

REVISED SYLLABUS FOR OBJECTIVE TYPE SUBJECT APTITUDE TEST (SAT) FOR RECRUITMENT TO POST OF LECTURER (SCHOOL NEW) IN CHEMISTRY, CLASS-III IN THE DEPARTMENT OF HIGHER EDUCATION. THIS PAPER WILL BE OF 02 HOURS DURATION OF 100 MARKS. THE OBJECTIVE TYPE SUBJECT APTITUDE TEST (SAT) SHALL COVER FOLLOWING TOPICS:-

Part-A (Common syllabus for Chemistry and Biochemistry) (60 Marks)

Inorganic Chemistry

Group theory: The concept of group, Symmetry elements and symmetry operations, Assignment of point groups to Inorganic molecules, some general rules for multiplications of symmetry operations, Multiplication tables for water and ammonia, Representations (matrices, matrix representations for C_{2V} and C_{3V} point groups irreducible representations), Character and character tables for C_{2V} and C_{3V} point groups. Applications of group theory to chemical bonding (hybrid orbitals for σ -bonding in different geometries and hybrid orbitals for π -bonding. Symmetries of molecular orbitals in BF_3 , C_2H_4 and B_2H_6 .

Non-Aqueous Solvents: Factors justifying the need of Non-Aqueous solution Chemistry and failure of water as a Solvent. Solution chemistry of Sulphuric acid: Physical properties, Ionic self-dehydration in H_2SO_4 , high electrical conductance in spite of high viscosity, Chemistry of H_2SO_4 as an acid, as a dehydrating agent, as an oxidizing agent, as a medium to carry out acid-base neutralization reaction and as a differentiating solvent. Liquid BrF_3 : Physical properties, solubilities in BrF_3 , self-ionization, acid base neutralization reactions, solvolytic reactions and formation of transition metal fluorides.

Inorganic Hydrides: Classification, preparation, bonding and their applications. Transition metal compounds with bonds to hydrogen, carbonyl hydrides and hydride anions. Classification, nomenclature, Wade's Rules, preparation, structure and bonding in boron hydrides (boranes) and carboranes,

Organic Reagents in Inorganic Chemistry: Chelation, factors determining the stability of chelates (effect of ring size, oxidation state of the metal, coordination number of the metal); Use of the following reagents in analysis:

Dimethylglyoxime (in analytical chemistry)

EDTA (in analytical chemistry and chemotherapy)

8-Hydroxyquinoline (in analytical chemistry and chemotherapy)

1, 10-Phenanthroline (in analytical chemistry and chemotherapy)

Thiosemicarbazones (in analytical chemistry and chemotherapy)

Dithiazone (in analytical chemistry and chemotherapy)

Metal-Ligand Bonding-I: Recapitulation of Crystal Field Theory including splitting of d -orbitals in different environments, Factors affecting the magnitude of crystal field splitting, structural effects (ionic radii, Jahn-Teller effect), Thermodynamic effects of crystal field theory (ligation, hydration and lattice energy), Limitations of crystal field theory, Adjusted Crystal Field Theory (ACFT), Evidences for Metal-Ligand overlap in complexes, *Molecular Orbital Theory* for octahedral, tetrahedral and square planar complexes (excluding mathematical treatment)

Atomic Spectroscopy: Energy levels in an atom, coupling of orbital angular momenta, coupling of spin angular momenta, spin orbit coupling, spin orbit coupling p^2 case,

Determining the Ground State Terms-Hund's Rule, Hole formulation(derivation of the Term Symbol for a closed sub-shell, derivation of the terms for a d^2 configuration), Calculation of the number of the microstates.

Electronic Spectra-I: Splitting of spectroscopic terms (S, P, D, F and G, H, I), $d^{11}-d^9$ systems in weak fields (excluding mathematics), strong field configurations, transitions from weak to strong crystal fields.

Electronic Spectra-II: Correlation diagrams ($d^{11}-d^9$) in Oh and Td environments, spin-cross over in coordination compounds. Tanabe Sugano diagrams, Orgel diagrams, evaluation of B, C and β parameters.

Magneto chemistry: Origin of Magnetic moment, Magnetic susceptibility (diamagnetic, paramagnetic), spin only moment, Russell Saunder's coupling, quenching of orbital angular moment, orbital contribution to a magnetic moment, magnetic moments from magnetic susceptibilities, temperature dependence of magnetic susceptibility, Factors determining paramagnetism, application of magnetochemistry in co-ordination chemistry in spin free and spin paired octahedral and tetrahedral complexes, Van Vlecks formula for magnetic susceptibility.

Organic Chemistry Stereochemistry: Introduction to Basic Concepts of Stereochemistry: Isomers and their properties, Threo and Erythro isomers, Chirality, Optical isomerism, Geometrical isomerism, Conventions for configurations- D, L and R, S systems, Racemic mixture and Racimization, Resolution of Racemic mixtures, Measurement of optical activity, optical purity, Streoselective and Streospecific reactions, epimerization, epimers, anomers and mutarotation, Axial Chirality (Allenes and Biphenyls), Planar chirality, Helicity, Chirality involving atoms other than carbon atoms, Prochirality: prostreoisomerism and Asymmetric synthesis.

Conformational and stereoisomerism of acyclic and cyclic systems, cyclohexane, decalins, effect of conformation on reactivity in acyclic and cyclohexane systems.

Reaction Mechanism: Structure and Reactivity: Thermodynamic and kinetic requirements, Kinetic and Thermo dynamic control, Hammonds postulate, Curtin-Hammett principle. Potential energy diagrams, transition states and intermediates.

Effect of structure on reactivity: resonance and field effects, steric effect. Quantitative treatment: Hammett equation and linear free energy relationship, Substituent and reaction constants, Taft equation. Methods of determining Reaction mechanisms,

Aliphatic Nucleophilic Substitution: Reactivity effect of substrate structure, leaving group and nucleophile. The SN_2 , SN_1 , mixed SN_1 and SN_2 , SET mechanisms & SN_i mechanism. The neighboring group mechanism, neighboring group participation by π and σ bonds, anchimeric assistance. Non-classical carbocations, phenonium ions, norbornyl system, common carbocation rearrangements-Wagner-Meerwein, Pinacol-Pinacolone and Demjanov ring expansion and ring contraction. Nucleophilic substitution at an allylic, aliphatic trigonal and a vinylic carbon. Esterification of carboxylic acid, transesterification, Phase-transfer catalysis, and ultrasound, ambident nucleophile, regioselectivity.

Free radical reactions: Geometry of free radicals, Types of free radical reactions, free radical substitution mechanism, mechanism at an aromatic substrate neighboring group assistance, Reactivity in aliphatic and aromatic substrates at a bridge head and attacking radicals. Effect of solvents on reactivity. Allylic halogenation (NBS), oxidation of aldehydes to carboxylic acids, auto oxidation, coupling of alkynes and arylation of aromatic compounds by diazonium salts (Gomberg Bachmann reaction), Hoffmann-Loffler-Freytag reaction, Hunsdiecker reaction.

Aromatic Electrophilic Substitution: Arenium ion mechanism, orientation and reactivity, The ortho/ para ratio, ipso attack, orientation in other ring systems. Quantitative treatment of

reactivity in substrates and electrophiles, Diazonium coupling, Vilsmeier-Haack reaction, Scholl reaction, Amination reaction, Fries rearrangement, Hofmann-Martius Reaction, Reversal of Friedel-Craft alkylation.

Aromatic Nucleophilic Substitution: S_NAr, S_N1, benzyne and S_{RN}1 mechanism. Reactivity, effect of substrate structure, leaving group and attacking nucleophile, Von Richter, Sommelet-Hauser, and Smiles rearrangements, Ullman reaction, Ziegler alkylation, Schiemann reaction.

Common Organic Reactions and Their Mechanisms: Perkin condensation, Michael reaction, Robinson annulation, Dieckmann reaction, Stobbe condensation, Mannich reaction, Knoevenagel condensation, Benzoin condensation, Wittig reaction, Hydroboration, Hydrocarboxylation, Ester hydrolysis, Epoxidation.

Reagents in Organic Synthesis: Synthesis and applications of BF₃, NBS, Diazomethane, Lead tetra-acetate, Osmiumtetroxide, Woodward Prevost hydroxylation reagent, LiAlH₄, Grignard reagent, organozinc and organolithium reagent.

Elimination Reactions: Discussion of E₁, E₂, E_{1c}B and E_{2c} Mechanisms and orientation, Reactivity: Effects of substrate structures, attacking base, leaving group and medium. Mechanism and Orientation in Pyrolytic eliminations, Cis elimination, elimination in cyclic systems, eclipsing effects, cleavage of quaternary ammonium hydroxides, Shapiro reaction, Conversion of Ketoxime to nitriles.

Pericyclic Reactions: Molecular orbital symmetry, Frontier orbitals of ethylene, 1,3-butadiene, 1,3,5 hexatrienes and allyl system. Classification of pericyclic reactions, Woodward-Hoffmann correlation diagrams. FMO and PMO approach. Electrocyclic reactions: conrotatory and disrotatory motions, 4n and 4n+2 and allyl systems. Cycloadditions- antarafacial and suprafacial additions, 4n and 4n+2 systems, 2+2 addition of ketenes, 1,3 dipolar cycloadditions and chelotropic reactions. Sigmatropic rearrangements- Suprafacial and Antarafacial shifts of H, sigmatropic shifts involving carbon moieties, Claisen, Cope and aza-Cope rearrangements, Ene reaction.

Physical Chemistry:

Resonance Spectroscopy: Principle and Theory of nuclear magnetic resonance (NMR). Chemical shift and spin-spin coupling. Factors influencing chemical shift and spin-spin coupling of ¹H-NMR. Spin-spin and spin-lattice relaxation processes. Line-width and rate processes. First and second order ¹H-NMR spectra. Principle and theory of Electron Spin Resonance (ESR). Hyper fine structure of ESR. Zero-field splitting of ESR signal., McConnell relation. Introduction to Mossbauer spectroscopy (isomer-shift, quadrupole interaction and magnetic hyperfine interaction).

Molecular Spectroscopy: Rotational spectra of non-rigid diatomic molecules and symmetric-top molecules. Anharmonic oscillator, overtones and hot bands. Diatomic vibrator-rotator (P, Q and R-branches). Rotational-vibrational spectra of symmetric-top molecules. Raman Spectroscopy. Rotational and vibrational Raman spectra of linear and symmetric top molecules, overtones and mutual exclusion principle.

Kinetics of complex reactions: Consecutive and competitive (parallel) first order reactions. Kinetic vs. thermo dynamic control reaction. Free radical reactions; thermal (H₂ - Br₂) and photochemical H₂ - Cl₂) reactions. Rice-Herzfeld mechanism of dissociation of organic molecules viz. dissociation of ethane, decomposition of acetaldehyde as 3/2 or 1/2 order reactions. Reaction rates and chemical equilibrium, principle of microscopic reversibility, activation energy and activated complex.

Transition state theory and its kinetic and thermodynamic formulation. Introduction to Potential energy surfaces. Kinetics in solutions: diffusion controlled reactions, their rates and influence of the solvent. Collisions and transition state theories in simple gas reactions, Lindman and Hinshel wood treatment.

Chemical Thermodynamics-I: Brief resume of laws of thermodynamics, Free energy functions, Gibb's and Helmholtz free energy functions and their significance, Gibbs-Helmholtz equation, thermodynamic equilibria and free energy functions, applications of Gibbs-Helmholtz equation, Clapeyron-Clausius equation, Thermodynamics of Elevation in boiling point, depression in freezing point, relation between osmotic pressure and elevation of boiling point, relation between osmotic pressure and depression in freezing point.

Chemical Thermodynamics-II: Chemical affinity, applications of chemical affinity, methods for determining the chemical affinity, partial molar properties, Physical significance of partial molar properties, chemical potential, Gibbs -Duhem equation, variation of chemical potential with temperature and pressure, chemical potential of a pure solid or liquid, chemical potential of a pure ideal gas and mixture of ideal gases, thermodynamic functions of mixing, fugacity, fugacity coefficient, determination of fugacity, variation of fugacity with temperature and pressure, Lewis Randall rule, Duhem-Margules equation, activity, activity coefficient, determination of activity and variation with temperature and pressure.

Non-Equilibrium Thermodynamics: Basic principles of non -equilibrium thermodynamics: Rate laws, second law of thermodynamics for open system, law of conservation of mass, charge and energy flow, electrokinetic phenomena and expressions for streaming potential, electro-osmotic pressure difference, streaming potential using the linear phenomenological equation.

Part-B (Chemistry) (subject specific) (20 Marks)

Metal π Complexes: Preparation, reactions, structures and bonding in carbonyl, nitrosyl and phosphine complexes, structural evidences from vibrational spectra. Structure and bonding in metal cyanides, stabilization of unusual oxidation states of transition metals.

Introductory Analytical Chemistry: Data Analysis-Types and sources of errors, propagation of errors, detection and minimization of various types of errors. Accuracy and precision, average and standard deviation, variance, its analysis and confidence interval, tests of significance (F-test, t-test and paired t-test), criteria for the rejection of analytical data (4d rule, 2.5drule, Q-test, average deviation and standard deviation), least-square analysis.

Photoelectron Spectroscopy: Basic principle, photoionization process, ionization energies, Koopman's theorem, ESCA, photoelectron spectra of simple molecules, (N_2 , O_2) Photoelectron spectra for the isoelectronic sequence Ne, HF, H_2O , NH_3 and CH_4 , chemical information from ESCA, Auger electron spectroscopy-basic idea.

Lanthanides and Actinides:-

Spectral and magnetic properties, comparison of Inner transition and transition metals, Transuranium elements (formation and colour of ions in aqueous solution), uses of lanthanide compounds as shift reagents, periodicity of translawrencium elements.

Ultra Violet and Visible Spectroscopy: Electronic transitions (185-800 nm), Beer- Lambert Law, Effect of solvent on electronic transitions, Ultra Violet bands of carbonyl compounds, unsaturated carbonyl compounds, dienes, conjugated polyenes, Steric effect in biphenyls, Fieser- Woodward rules for conjugated dienes and carbonyl compounds, ultra violet spectra of aromatic and heterocyclic compounds. Applications of UV-visible spectroscopy in organic chemistry.

Infrared Spectroscopy: Principle, Instrumentation and sample handling, Characteristic vibrational frequencies of common organic compounds, Effect of hydrogen bonding and

solvent effect on vibrational frequencies, overtones, combination bands and Fermi resonance. Introduction to Raman spectroscopy. Applications of IR and Raman spectroscopy in organic chemistry.

Nuclear Magnetic Resonance (NMR) Spectroscopy: General introduction, chemical shift, spin-spin interaction, shielding mechanism, chemical shift values and correlation of protons present in different groups in organic compounds. Chemical exchange, effect of deuteration, complex spin-spin interaction between two, three, four and five nuclei, virtual coupling. Stereo chemistry, hindered rotation, Karplus- relationship of coupling constant with dihedral angle. First and second order spectra, Simplification of complex spectra-nuclear magnetic double resonance, spin tickling, INDOR, contact shift reagents, solvent effects. Fourier transform technique, nuclear Overhauser effect (NOE). Introduction to resonance of other nuclei—¹³CNMR, 2-D and 3-D NMR, Applications of NMR in organic chemistry.

Mass Spectrometry: Introduction, ion production—EI, CI, FD and FAB, factors affecting fragmentation, ion analysis, and ion abundance. Mass spectral fragmentation of organic compounds with common functional groups, Molecular ion peak, Meta-stable peak, McLafferty rearrangement. Nitrogen Rule. Examples of mass spectral fragmentation of organic compounds with respect to their structure determination. Introduction to negative ion Mass spectrometry, TOF-MALDI. Problems based upon IR, UV, NMR and mass spectroscopy.

Statistical thermodynamics Basic Terminology: probability, phase space, micro and macro states, thermo dynamic probability, statistical weight, assembly, ensemble, The most probable distribution: Maxwell-Boltzmann distribution, quantum statistics: The Bose-Einstein statistics and Fermi- Dirac Statistics. Thermodynamic probability (W) for the three types of statistics. Lagrange's undetermined multipliers. Stirling's approximation, Molecular partition function and its importance.

Applications to ideal gases: The molecular partition function and its factorization. Evaluation of translational, rotational and vibrational partition functions, the electronic and nuclear partition functions. For monatomic, diatomic and polyatomic gases.

Thermodynamic properties of molecules from partition function: Total energy, entropy, Helmholtz free energy, pressure, heat content, heat capacity and Gibb's free energy, equilibrium constant and partition function, Heat capacity of crystals and statistical thermodynamics, Third law of thermodynamics and entropy. Ortho- and para-hydrogen, statistical weights of ortho and para states, symmetry number. Calculation of equilibrium constants of gaseous solutions in terms of partition function, Einstein theory and Debye theory of heat capacities of monatomic solids.

Basic Quantum Chemistry: Operators in quantum mechanics. Introduction to angular momentum. Eigenvalues and eigenfunctions. Hermitian operator. Postulates of quantum mechanics. Time dependent and time independent Schrodinger wave equations. Some analytically soluble problems (complete solutions) of particle in a one and three dimensional box, harmonic-oscillator, the rigid rotor, the hydrogen atom and the quantum mechanical tunnelling.

OR

Part-C (Biochemistry) (subject specific)

(20 Marks)

APPLICATION OF BIOCHEMISTRY TO BIOTECHNOLOGY:

Micro methods in Protein Chemistry: Isolation of peptides for Sequence analysis. Peptide mapping, chemical and enzymatic hydrolysis of proteins. Extraction and fractionation of RNA and DNA, Isolation of plasmids, plasmid derived vectors, phages and yeast vectors, Enzymes involved in recombinant DNA technology, Genomic and cDNA library. Ti plasmid as tool for genetic engineering in plants, Bacterial transformation screening of transformants.

N-labelling Random labeling of nucleic acid probes, Nick translation, Hybridization and blotting techniques. dotblot. Northern and Southern blot, South-Western blot analysis, biotin-avidin system applications in detection of bio-molecules. Techniques to study DNA protein interactions, Transgenic animals and plants, knockout animals.

Chemical Synthesis of oligonucleotides: Polymerase Chain Reaction (PCR), Basic principle, method, Variations of PCR, Amplification of specific DNA fragments: Applications in medicine and forensic sciences. Techniques to detect polymorphism: RAPD, RFLP, AFLP etc. DNA based diagnosis of genetic disorders, Recombinant DNA technology in medicine and industry. *In situ* Hybridization, gene therapy.

Monoclonal Antibodies and Vaccines: Definition and nature of monoclonal antibodies (MCA); Antigen preparation for MCA production; Methodology producing MCA; Immunization and generation of immune response, Myeloma cells for hybridization; cell fusion and selection of hybrids using HAT medium. Cloning and isolation of hybrid cell lines. In vitro and in vivo culture of hybrid cell lines, Screening of specific MCA; Purification and labeling of MCA, uses and applications of MCA. T-cell hybridomas and their applications. Vaccines (subunit, live recombinant, attenuated and DNA Vaccines).

CLINICAL BIOCHEMISTRY

Diagnostic Enzymes: Enzyme assay in serum/plasma, urine and cells. Clinically important enzymes, use of isoenzymes in diagnosis. Organ function tests: Assessment and clinical manifestation of hepatic, renal, gastrointestinal and pancreatic functions.

Disorders of Metabolism: Carbohydrates-Diabetes mellitus, Glycogen Storage diseases, galactosemia, pentosuria. Amino Acids- Disorders of glycine, sulfur containing amino acids, aromatic amino acids, histidine, branched chain amino acids and proline, disorders of propionate and methylmalonate metabolism. Disorders in urea biosynthesis.

Lipids: Hyperlipoproteinemia, Abetalipoproteinemia, Hyperlipidemia, Tay-Sachs Disease (Gangliosidosis), Neimann Pick Disease, Gaucher's Disease, Krab's Disease, Metachromatic leukodystrophy and Fabry's Disease, Wolman's Disease, Disorders of porphyrin and heme metabolism, Disorders in purine and pyrimidinemetabolism.

BIOCHEMICAL TOXICOLOGY

Definition, scope and relationship of Toxicology to other sciences. Nature of toxic effects. Acute and chronic exposure. Dose: response relationship, Determination of LD-50, no observed effect level (NOEL), acceptable daily intake, bioavailability, volume of distribution, plasma half life, total body burden, total body clearance. Synergism and Antagonism Metabolism of Toxicant- Introduction, absorption and distribution. Cytochrome P-450, MFO system and their role in xenobiotic metabolism. Non-microsomal oxidation. Phase-I and Phase-II reactions, conjugations, Glucuronide conjugates, Conjugations catalysed by sulfo

transfereases, methyl transferases and acetyl transferases. Glutathione conjugation and Amino acid conjugations.

Toxicity Testing and Target organ toxicity, Ames test, Host mediated assay and dominant lethal test, Drosophillia sex linked recessive lethal test, micronucleus test. Toxicology of Medical devices, Haemotoxicology, Hepatotoxicity.

MOLECULAR CELL BIOLOGY

Cell Cycle: Cell cycle control system, cell cycle events in *S. pombe*, *S. cerevisiae*, and mammalian system, M phase kinase, protein phosphorylation and dephosphorylation, p34 as key regulator in yeast, CDC 28, function of CDK-cyclin complex. CDK inhibitors, reorganization of the cell at mitosis.

Apoptosis and cell proliferation: Extrinsic and intrinsic pathways of apoptosis, techniques to analyze apoptosis, molecular basis of cancer, multistep carcinogenesis, signal transduction and cancer, tumor suppressor genes and proto-oncogenes and oncogenes, tumor causing viruses, DNA viral genes, Retroviral-associated oncogenes in growth regulation, strategies for cancer prevention and cure.

Signaling molecule and cell surface receptors: Intracellular signal transduction, second messengers, protein functioning as signal transducers, localization of receptors and signal transducers, G-protein coupled receptors and downstream signaling, TGF receptors and activation of SMADS, cytokine receptors and JAK-STAT signaling, receptor tyrosine kinases and activation of Ras, Raf, MAP kinase signaling, phosphoinositide as signal transducer, pathways that involve signal induced protein cleavage (NF-KB and NOTCH), Hedge hog and wnt signaling pathways (classical and non classical) down regulation of receptor signaling.

Part-D (B.Ed. portion) (Common) (20 marks)

Foundation of Education System

- Concept and Nature of Knowledge, Knowledge Acquiring Process.
- Indian Knowledge System; Vedic Education System, Buddhist Education System
- Concept of Education; Meaning, Nature, Modes of Education, Objectives of Education, Approaches to Education.
- Philosophical, Psychological, Sociological and Technological Basis of Education (Meaning and Needs)
- Concept of important Variables: Personality, Intelligence, Creativity, Academic Achievement, Problem Solving Ability

Teacher Education and Related Aspects:-

- Concept of Teacher Education, Historical Aspects of Teacher Education in India, Scope of Teacher Education, Types and Levels of Teacher Education Programmes.
- Teacher and Teaching related Concepts, Learner and Learning Related Concepts, Relation between Teaching and Learning, Learning Environment, Pillars of Learning.
- Challenges in the field of Teacher Education (Discussion with reference to NEP 2020 also)

Pedagogy and Teaching Learning Experiences:-

- Communication Skills and its Use

- Models of Teaching; Advance organizer, Concept Attainment, Information Processing, Inquiry Training
- Methods of Teaching
- Preparation and Use of Teaching Learning Material

Information Technology in Teaching Learning Process

- ICT; Its meaning and use in Teaching Learning Process
- Concept of Open Educational Resources, SWAYAM and MOOCs
- Digital Initiatives in School Education by Government of India
