. Skraup synthesis, Fischer indole synthesis.
- 30 **Reagents in Organic Synthesis** : Use of following reagents in organic synthesis and functional group transformations-Complex metal hydride. Gilman's reagent, lithium, dimethylcuprate, lithium, diisopropylamide (LDA) dicyclohexylcarbodiimide, 1, 3-dithiane (reactivity umpolung). Trimethylsilyl iodide, tri-n-butyltin hydride, Woodward and Prevost hydroxylation, osmium tetroxide, DDQ, selenium dioxide, phase transfer catalysts, crown ethers and Merrifield resin. Peterson's synthesis, Wilkinson's catalyst, Baker's yeast.
- 31 **Chemistry of Natural Products** : Familiarity with methods of structure elucidation and biosynthesis of alkaloids, terpenoids, steroids, carbohydrates and proteins, Conformations of proteins and nucleic acids.
- 32 **Bioorganic Chemistry** : Elementary structure and function of biopolymers such as proteins and nucleic acids, Genetic code, Mechanism of enzyme action.
- 33 **Photochemistry** : Principles of energy transfer, cis-trans isomerization, Paterno-Buchi reaction, Norrish Type I and II reactions, photoreduction of ketones, di-pi-methane rearrangement, photochemistry of arenes.
- 34 **Spectroscopy** : Combined applications of mass, UV-VIS, IR and NMR spectroscopy for structural elucidation of compounds.
