Himachal Pradesh
Public Service Commission

No.03-15/2024-PSC (R-II) **Dated:19-08-2025**

Syllabus of Paper-II i.e. Descriptive Type Subject Aptitude Test (SAT) for recruitment to the post of Assistant Director (Chemistry & Toxicology), Class-I (Gazetted) in the Directorate of Forensic Services, Home Department, Himachal Pradesh. The SAT paper shall be of 03 hours duration having 120 Marks. The SAT paper shall have two parts i.e. Part-I and Part-II and cover the following topics of:-

{Master of Science (Chemistry) level}

PART-I (60 MARKS)

1. 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 C2V and C3V point groups irreducible representations), Character and character tables for C2V and C3V 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 for 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 despite 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, Metal 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: Use of Dimethylglyoximein analytical chemistry, Use of EDTA, 8-Hydroxyquinoline, Thiosemicarbazones, Dithiazone and 1,10-Phenanthroline in analytical chemistry and chemotherapy.

Supramolecular Chemistry: Introduction, Some important concepts, Introduction to Recognition, information and complementarity, Principles of molecular receptor designs, Spherical recognition (cryptates of metal cations), Tetrahedral recognition by macrotricyclic cryptands, Recognition of ammonium ions, Recognition of neutral molecules and anionic substrates (anionic coordination).

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, 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 d2 configuration), Calculation of the number of the microstates.

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 trans-lawrencium elements.

Nuclear Chemistry: Nuclear binding energy and stability, nuclear models (nuclear shell model and collective model). Nuclear reactions: types of reactions, nuclear crosssections, Q-value. Natural and artificial radioactivity, radioactive decay and equilibrium, Nuclear fission, fission product and fission yields, nuclear fusion.

Radioactive techniques: Tracer technique, (neutron activation analysis), counting techniques such as G.M. Ionization and proportional counters.

2. 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 streoisomerism of acylic and cylic systems, cyclohexane, decalins, effect of conformation on reactivity in acylic and cyclohexane systems.

Reaction Mechanism: Structure and Reactivity: Thermodynamic and kinetic requirements, Kinetic and Thermodynamic control, Hammond's 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 SN2, SN1, mixed SN1 and SN2, SET mechanisms & SNi mechanism. The neighboring group mechanism, neighboring group participation by π and σ bonds, and

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,

Aliphatic Electrophilic substitution: Bimolecular mechanisms- SE2 and SEi. The SE1 mechanism, electrophilic substitution accompanied by double bond shifts, halogenation of aldehydes, ketones, acids, and acyl halides. Effect of substrates, leaving group, and the solvent system on reactivity. Aliphatic diazonium coupling, Acylation at aliphatic carbon, alkylation of alkanes, Stork-enamine reaction.

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 bridgehead 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, Vilsmeir-Haack reaction, Scholl reaction, Amination reaction, Fries rearrangement, Hofmann-Martius Reaction, Reversal of Friedel-Craft alkylation.

Aromatic Nucleophilic Substitution: SNAr, SN1, benzyne, and SRN1 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, Diekmann reaction, Stobbe condensation, Mannich reaction, Knoevenagel condensation, Benzoin condensation, Witting reaction, Hydroboration, Hydrocarboxylation, Ester hydrolysis, Epoxidation, Reagents in Organic Synthesis: Synthesis and applications of BF_3, NBS, Diazomethane, Lead tetra-acetate, Osmium tetraoxide, Woodward Prevorst hydroxylation reagent, $LiAlH_4$, Grignard reagent, organozinc and organolithium reagent.

Elimination Reactions: Discussion of E1, E2, E1cB, and E2C Mechanisms and orientation, Reactivity: Effects of substrate structures, attacking base, leaving group, and reaction 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 rearrangementsSuprafacial and Antarafacial shifts of H, sigmatropic shifts involving carbon moieties, Claisen, Cope and aza-Cope rearrangements, Ene reaction.

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. Stereochemistry, hindered rotation, Karplus relationship of coupling constant wrt 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 –^{13}C NMR, 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, metastable peak, and McLafferty rearrangement. Nitrogen Rule. Examples of mass spectral fragmentation of organic compounds for their structure determination. Introduction to negative ion Mass spectrometry, TOF-MALDI. Problems based on IR, UV, NMR, and mass spectroscopy.

Photochemistry I: Introduction and Basic principles of photochemistry. Interaction of electromagnetic radiations with matter, Types of excitations, fate of excited molecules, quantum yield, transfer of excitation energy, actinometry. Photochemistry of alkenes: cis-trans isomerization, dimerization of alkenes, photochemistry of conjugated olefins, photo-oxidation of alkenes and polyenes Photochemistry of Aromatic compounds: Isomerization, addition and substitution, photo-reduction of aromatic hydrocarbons, Photochemistry – II: Photochemistry of Carbonyl compounds: Norrish Type I and II, Intermolecular and Intramolecular hydrogen abstraction, Paterno-Buchi reaction, α and β- cleavage reactions of cyclic and acyclic carbonyl compounds, Formation of oxetane and cyclobutane from α,β unsaturated ketones, Photo-reduction of carbonyl compounds, Photo- rearrangement of enones, dienones, epoxyketones, Photo Fries rearrangement.

3. 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 ^{1}H-NMR. Spin-spin and spin–lattice relaxation processes. Line–width and rate processes. First and second order ^{1}H-NMR spectra. Principles and theory of Electron Spin Resonance (ESR). Hyperfine 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 the mutual exclusion principle.

Kinetics of complex reactions: Consecutive and competitive (parallel) first-order reactions. Kinetic vs. thermodynamic control reactions. Free radical reactions; thermal (H_2–Br_2) and photochemical H_2–Cl_2) reactions. Rice–Herzfeld mechanism of dissociation of organic molecules, viz., dissociation of ethane, decomposition of acetaldehyde as 3/2 or ½ 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 Hinshelwood treatment, Catalytic activity at surfaces: adsorption and catalysis, the Langmuir–Hinshelwood mechanism, the Eley–Rideal mechanism. Examples of catalysis: hydrogenation, oxidation and cracking, and reforming (qualitative treatment only). Introduction to fast reactions. Flash photolysis and stopped flow methods to study the kinetics of fast reactions,

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, Nernst heat theorem and third law of thermodynamics and its application. Thermodynamic derivation of the phase rule and its application to two-component systems. Distribution law, its thermodynamic derivation and application, 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, Colloidal State: Classification of colloids, charge and stability of colloidal dispersions, Hardy-Schulze Law, gold number, electrical properties of colloids, electrical double layer and its structure, Stern‘s theory of double layer, zeta-potential, electrophoresis and electroosmosis, emulsions and their classification, emulsifiers, gels and their classification.

Statistical Thermodynamics: Basic Terminology: probability, phase space, micro and macro states, thermodynamic 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.

PART-II (60 MARKS)

1. INORGANIC CHEMISTRY SPECIAL THEORY-I:

Inorganic Photochemistry: Basic principles, absorption, excitation, Kasha rule, electronically excited state, its lifetime, and energy dissipation process. Photochemical behavior of transition metal complexes, charge transfer spectra of crystalline and gaseous alkali halides. Photochemistry of chromium (III) octahedral complexes, $[Cr(H_2O)_6]^{3+}$ and $[Cr(NH_3)_6]^{3+}$. Photochemistry of cobalt (III) complexes, $[Co(NH_3)_5X]^{2+}$ and $[Co(en)_3]^{3+}$.

Inorganic Reactions and Mechanism: Substitution reactions in octahedral complexes, acid hydrolysis reactions, base hydrolysis and anation reactions, substitution reactions, reactions occurring without rupture of metal-ligand bond. Substitution reactions of square planar complexes. Theories of trans-effect, labile, and inert complexes. Mechanism of redox reactions.

Polymeric Inorganic Compounds: General chemical aspects (synthesis, properties and structure)of phosphazenes, borazines, silicones, sulphur-nitrogen cyclic compounds and condensed phosphates.

Stability of Coordination Compounds – Stability constants, stepwise formation constants, overall formation constants, relationship between stepwise and overall formation constants, factors affecting the stability constants (with special reference to metal and ligand ions), Difference between thermodynamic and kinetic stability. Determination of stability constants by: Spectrophotometric methods (Job's method, Mole ratio and slope ratio method), Bjerrum's method, Polarographic method.

Electronic Spectra–III (Electronic spectra of complex ions): Selection rules (Laporte, orbital and spin selection rules), band intensities, band widths, spectra in solids, spectra of aqueous solutions of d1-d9 ions in Oh and Td environments, Evaluation of 10 Dq, Spectrochemical and Nephelauxetic series, charge- transfer spectra.

PHYSICAL CHEMISTRY SPECIAL THEORY-I:

Adsorption at solid–gas interface: Concept of ideal and non–ideal adsorption. Heat of adsorption. Types of adsorption isotherms. Single–layer adsorption– Langmuir adsorption isotherm and its derivation. Multilayer adsorption – B.E.T. theory and its kinetic derivation. Application of the BET theory in its determination of the surface area of the solid. Catalytic

activities at surfaces: adsorption and catalysis, Adsorption at solid–liquid interface: Gibbs adsorption equation. Isotherms of concentration and temperature change for the adsorption in solutions.

Chromatographic adsorption: Column chromatography and its theory. Theory of chromatography involving one solute and several solutes,

Solution and Interfacial Behaviour of Surfactants: Definition and classification of surfactants. Solution properties of surfactants: micelle formation, critical micelle concentration (CMC), dependence of CMC on chain length of the surfactant, micelle shape, and size. Thermodynamics of micelle formation, hydrophobic effect (a qualitative view only). Aggregation at high surfactant concentration (a qualitative aspect) to micelles. Surface tension and detergent, Practical application of surfactants.

Electrochemistry: Quantitative treatment of Debye-Hückel and Debye-Hückel-Onsagar (DH-O) theory of conductance of electrolyte solution, their limitations and modifications. Pairwise association of ions (Bjerrum and Fuoss treatment). Determination of association constant (KA) from Debye–Huckel Limiting Law. Extended Debye–Huckel Law. Qualitative treatment of ion–solvent interactions (ion solvation).

Chemistry of nano–materials: Definition and historical perspective. Effect of nanoscience and nanotechnology in various fields. Synthesis of nanoparticles by chemical routes and their characterization techniques. Properties of nanostructured material: optical, magnetic and chemical properties. An overview of the applied chemistry of nanomaterials.

2. Organic Synthesis:

Organic Reagents: Reagents in organic synthesis: Willkinson catalyst, Lithium dialkyl cuprates (Gilman‘s reagents), Lithium diisopropylamide (LDA), 1,3-Dithiane (Umpolung), Dicyclohexylcarbodiimide (DCC), and Trimethylsilyliodide, DDQ, SeO_2, Baker yeast, Tri-n-butyltinhydride, Nickel tetracarbonyl, Trimethylchlorosilane. Grubbs Catalysts,

Oxidations: Introduction, Different oxidative processes. Aromatization of six-membered ring, dehydrogenation yielding C-C double bond, Oxidation of alcohols, Oxidation involving C-C double bond, Oxidative cleavage of ketones, aldehydes and alcohols, double bonds and aromatic rings, Ozonolysis, oxidized decarboxylation, Bisdecarboxylation, Oxidation of methylene to carbonyl, Oxidation of olefins to aldehydes and ketones.

Reductions: Introduction, Different reductive processes. Reduction of carbonyl to methylene in aldehydes and ketones, Reduction of nitro compounds and oximes, Reductive coupling, Bimolecular reduction of aldehydes or ketones to alkenes, metal hydride reduction, Acyloin ester condensation, Cannizzaro reaction, Tishchenko reaction, Willgerodt reaction.

Rearrangements: General mechanistic considerations- nature of migration, migratory aptitude, memory effects. A detailed study of the following rearrangements: Benzil-Benzilic acid, Favorskii, Arndt-Eistert synthesis, Neber, Backmann, Hofmann, Curtius, Schmidt, Benzidine, Baeyer-Villiger, Shapiro reaction, Witting rearrangement, and Stevens rearrangement.

Disconnection Approach: An introduction to synthons and synthetic equivalents, disconnection approach, functional group inter-conversions, the importance of the order of events in organic synthesis, one group C-X and two group C-X disconnections, chemoselectivity, reversal of polarity cyclisation reactions, amine synthesis. Protecting

Groups: Principle of protection of alcohol, amine, carbonyl and carboxyl groups. Alkene synthesis, use of acetylenes in organic synthesis.

3. NATURAL PRODUCTS:

Terpenoids: Classification, nomenclature, occurrence, isolation, general methods of structure determination, isoprene rule. Structure determination, biosynthesis and synthesis of the following representative molecules: Monoterpenoids: Citral, geraniol (acyclic), α-terpeneol, menthol (monocyclic). Sesquiterpenoids: Farnesol (acyclic), zingiberene (monocyclic), santonin (bicyclic), Diterpenoids: Phytol and abietic acid, Carotenoids and Xanthophylls: General methods of structure determination of Carotenes: β-carotene, α-carotene, γ-carotene, lycopene and vitamin A. Xanthophylls: Spirilloxanthin, Capsorubin, Fucoxanthin. Carotenoid acids (Apocarotenoids): Bixin and Crocetin. Bio synthesis of carotenoids.

Alkaloids: Definition, nomenclature and physiological action, occurrence, isolation, general methods of structure elucidation, degradation, classification based on nitrogen heterocyclic ring, role of alkaloids in plants. Structure, synthesis, and biosynthesis of the following: Ephedrine, Coniine, Nicotine, Atropine, Quinine, and Morphine.

Steroids: Occurrence, nomenclature, basic skeleton, Diel's hydrocarbon and stereochemistry. Isolation, structure determination and synthesis of Cholesterol, Androsterone, Testosterone, Estrone, Progestrone. Biosynthesis of steroids.

Plant Pigments: Occurrence, nomenclature, and general structure determination methods. Isolation and synthesis of Anthocyanins (Cyanin and pelargonidin), polyphenols: Flavones (chrysin), Flavonols (quercitin), and isoflavones (daidzein), coumarin, Quinones (lapachol), Hirsutidin. Biosynthesis of flavonoids: Acetate pathway and Shikimic acid pathway.

4. MEDICINAL CHEMISTRY:

Drug Design: Development of new drugs, procedures followed in drug design, concepts of lead compound and lead modification, concepts of prodrugs and soft drugs, structure-activity relationship (SAR), factors affecting bioactivity, resonance, inductive effect, isosterism bio-bio-isosterism, spatial considerations. Theories of drug activity: occupancy theory, rate theory, induced fit theory. Quantitative structure-activity relationship. History and development of QSAR. Concepts of drug receptors. Elementary treatment of drug receptor interactions. Physico-Chemical parameters: lipophilicity, partition coefficient, electronic ionization constants, steric, Free-Wilson analysis, Hansch analysis, relationships between Free-Wilson and Hansch analysis.

Pharmacokinetics and Pharmacodynamics: Pharmacokinetics: Introduction to drug absorption, disposition, and elimination using pharmacokinetics. Important pharmacokinetic parameters in defining drug disposition and in therapeutics. Mention of uses of pharmacokinetics in the drug development process, Pharmacodynamics: Introduction, elementary treatment of enzyme stimulation, enzyme inhibition, sulphonamides, membrane active drugs, drug metabolism, xenobiotics, biotransformation. Significance of drug metabolism in medicinal chemistry.

Antibiotics and Anti-infective Drugs: Antibiotics: Structure, SAR, and biological action of antibiotics. Examples: penicillin (penicillin G, penicillin V), ampicillin, amoxicillin, chloramphenicol, cephalosporin, tetracycline, and streptomycin.Sulfonamides: Structure,

SAR, and mode of action of sulfonamides, sulfonamide inhibition, and probable mechanisms of bacterial resistance to sulfonamides. Examples: sulfadiazine, sulfafurazole, acetyl sulfafurazole, Sulfagnanidine, Phthalylsulfo acetamide, Mafenide. Sulphonamide-related compounds, Dapsone.

Local anti-infective drugs: Introduction and mode of action. Examples: sulphonamides, furazolidone, nalidixic acid, ciprofloxacin, norfloxacin, chloroquine, and primaquine.

Psychoactive Drugs: Introduction, neurotransmitters, CNS depressants, and stimulants. SAR and Mode of action.

Central Nervous System Depressant: General anaesthetics, Sedatives & Hypnotics: Barbiturates and Benzodiazepines,

Anticonvulsants: Barbiturates, Oxazolidinediones, Succinimides, Phenacemide and Benzodiazepines.

Psychotropic Drugs: The neuroleptics (Phenothiazines and butyrophenones), antidepressants (Monoamine oxidase inhibitors and Tricyclic antidepressants) and anti-anxiety agents(Benzodiazepines).

Central Nervous System Stimulants: Strychnine, Purines, Phenylethylamine, analeptics, Indole ethylamine derivatives, Therapeutic Agents, SAR and Their mode of Actions:

Antineoplastic Agents: Cancer chemotherapy, role of alkylating agents and antimetabolites in the treatment of cancer. Mention of carcinolytic antibiotics and mitotic inhibitors. Biological action of mechlorethamine, cyclophosphamide, melphalan, uracil, and 6-mercaptopurine.

Cardiovascular Drugs: Antihypertensive and hypotensive drugs, antiarrhythmic agents, and vasopressor drugs acting as arteriolar dilators. Biological action of methyldopa, propranolol hydrochloride, amyl nitrate, sorbitrate, verapamil, and Atenolol.

5. BIO-INORGANIC AND SUPRAMOLECULAR CHEMISTRY:

Metalloporphyrins: Porphyrins and their salient features, characteristic absorption spectrum of porphyrins, chlorophyll (structure and its role in photosynthesis). Transport of Iron in microorganisms (siderophores), types of siderophores (catecholate and Hydroxamato siderophores).

Metalloenzymes: Definitions: Apoenzyme, Coenzyme, Metalloenzyme, structure and functions of carbonic anhydrase A & B, carboxypeptidases.

Oxygen Carriers: Natural oxygen carriers: Structure of hemoglobin and myoglobin, Bohr effect, Models for cooperative interaction in hemoglobin, oxygen Transport in human body (Perutzmechanism), Cyanide poisoning and its remedy. Non-heme proteins (Hemerythrin & Hemocyanin), Synthetic oxygen carriers: Oxygen molecule and its reduction products, model compounds for oxygen carrier (Vaska's Iridium complex, cobalt complexes with dimethyl glyoxime and Schiff base ligands).

Transport and storage of metals: The transport mechanism, transport of alkali and alkaline earth metals, ionophores, transport by neutral macrocycles and anionic carriers, sodium/potassium pump, transport and storage of Iron (Transferrin & Ferritin).

Inorganic compounds as therapeutic Agents: Introduction, chelation therapy, synthetic metal chelates as antimicrobial agents, antiarthritis drugs, antitumor, anticancer drugs (Platinum complexes), Lithium and mental health,

Supramolecular Chemistry: Introduction, Some important concepts, Introduction to Recognition, information and complementarily, Principles of molecular receptor designs, Spherical recognition (cryptates of metal cations), Tetrahedral recognition by macrotricyclic cryptands, Recognition of ammonium ions, Recognition of neutral molecules and anionic substrates (anionic coordination).

{Master Degree (Pharmacy) level}

PART-I (60 MARKS)

1. **MODERN PHARMACEUTICAL ANALYTICAL TECHNIQUES:**

A. UV-Visible spectroscopy: Introduction, theory, laws, and instrumentation associated with UV-visible spectroscopy, choice of solvent, solvent effect, and applications of UV-visible spectroscopy, difference and derivative spectroscopy. **B. IR spectroscopy:** Theory, modes of molecular vibrations, sample handling, instrumentation of dispersive and Fourier-transform IR spectrometers, factors affecting vibrational frequencies, and applications of IR spectroscopy, data interpretation. **C. Spectrofluorimetric:** Theory of fluorescence, factors affecting fluorescence (characteristics of drugs that can be analysed by fluorimetry), quenchers, instrumentation and applications of fluorescence spectrophotometry. **D. Flame emission spectroscopy, atomic absorption spectroscopy and ICP-MS:** Principle, instrumentation, interferences and applications, **NMR spectroscopy:** Quantum numbers and their role in NMR, principle and instrumentation of NMR, solvent choice, relaxation process, NMR signals, chemical shift, factors influencing chemical shift, spin-spin coupling, coupling constant, nuclear magnetic double-resonance spectrum, brief outline of principles of FT-NMR and 13C NMR. Applications of NMR spectroscopy, **Mass Spectroscopy:** Principle, theory, instrumentation of mass spectroscopy, different types of ionizations like electron impact, chemical, field, fast atom bombardment (FAB), matrix-assisted laser desorption ionization (MALDI), atmospheric pressure chemical ionization (APCI), atmospheric pressure photo ionization (APPI), electrospray ionization (ESI), analyzers of quadrupole and time-of-flight, mass fragmentation and its rules, meta stable ions, isotopic peaks and applications of mass spectroscopy, **Chromatography:** Principle, apparatus, instrumentation, chromatographic parameters, factors affecting resolution, data interpretation and applications of the following: **a.** Thin layer chromatography **b.** High performance thin layer chromatography **c.** Ion exchange chromatography **d.** Column chromatography **e.** Gas chromatography **f.** High performance liquid chromatography **g.** Ultra high performance liquid chromatography **h.** Affinity chromatography **i.** Gel chromatography, **Electrophoresis:** Principle, instrumentation, working conditions, factors affecting separation and applications of the following: **a.** Paper electrophoresis **b.** Gel electrophoresis: Zone electrophoresis, moving boundary electrophoresis **c.** Capillary electrophoresis **d.** Iso-electric focusing, **X-ray crystallography:** Production of X-rays, different X-ray methods, Bragg's law, rotating crystal technique, X-ray powder technique, types of crystals and applications of X-ray diffraction, **Immunological assays:** Biological standardization, Bioassays, types of Bioassays, ELISA, RIA, Radio immuno assay of digitalis and insulin, Bioluminescence, **Genotoxicity assays:a.** Bacterial Reverse Mutation Test (Ames test) **b.** In vitro mammalian chromosomal aberration test **c.** In

vitro mammalian cell micronucleus test **d.** Single cell gel electrophoresis ("Comet") assay and alkaline elution assay,**Potentiometry:** Principle, working, ion-selective electrodes and application of potentiometry,**Thermal techniques:** Principle, thermal transitions and instrumentation (heat flux and power-compensation and designs), modulated differential scanning calorimeter (DSC), hyper DSC, experimental parameters (sample preparation, experimental conditions, calibration, heating and cooling rates, resolution, sources of error) and their influence, advantages and disadvantages, pharmaceutical applications. Differential thermal analysis (DTA)-principle, instrumentation, advantage, disadvantages, pharmaceutical applications. Derivative differential thermal analysis (DDTA). Thermal gravimetric analysis (TGA)-principle, instrumentation, factors affecting result, advantages, disadvantages and pharmaceutical applications.

2. DRUG DELIVERY SYSTEM:

Sustained Release (SR) and Controlled Release (CR) Formulations:a. Introduction & basic concepts, advantages/disadvantages, factors influencing, physicochemical & biological approaches for SR/CR formulation, mechanism of Drug Delivery from SR/CR formulation. **b.Polymers**: introduction, definition, classification, properties and application, **Dosage forms for personalized medicine:**Introduction, definition, pharmacogenetics, categories of patients for personalized medicines. Customized drug delivery systems; Bioelectronic Medicines; 3D printing of pharmaceuticals; Telepharmacy, **Rate-controlled Drug Delivery Systems:** Principles & fundamentals, types, activation; Modulated drug delivery systems: Mechanically activated, pH activated, enzyme activated, and osmotic activated drug delivery systems; feedback regulated drug delivery systems; principles & fundamentals,**Gastro-Retentive Drug Delivery Systems:** Principle, concepts, advantages and disadvantages, modulation of GI transit time approaches to extend GI transit, **Buccal drug delivery systems:** principle of mucoadhesion, advantages and disadvantages, mechanism of drug permeation, methods of formulation and its evaluation, **Ocular Drug Delivery Systems:** Barriers to drug permeation, methods to overcome barriers, **Transdermal Drug Delivery Systems:** Structure of skin and barriers, penetration enhancers, transdermal drug delivery systems, formulation and evaluation,**Protein and Peptide Delivery:** Barriers for protein delivery; formulation and evaluation of delivery systems for proteins and other macromolecules,**Vaccine delivery systems:** Vaccines, uptake of antigens, single shot vaccines, mucosal and transdermal delivery of vaccines.

3. MODERN PHARMACEUTICS:

Preformulation Concepts: Drug excipient interactions – different methods, kinetics of stability, stability testing,**Optimization Techniques in Pharmaceutical Formulation:** Concept and parameters of optimization. Optimization techniques in pharmaceutical formulation and processing. Statistical design, response surface method, contour designs, factorial designs and application in formulation, Theories of dispersion and pharmaceutical dispersion (emulsion and suspensions, SMEDDS) preparation and stability, Large and small volume parenterals physiological and formulation considerations, manufacturing and evaluation, **Validation:** Introduction to pharmaceutical validation, scope & merits of validation, validation and calibration of master plan, ICH & WHO guidelines for calibration and validation of equipments, validation of specific dosage form. Types of validation.

Government regulation, manufacturing process model, URS, DQ, IQ, OQ & P.Q. of facilities,**cGMP & Industrial Management:** Objectives and policies of current good manufacturing practices, layout of buildings. Services, equipments and their maintenance Production management: production organization, materials management-handling and transportation, inventory management and control, production and planning control, sales forecasting, budget and cost control, industrial and personal relationship. Concept of total quality management (TQM), **Compression and Compaction:** Physics of tablet compression, compression and consolidation, effect of friction, distribution of forces, compaction profiles,**Study of Consolidation Parameters:** Diffusion parameters, dissolution parameters and pharmacokinetic parameters, Heckel plots, similarity factors – f2 and f1, Higuchi and Peppas plot, linearity, concept of significance, standard deviation, Chi square test, students T-test, ANOVA test.

4. REGULATORY AFFAIR:

Documentation in Pharmaceutical Industry: Master formula record, DMF (Drug Master File), distribution records. Generic drugs product development: introduction, Hatch–Waxman act and amendments, CFR (code of federal regulation), drug product performance documentation in support of in-vitro/invivo correlations, ANDA regulatory approval process, NDA approval process, BE and drug product assessment, scale-up process approval changes, postmarketing surveillance, outsourcing BA and BE to CRO,**Regulatory Requirement for Product Approval:** API, biologics, novel, therapies, Obtaining NDA, ANDA for generic drugs. Ways and means of US registration for foreign drugs,**CMC, Post approval Regulatory Affairs:** Regulation for combination products and medical devices, CTD and eCTD format, industry and FDA liaison. Guidelines of ICH-Q, S, E, M. Regulatory requirements of EU, MHRA, TGA and Rest of World (RoW) countries,**Non-clinical Drug Development:** Global submission of IND, NDA, ANDA, Investigation of medicinal products dossier (IMPD) and investigator brochure (IB), **Clinical trials:** Developing clinical trial protocols. Institutional review board (IRB). Independent ethics committee (IEC), formulation and working procedures, informed consent process and procedures. Hearth Insurance Portability and Accountability Act (HIPAA) – new, requirement to clinical study process, pharmacovigilance, safety monitoring in clinical trials.

PART-II (60 MARKS)

1. MOLECULAR PHARMACEUTICS (NANO TECH AND TARGETED DDS):

Targeted Drug Delivery Systems: Concepts, events and biological processes involved in drug targeting. Tumor targeting and brain specific delivery,**Targeting Methods:** Introduction, preparation and evaluation. Nanoparticles & liposomes: Types, preparation and evaluation,**Micro Capsules/Micro Spheres:** Types, preparation and evaluation, monoclonal antibodies; preparation and application, preparation and application of niosomes, aquasomes, phytosomes, electrosomes, **Pulmonary Drug Delivery Systems:** Aerosols, propellents, containers types, preparation and evaluation, intranasal route delivery systems; types, preparation and evaluation,**Nucleic acid based therapeutic delivery systems:** Gene therapy, introduction (ex-vivo & in-vivo gene therapy). Potential target, diseases for gene therapy (inherited disorder and cancer). Gene expression systems (viral and nonviral gene transfer).

Liposomal gene delivery systems. Biodistribution and pharmacokinetics. Knowledge of therapeutic antisense molecules and aptamers as drugs of future.

2. ADVANCED BIOPHARMACEUTICS & PHARMACOKINETICS:

Drug Absorption from the Gastrointestinal Tract: Gastrointestinal tract, mechanism of drug absorption, factors affecting drug absorption, pH–partition theory of drug absorption. Formulation and physicochemical factors: dissolution rate, dissolution process, Noyes–Whitney equation and drug dissolution, factors affecting the dissolution rate. Gastrointestinal absorption and role of the dosage form: solution (elixir, syrup and solution) as a dosage form, suspension as a dosage form, capsule as a dosage form, Tablet as a dosage form. **Dissolution methods:** formulation and processing factors, correlation of in vivo data with in vitro dissolution data. **Transport model:** permeability-solubility-charge state and the pH partition hypothesis, properties of the gastrointestinal tract (GIT), pH microclimate intracellular pH environment, tight-junction complex,**Biopharmaceutic Considerations in Drug Product Design and In Vitro Drug Product Performance:** Introduction, biopharmaceutic factors affecting drug bioavailability, rate-limiting steps in drug absorption, physicochemical nature of the drug formulation factors affecting drug product performance, in vitro: dissolution and drug release testing, compendial methods of dissolution, alternative methods of dissolution testing, meeting dissolution requirements, problems of variable control in dissolution testing performance of drug products. In vitro–in vivo correlation, dissolution profile comparisons, drug product stability, considerations in the design of a drug product,**Pharmacokinetics:** Basic considerations, pharmacokinetic models, compartment modelling: one compartment model- IV bolus, IV infusion, extra-vascular. Multi compartment model: two compartment – model in brief. Non-linear pharmacokinetics: cause of non-linearity, Michaelis–Menten equation, estimation of kmax and vmax. Drug interactions: Introduction, the effect of protein-binding interactions, the effect of tissue-binding interactions, cytochrome p450-based drug interactions, drug interactions linked to transporters,**Drug Product Performance, In Vivo: Bioavailability and Bioequivalence:** drug product performance, purpose of bioavailability studies, relative and absolute availability. Methods for assessing bioavailability, bioequivalence studies, design and evaluation of bioequivalence studies, study designs, crossover study designs, evaluation of the data, bioequivalence example, study submission and drug review process. Biopharmaceutics classification system and methods. Permeability: in-vitro, in-situ and in-vivo methods. Generic biologics (biosimilar drug products), clinical significance of bioequivalence studies, special concerns in bioavailability and bioequivalence studies, generic substitution,**Application of Pharmacokinetics:** Modified-release drug products, targeted drug delivery systems and biotechnological products. Introduction to pharmacokinetics and pharmacodynamic drug interactions. Pharmacokinetics and pharmacodynamics of biotechnology drugs. Introduction to proteins and peptides, monoclonal antibodies, oligonucleotides vaccines (immunotherapy), gene therapy.

3. COMPUTER AIDED DRUG DELIVERY SYSTEM:

Computers in Pharmaceutical Research and Development: A general overview: History of computers in pharmaceutical research and development. Statistical modeling in

pharmaceutical research and development: descriptive versus mechanistic modeling, statistical parameters, estimation, confidence regions, nonlinearity at the optimum, sensitivity analysis, optimal design, population modeling, **Quality-by-Design In Pharmaceutical Development:** Introduction, ICH Q8 guideline, regulatory and industry views on QbD, scientifically based QbD - examples of application, **Computational Modeling of Drug Disposition:** Introduction, modeling techniques: drug absorption, solubility, intestinal permeation, drug distribution, drug excretion, active transport; P-gp, BCRP, Nucleoside transporters, hPEPT1, ASBT, OCT, OATP, BBB-Choline Transporter, C**omputer-aided formulation development:** Concept of optimization, optimization parameters, factorial design, optimization technology & screening design. Computers in pharmaceutical formulation: development of pharmaceutical emulsions, microemulsion drug carriers. Legal protection of innovative uses of computers in R&D, the Ethics of computing in pharmaceutical research, computers in market analysis,**Computer-aided biopharmaceutical characterization:** Gastrointestinal absorption simulation. Introduction, theoretical background, model construction, parameter sensitivity analysis, virtual trial, fed vs. fasted state, In vitro dissolution and in vitro in vivo correlation, biowaiver considerations,**Computer Simulations in Pharmacokinetics and Pharmacodynamics:** Introduction, computer simulation: whole organism, isolated tissues, organs, cell, proteins and genes**, Computers in Clinical Development:** Clinical data collection and management, regulation of computer systems,**Artificial Intelligence (AI), Robotics and Computational Fluid Dynamics:** General overview, pharmaceutical automation, pharmaceutical applications, advantages and disadvantages, current challenges and future directions.

4. <u>COSMETIC AND COSMECEUTICALS:</u>

Cosmetics–Regulatory: Definition of cosmetic products as per Indian regulation. Indian regulatory requirements for labeling of cosmetics, Regulatory provisions relating to import of cosmetics, misbranded and spurious cosmetics. Regulatory provisions relating to the manufacture of cosmetics – conditions for obtaining a license, prohibition of manufacture and sale of certain cosmetics, loan license, offences and penalties,**Cosmetics–Biological Aspects:** Structure of skin relating to problems like dry skin, acne, pigmentation, prickly heat, wrinkles, and body odor. Structure of hair and hair growth cycle. Common problems associated with the oral cavity. Cleansing and care needs for face, eyelids, lips, hands, feet, nails, scalp, neck, body, and underarms.**Formulation Building Blocks:** Building blocks for different product formulations of cosmetics/cosmeceuticals. Surfactants–Classification and application. Emollients and rheological additives: Classification and application. Antimicrobials used as preservatives: their merits and demerits. Factors affecting microbial preservative efficacy. Building blocks for formulation of a moisturizing cream, vanishing cream, cold cream, shampoo and toothpaste. Soaps and syndet bars. **Perfumes:** Classification of perfume ingredients listed as allergens in EU regulation. **Controversial ingredients:** Parabens, formaldehyde liberators, dioxane.**Design of Cosmeceutical Products:** Sun protection, sunscreens classification and regulatory aspects. Addressing dry skin, acne, sun-protection, pigmentation, prickly heat, wrinkles, body odour, dandruff, dental cavities, bleeding gums, mouth odour and sensitive teeth through cosmeceutical formulations,**Herbal Cosmetics:** Herbal ingredients used in hair care, skin care and oral care. Review of guidelines for herbal

cosmetics by private bodies like Cosmos with respect to preservatives, emollients, foaming agents, emulsifiers and rheology modifiers. Challenges in formulating herbal cosmetics.

{Master of Science (Biochemistry) level}

PART-I (60 MARKS)

1. **APPLICATION OF BIOCHEMISTRY TO BIOTECHNOLOGY:**

Micromethods 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. dot blot. 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; Purificatin and labeling of MCA, uses and applications of MCA. T-cell hybridomas and their applications. Vaccines (subunit, live recombinant, attenuated and DNA Vaccines).

2. **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, Krabb's Disease, Metachromatic leukodystrophy and Fabry's Disease, Wolman's Disease, Disorders of porphyrin and heme metabolism, Disorders in

purine and pyrimidine metabolism, Myocardial infarction and atherosclerosis, Electrolytes and acid-base balance, regulation of electrolyte content of body fluids and maintenance of pH, Disorders of electrolyte, water and acid-base balance, Quality control in Clinical Biochemistry.

3. 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, Glucoronide conjugates, Conjugations catalysed by sulfotransferases, methyl transferases, and acetyl transferases. Glutathione conjugation and Amino acid conjugations, Toxicity Testing,target organ toxicity, Ames test, host-mediated assay, dominant lethal test, Drosophila sex linked recessive lethal test, micronucleus test. Toxicology of Medical devices, Haemotoxicology, Hepatotoxicity, Toxicity of Pesticides-Classes of pesticides: Organochlorine, Organophosphates and carbamates. DDT: Metabolism, toxicity, persistence, and bioaccumulation. Organophosphate-Metabolism and mechanism of insecticidal action. Metal Toxicity: The Toxicity of Lead and Its Effect on Heme Synthesis, Toxicology of various forms of mercury, Arsenic Toxicity, Drug Toxicity-Paracetamol, Metabolism and its Toxic effects.

4. MOLECULAR CELL BIOLOGY:

Cell Cycle: Cell cycle control system, cell cycle events in S. pombe, S. cerevisae, 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 nonclassical) down regulation of receptor signaling, Specialized tissues and stem cells: Renewal of epidermis, sensory epithelia, airways and the gut, blood vessels, multipotent stem cells, connective tissue cell family, stem cell engineering.

PART-II (60 MARKS)

1. ADVANCED ENZYMOLOGY:

Concept of convergent and divergent evolution of enzymes, Purification of enzymes: strategy & criteria of enzyme purity, judging the success of purification procedure. Kinetics of multi substrate enzyme catalyzed reactions: classification, kinetics of multisubstrate reactions, Investigation of reaction mechanism by using initial velocity, inhibition and isotope exchange studies; Practical aspects of kinetic studies: Enzyme assays, coupled assays, Reaction conditions optimization (pH, temperature, substrate concentration), Design of inhibition experiments, Methods of pre-steady state analysis: Rapid mixing and sampling techniques, Relaxation methods, Absolute concentration of enzymes, Sigmoidal Kinetics: Cooperativity phenomenon for protein ligand binding, symmetric & sequential models for action of allosteric enzymes and their significance, Hill and Scatchard plots; Identification of active site of enzymes: By trapping of enzyme-substrate complex, use of substrate analogues, enzyme modification by chemical procedures affecting amino acid side chains, treatment with class-specific inhibitors and site-directed mutagenesis, by studying the effect of changing pH. A brief account of the investigation of thethree-dimensional structure of the active site, Structures & mechanisms of selected enzymes: Dehydrogenases, proteases, ribonuclease, and lysozyme. Practical applications of protein inhibitors, Enzyme turnover: Kinetics of turnover, methods for measuring rates of enzyme turnover, Correlation between rates of turnover and the structure and functions of enzymes, Mechanism of enzyme degradation, significance of enzyme turnover.

2. MOLECULAR AND CELLULAR IMMUNOLOGY:

Diversity/ Polymorphism of receptors:T-cell receptor, Immunoglobulins, Major histocompatibility complex. Homing, migration, and homeostasis of cells of the immune system. Immune mechanisms at: immune privilege sites, mucosal lining maternal-fetal interface; immune senescence;host-pathogen interaction: invasion & evasion strategies of pathogens; microbial infections: bacterial (intracellular/ extracellular), viral, and parasitic. Molecular mechanisms of drug resistance; manipulation of immune response: immunotherapy, clinical trials; Immunodeficiency: Primary & Secondary; Neuroimmunology: immune functions (blood brain barrier, etc) Glycosylation-In health and disease, cell adhesion; Tumor Immunology; vaccine strategies for diverse pathogens, cancer, Epigenetic regulation of immune system: role of histone modifying enzymes; Immunotechnology: Variations in generating antibodies. Biosensors & Microarrays.

3. GENOMICS AND BIOINFORMATICS:

Introduction to Genomics, Proteomics, Open Reading Frames (ORFs), Detecting ORFs. Concepts of Introns, Exons. Notion of homology: Orthologs, Paralogs, Analogs. Understanding Identity, Homology & Similarity with reference to evolutionary relationships. History of Genome sequencing project, the human Genome project-The human genome sequence annotation–Repeats, coding regions, non-coding regions; Genome Sequencing strategies: Hierarchical and Whole genome Sequencing strategies, Nucleotide and Protein databases: Primary, secondary and composite database (GenBank, EMBL, DDBJ, Uniprot, Swissprot, PIR, PDB, Genpepts). NCBI, EBI, DDBJ. Nucleotide sequence flat files. Sequence

formats: Genbank, FASTA,ASN. Introduction to metabolic pathway databases on the web-KEGG, EcoCyc, and Metacyc. Enzyme databases-BRENDA, LIGAND database. Molecule visualization softwares: RasMol, Pymol, Cn3D, VMD etc. Information retrieval from biological databases- NCBI resource, Entrez, PubMed, MEDLINE.Introduction to sequence alignment: Pairwise Sequence Alignment, Global alignment and Local alignment, general, gap, and affine penalty. DotPlot, scoring functions, Substitution Matrices- PAM and BLOSUM matrices. Heuristic algorithms, Word methods or k-tuple methods, Dynamic Programming-implementation of the Needleman and Wunsch algorithm and Smith-Waterman Algorithm for pairwise alignment and testing alignment score, Multiple Sequence Alignment-consensus sequence, motifs and profiles. SP (Sum of Pairs) measure, Position specific scoring matrices, Hidden Markov Model, Clustal W, Clustal X, Blasta and Fasta, Blastp, Blastx, tBlastx, Blastn, PSI-BLAST, Significance of alignment: Scores, E value, p value. Comparative Genomics, Methods for predicting protein structure (secondary and tertiary).

4. <u>COMPUTATIONAL TECHNIQUES &BIOSTATISTICS:</u>

Overview of C program: Brief history of C program, general structure of a C program, stages in the development of a C program, Basic building blocks of C Language. Data Types, Operators & Expressions: Constants and variables, data types, declaring variables, storage classes, different types of expressions and their evaluation, conditional expression, assignment statement, enumerated data type, type casting. Console Input/Output: Standard input/output devices, unformatted input/output functions (character I/O functions and string I/O functions), formatted input/output functions (scanf () function and printf () function, Control Statements: Decision making using if, ifelse, elseif and switch statements, Looping using for, while and do-while statements, transferring program control using break and continue statements, programming examples to illustrate the use of these control statements. Pointers: What is a pointer? Why pointers? Declaring pointers, accessing values via pointers, pointer arithmetic, and types of pointers. Functions: Defining a function, local variables, return statement, invoking a function, specifying and passing arguments to a function, function prototyping, pointer to a function, recursion, Arrays & Strings: Introduction to arrays, declaring arrays, initializing arrays, processing of arrays, pointers & Arrays, introduction to strings, programming examples to illustrate the use of arrays and strings. Discussion on arrays is to be limited to 2-D arrays only. Structures & Unions: Introduction to structures, declaring structures, initializing structures, accessing elements of structures, pointers to structures, passing structures as arguments to a function, introduction to unions. Data Files: Introduction to data files, different ways of file processing (standard I/O & system I/O), description of various library functions for file handling, updating files, programming examples to illustrate the processing of files, Biostatistics: Expression and critical evaluation, interpretation and presentation of data, Statistical methods for analysis of data- Probability, Mean, median, frequency, t-test (paired and unpaired), ANOVA and correlations, statistical software.

Master Degree in Forensic Science
(specialization in Forensic Chemistry & Toxicology) level

PART-I (60 MARKS)

1. Analysis of corrosive chemicals-acids and alkalies, Examination of contact traces, Detective dyes, Bribery-definition under Indian penal code, Motives, Chemistry of detective dyes, Analysis, Restoration of erased numbers and importance of numbers, Theory, Methods of marking of numbers on different surfaces, Obliteration and restoration of erased numbers on different surfaces.

2. **Alcohol:** Forensic significance, problems of prohibition, nature, production of different types of alcohols including wines, liquors, IMFS, rectified sprit and absolute alcohol, Proof spirit, Analysis of alcohol: Percentage of alcohol by specific gravity method, acidity, Methanol poisoning Breath-alcohol instrumentation, Interpretation and presentation of alcohol: Retrograde exploration or back calculation of alcohol concentration, Widmark's equation, Identifying the alcohol-impaired driver: Tests of impairment, Alcohol measurement (using blood, breath, urine, saliva and oral fluid).

3. **Arson:** Definition under IPC, Nature of fire, Progress, Control, Burnt bodies, Seat and time of fire, Natural causes of fires, suspected arson, motives, person responsible, Search and collection of evidence, Isolation and extraction of accelerants, analysis by GC/GC-MS method, Petroleum products-production, Classification and properties, ISI of Gasoline, Kerosene and Diesel (HSD & LDO), Analysis of Gasoline, Kerosene and Diesel (HSD & LDO), Forensic relevance.

4. **Analytical Chemistry:** Overview, Sample collection, Preservation and Preparation 2 Analysis: Ionic equilibrium, pH scale, hydrolysis, solubility, and ionic product. 3 Disposition: Absorption, Distribution, Excretion and Influencing Factors 4 Detection of drugs in alternative specimens: Hair, Oral fluids, Sweat.

PART-II (60 MARKS)
FORENSIC TOXICOLOGY AND DRUGS OF ABUSE

1. Toxicology-Concept and scope, Classification of poisons, Characteristics of exposure: Acute and chronic, Route, Site, Duration and Frequency, Spectrum of Toxic Effects, Dose-Response Relationship, Lethal dose: Methods, Conflict Poisoning-Warfare Agents of Mass destruction, Extraction, Isolation and Identification of Poisons: Solvent Extraction–Stas Otto method, Ammonium sulphate method, Solid Phase Extraction, Clean-up Procedures, Metallic poisons: Identification and toxicology, Drug Analysis: Screening and detection, Extraction pathways.

2. **Pharmacokinetics and Metabolism:** Types of Metabolic reactions, Drug Metabolism: phase I and II (Analgesics, Tranquilizers, Barbiturates and Benzodiazepines) Factors influencing Metabolism, Pesticide intricacies: Organophosphate insecticides, Carbamates, Forensic relevance, Plant Poison: Nature (Cardiac, Deliriant, Spinal) Active constituents, Mode of action, Isolation and Identification.

3. Definition of Tolerance, Addiction, Use of Drugs, Withdrawal Symptoms, Classification and Effects of Drugs, Synonyms, Diluents and Adulterants, NDPS Act, Drugs and Crime, Identification of Addict, Depressants (Barbiturates, Benzodiazepines, Methaqualone): Description of compounds, Production, Physical and chemical characteristics of derivatives, Analysis.

4. **Opiates:** Production of opium, Isolation of Morphine, Production of Heroin, Alkaloid constituents of opium and heroin, Stimulants (Amphetamines, Cocaine): Description of compounds, Production, Physical and chemical characteristics of derivatives; Analysis, Hallucinogens (Cannabis, Ergot-LSD): Production, Description, Physical characteristics, Extraction, Chemical constituents, Drugs of Abuse in sports: Prohibited substances, Analytical approach; Drug facilitated sexual assault: Drugs, Metabolism and analysis.

Sd/
Under Secretary
H. P. Public Service Commission