M.Sc., Pharmaceutical Chemistry Program and Course Outcome.

Program Specific Outcomes

After successful completion of program,

1. Students will conduct experiments utilizing diverse laboratory techniques, instruments, and methodologies commonly employed in chemical analysis and synthesis.
2. Applying theoretical pharmaceutical chemistry principles, students will address real-world issues, designing and optimizing chemical processes, developing novel materials, and investigating environmental concerns.
3. Students will gather, analyze, and interpret data from chemical experiments, instrumental analysis, and computational simulations, drawing meaningful conclusions from their findings.
4. Through written reports, oral presentations, and visual representations, students will effectively communicate scientific concepts, experimental procedures, and research findings, adhering to professional standards.
5. Collaborating with peers and professionals, students will demonstrate ethical behavior, respect for diversity, and adherence to safety protocols in interdisciplinary teams.
6. Students will proficiently identify and define complex Medicinal/Pharmaceutical problems, employing logical and systematic approaches to solve them, and critically evaluating the validity and reliability of their solutions.
7. Students will be able to apply their knowledge of chemistry to address societal challenges such as sustainability, energy production, environmental pollution, and public health, demonstrating awareness of the ethical, social, and global implications of their work.
8. Students will be equipped with the skills and motivation to pursue lifelong learning and professional development opportunities, staying abreast of advances in chemistry and related fields, and continuously enhancing their knowledge and skills throughout their careers.
9. Demonstrate Leadership and Initiative: Students will be able to demonstrate leadership qualities, take initiative in problem-solving and decision-making, and contribute positively to the advancement of the field of chemistry and the broader scientific community.
10. Students will be able to identify opportunities for innovation and entrepreneurship in the field of chemistry, develop novel ideas, products, or processes, and effectively communicate and implement their innovations for societal benefit and economic growth.
11. Graduates proficiently interpret spectroscopic data and chromatographic separations, enabling accurate identification and characterization of pharmaceutical compounds in diverse formulations.
12. Students apply pharmacokinetic principles to assess drug absorption, distribution, metabolism, and excretion, optimizing dosage regimens for enhanced therapeutic efficacy.
13. Graduates utilize computational tools and structure-activity relationships to design novel pharmaceutical agents with improved potency, selectivity, and therapeutic profiles.

14. Students comprehend ethical and regulatory standards governing pharmaceutical research, ensuring adherence to legal requirements and industry best practices in drug development and manufacturing.
15. Graduates effectively communicate and collaborate with multidisciplinary teams, facilitating seamless integration of scientific knowledge and expertise to achieve common goals in pharmaceutical research and development.
16. Graduates demonstrate adept critical thinking skills, analyzing complex scientific challenges in pharmaceutical chemistry and proposing innovative solutions to advance drug discovery and development efforts.
17. Students embrace lifelong learning, engaging in ongoing professional development activities to stay updated with emerging trends, technologies, and regulatory advancements in the pharmaceutical industry.
18. Graduates contribute to society by developing safe, effective, and affordable pharmaceutical products that address unmet medical needs, improving healthcare outcomes and enhancing quality of life for patients worldwide.
19. Graduates exhibit leadership qualities, driving innovation and entrepreneurship in pharmaceutical sciences, fostering a culture of creativity and excellence in drug discovery and development endeavors.
20. Students appreciate the global impact of pharmaceutical research and development, demonstrating cultural sensitivity and ethical awareness in addressing healthcare challenges across diverse populations and regions.

Semester I Paper Title PC.HC. 1.01: INORGANIC CHEMISTRY

Student Learning Course Outcomes
After successful completion of this course students will be able to: -

1. Students will grasp atomic trends like size, ionization potential, and electronegativity, and their implications in chemical behavior and periodic trends.
2. Comprehensive understanding of s, p, d, and f block elements including electronic configurations, oxidation states, and chemical properties.
3. Students will correlate electronic configurations with characteristic properties of transition elements and analyze trends within transition metal chemistry.
4. Understanding of electronic configurations, oxidation states, absorption spectra, and comparison with other block elements.
5. Students will learn preparation methods and structures of xenon compounds, gaining insights into the unique chemistry of noble gases.
6. Understanding of atomic and molecular orbitals, various bonding types, hybridization, resonance, and significance of hydrogen bonding in molecules.
7. Comprehensive understanding of ionic bonding principles including lattice energy, defects, and factors influencing ionic radii, with applications of Fajan's rule and hydration energy.
8. Analysis of coordination compounds using valence bond, crystal field, and molecular orbital theories, including bonding, crystal field splitting, and spectrochemical series.
9. Grasping the electronic spectra and magnetic properties of transition metal complexes, including selection rules and magnetic behavior.
10. Students will explore modern acid-base theories like Bronsted, Lewis, and HSAB concepts, understanding their applications and theoretical principles in diverse chemical systems.

Semester 1Paper Title PC.HC.1.02: ORGANIC CHEMISTRY

Student Learning Course Outcomes
After successful completion of this course, students will be able to: -

1. Understand acidity and basicity effects of substituents, hybridization concepts, and resonance effects in molecules.
2. Master homolysis, heterolysis, formation, stability, and reactions of carbocations, carbanions, free radicals.
3. Explore aromaticity, including Huckel's rule, in benzenoid and nonbenzenoid compounds, understanding ring systems.
4. Utilize a variety of organic reagents in reactions, including DCC, Lead tetraacetate, and Osmium tetraoxide etc,
5. Learn mechanisms and applications of named reactions.
6. Grasp chirality concepts, absolute configurations, enantiomers, epimers, and stereochemistry in molecules.
7. Apply methods for determining configuration, including physical and chemical methods, and conformational analysis.
8. Study effects of conformation on reactivity, including in acyclic and cyclic systems.
9. Explore chiral technology applications in organic synthesis, such as asymmetric hydrogenation and hydroformylation.
10. Develop problem-solving skills through understanding reaction mechanisms and applying theoretical concepts.

Semester 1Paper Title PC.HC. 1.03: PHYSICAL CHEMISTRY

Student Learning Course Outcomes
After successful completion of this course, students will be able to: -

1. Understand thermodynamics terminology, laws, entropy, free energy, and Maxwell's relations, including applications of partial molar properties and the third law.
2. Explore quantum chemistry concepts, including atomic spectra, quantum mechanics postulates, wave equations, and their application to particle behavior.
3. Learn about polymer types, molecular weight distributions, polymerization processes, and analytical techniques for characterizing polymers in various applications.
4. Study reaction kinetics, including rate law determination methods, collision and transition state theories, and kinetics in solutions and fast reactions.
5. Grasp electrochemistry principles, including electrolytic solutions, Debye-Huckle theory, electrode potentials, and applications in batteries and fuel cells.
6. Analyze chemical dynamics, understanding terminology, methods for determining rate laws, and theories such as Arrhenius, collision, and transition state theories.
7. Explore black body radiation, Bohr model, de-Broglie hypothesis, and atomic spectra, providing a foundation for understanding elementary quantum chemistry principles.
8. Understand the concept of activity and activity coefficients, including the Debye-Huckel equation and its application to electrolytic solutions.
9. Learn about polarization, overvoltage, reversible electrodes, and electrochemical energy systems, including batteries, fuel cells, and their electrochemistry.

10. Gain proficiency in various analytical techniques such as viscosity method, ultracentrifugation method, and chemical and X-ray diffraction analysis in polymer chemistry.

Semester I Paper Title PC.HC. 1:04. ANALYTICAL CHEMISTRY

Student Learning Course Outcomes
After successful completion of this course, students will be able to: -

1. Grasp analytical method classification, error analysis, confidence intervals, significance testing, and sampling techniques for solid, liquid, and gaseous samples.
2. Understand titrimetric analysis principles, including acid-base, redox, complexometric, non-aqueous titrations, gravimetric analysis, and TGA applications.
3. Comprehend solvent extraction techniques, ultracentrifugation, supercritical fluid extraction, and extraction of metal organic complexes and drug impurities.
4. Learn about drug impurities, sources, effects, and purity tests, as well as pharmacopoeias and formularies in pharmaceutical chemistry.
5. Understand instrumentation principles and applications in analytical techniques such as fluorescence spectroscopy, atomic absorption spectroscopy, and colorimetry.
6. Master titrimetric analysis, including acid-base, redox, and complexometric titrations, and gravimetric analysis, understanding principles and applications in pharmaceutical analysis.
7. Explore solvent extraction methods, ultracentrifugation, and supercritical fluid extraction, understanding their principles and applications in pharmaceutical analysis and drug formulation.
8. Analyze drug impurities, understanding their sources, effects, and methods for purity testing, as well as the importance of pharmacopoeias and formularies.
9. Gain proficiency in using various analytical instruments, such as fluorescence spectroscopy, flame photometry, and atomic absorption spectroscopy, in pharmaceutical analysis.
10. Develop skills in interpreting analytical data, performing error analysis, and ensuring accuracy and precision in pharmaceutical analysis and drug formulation processes.

Semester I Practical-I, PC: 1.05: Inorganic Chemistry

Student Learning Course Outcomes
After successful completion of this course students will be able to : -

1. Analyze and quantify the levels of temporary, permanent, and total hardness in water samples using complexometric titrations, demonstrating proficiency in water quality assessment.
2. Employ complexometric titrations to accurately estimate the concentration of calcium ions in various aqueous solutions, showcasing mastery in quantitative analysis techniques.
3. Utilize complexometric titrations to determine the concentration of magnesium ions in solution, demonstrating competency in analytical chemistry methods.

4. Perform redox titrations to quantify the concentration of ferrous (Fe(II)) ions in solution, showcasing expertise in oxidation-reduction reactions and titration techniques.
5. Employ redox titrations to determine the concentration of ferric (Fe(III)) ions in samples, demonstrating proficiency in advanced analytical methods.
6. Conduct redox titrations to accurately measure the concentration of copper ions in copper sulfate solutions, showcasing practical skills in transition metal chemistry.
7. Successfully prepare various metal complexes, including chloropentammine cobalt (III) chloride, potassium trisoxalato ferrate (III) trihydrate complex, mercury (II) tetrathiocyanato cobaltate complex, and hexaminecobalt (III) chloride, demonstrating practical knowledge in coordination chemistry synthesis techniques.
8. Analyze coordination compounds to determine the metal and ligand contents, demonstrating proficiency in qualitative and quantitative analysis of complex chemical systems.

Semester I Practical-II, PC: 1.06: Organic chemistry

Student Learning Course Outcomes
After successful completion of this course students will be able to : -

1. Identify and classify organic compounds based on their functional groups, utilizing a variety of qualitative analysis techniques such as solubility tests, precipitation reactions, and characteristic color changes.
2. Apply chemical tests and reactions to elucidate the presence of specific functional groups in organic compounds, enabling qualitative identification and characterization.

Semester I Practical-III, PC: 1.07: Physical Chemistry

Student Learning Course Outcomes
After successful completion of this course students will be able to : -

1. Students will be able to explain the mechanism and factors influencing acid-catalyzed hydrolysis reactions, such as ester hydrolysis.
2. Students will be able to design and conduct experiments to determine rate constants of chemical reactions, including the use of Arrhenius equation to calculate activation energies.
3. Students will understand the concept of ionic strength and its influence on reaction rates, as well as how to experimentally investigate this effect.
4. Students will be proficient in using viscometry techniques to measure polymer solution viscosity and correlate it with molecular weight.
5. Students will be able to design and carry out experiments to study the adsorption behavior of solutes on solid surfaces, such as charcoal.
6. Students will gain practical experience in conducting conductometric titrations to determine acid strengths and compositions in mixtures.
7. Students will be able to perform pH titrations and analyze titration curves to determine the pH of acids and bases.
8. Students will learn to use potentiometric techniques to determine acid dissociation constants (pKa) of weak acids.

9. Students will develop skills in analyzing experimental data, drawing conclusions, and relating results to theoretical concepts in chemistry.
10. Students will gain hands-on experience in conducting experiments safely and accurately, including proper handling of chemicals and equipment.

Semester II Paper Title PC.HC.2.01: ADVANCED INORGANIC CHEMISTRY

Student Learning Course Outcomes
After successful completion of this course, students will be able to: -

1. Understand symmetry principles, point groups, and molecular symmetry operations, identifying molecular point groups and their implications in molecular properties.
2. Master organometallic chemistry, including the 16 and 18-electron rules, synthesis, reactions, and catalytic applications of organometallic compounds.
3. Explore properties of non-transition elements, including carbon, nitrogen, oxygen, halogens, boron compounds, and their biological significance in transport mechanisms.
4. Study oxygen and electron carriers, including hemoglobin, myoglobin, hemerythrin, and iron-sulfur proteins, understanding their structures, functions, and biological roles.
5. Analyze metal ion deficiency, toxicity, and treatment, studying the toxic effects of metals like iron, copper, arsenic, and mercury in biological systems.
6. Understand metal chelation therapy applications in medicine, including its role in treating metal ion toxicity and its use in anticancer therapy.
7. Grasp the substituent effects on porphyrin rings in oxygen carriers, understanding their structures, stereochemistry, and oxygenation mechanisms.
8. Explore the chemistry of metal carbonyls, nitrosyls, and cyclopentadienyl metal complexes, including their synthesis, bonding, and catalytic applications.
9. Analyze the role of metal ions in biological systems, including their transport across biological membranes and their involvement in essential metabolic processes.
10. Gain proficiency in identifying and understanding the biological effects of metal ions, toxicity mechanisms, and therapeutic applications of metal chelation in medicine.

Semester II Paper Title PC.HC.2.02: ADVANCED ORGANIC CHEMISTRY

Student Learning Course Outcomes
After successful completion of this course, students will be able to: -

1. Students will understand molecular orbital symmetry, Woodward-Hoffmann correlation diagrams, electrocyclic reactions, cycloadditions, and sigmatropic rearrangements with emphasis on mechanisms and applications.
2. Students will grasp the laws, quantum yields, Jablonski diagram, and various photochemical reactions including photoreduction, photooxidation, photolysis, di-pi-methane rearrangement, and Paterno-Buchi reaction.
3. Students will master the synthesis, reactions, and mechanisms of pyrrole, furan, thiophene, pyridine, indole, benzofuran, benzothiophene, quinoline, and isoquinoline, with emphasis on electrophilic and nucleophilic substitutions.

4. Students will classify and comprehend nucleophilic, electrophilic, and radical rearrangements involving migration to electron-deficient or electron-rich centers, as well as aromatic rearrangements such as Fries and Claisen rearrangements.
5. Students will learn about synthons, synthetic equivalents, functional group interconversions, protecting group principles, and strategic considerations in organic synthesis, including one-group and two-group C-X disconnections.
6. Students will understand various coupling reactions such as Hiyama, Kumada, McMurry, Negishi, Stille, Suzuki-Miyaura, and Ullmann couplings in organic synthesis, considering chemo-, regio-, and stereoselectivity.
7. Students will enhance their ability to solve complex problems in advanced organic chemistry, applying theoretical knowledge to practical scenarios in synthesis and mechanistic understanding.
8. Students will critically evaluate the mechanisms, stereochemistry, and applications of advanced organic reactions, developing a deeper understanding of their scope and limitations.
9. Students will learn to design synthetic routes strategically, considering reactivity, selectivity, and efficiency, with the ability to plan multistep syntheses using retrosynthetic analysis.
10. Students will integrate theoretical principles with laboratory practice, applying advanced organic chemistry concepts in experimental design, data interpretation, and synthesis optimization.

Semester II Paper Title PC.HC.2.03: ADVANCED PHYSICAL CHEMISTRY

Student Learning Course Outcomes
After successful completion of this course, students will be able to: -

1. Understanding catalytic reactions, kinetics of enzyme-catalyzed reactions, and heterogeneous catalysis principles, including factors affecting surface reactions and oscillatory reactions.
2. Mastery of the phase rule application to one, two, and three-component systems, including water, sulfur, potassium iodide-water, and ferric chloride-water systems.
3. Grasping adsorption phenomena by solids, adsorption isotherms, surface area measurement techniques, and Gibbs adsorption isotherm principles, with applications in surface films and multilayer adsorption.
4. Comprehensive knowledge of colloidal systems, including properties like the Tyndall effect and Brownian movement, and pharmaceutical applications such as emulsions and suspensions stability.
5. Understanding surface and interfacial tension measurements, surfactants classification, micelle formation, and their pharmaceutical applications in solubilization and wetting agents.
6. Grasping diffusion laws, types, and factors affecting dissolution rates, including the development of dissolution models and drug release mechanisms in dosage form design.
7. Analysis of factors influencing dissolution and diffusion, methods to enhance solubility of poorly soluble drugs, and understanding drug release mechanisms for effective preformulation studies.
8. Understanding particle size distribution, surface area determination methods, flow properties of powders, and various techniques for particle size determination in micromeritics analysis.

9. Proficiency in modeling drug release through polymer matrix and laminates, and understanding the concept of membrane-controlled delivery for dosage form design.
10. Recognizing the pharmaceutical applications of surfactants, colloids, and micromeritics principles in drug formulation and delivery systems.

Semester II Paper Title PC.HC.2.04: ADVANCED ANALYTICAL AND NANOCHEMISTRY

Student Learning Course Outcomes
After successful completion of this course, students will be able to: -

1. Understanding electromagnetic radiation characterization, quantization of energy levels, and analysis of rotational, vibrational, and electronic spectra in molecules.
2. Grasping Raman scattering principles, polarization of Raman lines, and interpretation of Raman spectra, with comparisons to IR spectra.
3. Mastery of X-ray diffraction fundamentals, crystal systems, and experimental methods for crystal structure determination.
4. Interpreting Mössbauer spectra, including isomer shift, quadrupole splitting, and magnetic hyperfine structure, with applications in structure determination.
5. Understanding ESR principles, rules for spectrum interpretation, and applications in studying free radicals, biological structures, and coordination compounds.
6. Grasping the fundamentals and importance of nanochemistry, including the structure, properties, and applications of carbon nanoparticles and nanotubes.
7. Understanding the nature of carbon bonds, carbon clusters, and carbon nanotube properties, fabrication methods, and applications in various fields.
8. Mastery of chemical vapor deposition for nano material fabrication and applications of nanomaterials in medicine, including drug delivery and medical diagnosis.
9. Understanding the significance of nano materials in medicine, such as immunogold labeling, and their potential in various fields due to their unique properties.
10. Recognizing the interdisciplinary nature of nanochemistry and its applications in medicine, material science, and analytical chemistry for advancing technology and research.

Semester II Paper Title PC.2.05: ELECTIVE: DRUG DISCOVERY AND DEVELOPMENT

Student Learning Course Outcomes
After successful completion of this course, students will be able to: -

1. Grasping the process from initial extract preparation to compound development, with insights from Taxol's natural product drug development.
2. Overviewing enzyme catalysis, reversible and irreversible inhibition mechanisms, with examples like AZT and clavulanic acid for understanding drug action.
3. Distinguishing oral solids, liquids, suspensions, and other forms, understanding their properties and applications in drug delivery systems.
4. Evaluating advantages and disadvantages of local, oral, and parenteral routes, including various administration methods like inhalation and injection.
5. Grasping the methods for initial screening of natural product extracts and understanding the importance of compound identification.

6. Mastering techniques for structural identification of compounds derived from natural products, crucial for drug development and optimization.
7. Understanding the general concept of enzyme inhibition, including reversible and irreversible mechanisms, and their significance in drug discovery.
8. Identifying and contrasting various dosage forms like oral solids, liquids, and topical semi-solids, considering their properties and applications.
9. Understanding the pros and cons of different administration routes, including local, oral, and parenteral methods for effective drug delivery.
10. Applying knowledge of dosage forms and administration routes to optimize drug delivery systems for specific therapeutic needs and patient preferences.

Semester II Practicals-I, PC: 2.06: Inorganic chemistry

Student Learning Course Outcomes
After successful completion of this course students will be able to : -

1. Students will develop the ability to identify and classify common inorganic ions based on their chemical properties and behavior in qualitative analysis tests.
2. Students will gain hands-on experience in conducting qualitative analysis experiments, including the use of reagents, test tubes, and laboratory equipment to identify the presence of specific ions in solution.
3. Students will apply fundamental principles of inorganic chemistry, including solubility rules, acid-base reactions, and precipitation reactions, to interpret experimental observations and identify unknown ions.
4. Through the analysis of experimental data and the interpretation of results, students will enhance their critical thinking and problem-solving abilities, particularly in the context of identifying unknown ions in complex mixtures.

Semester II Practicals – II, PC: 2.07: Advanced organic chemistry

Student Learning Course Outcomes
After successful completion of this course students will be able to : -

1. Students will be able to perform various organic synthesis reactions, including acetylation, benzylation, nitration, bromination, and hydrolysis, with appropriate reagents and conditions.
2. Students will develop a deeper understanding of the mechanisms underlying organic synthesis reactions, including electrophilic aromatic substitution, nucleophile substitution, and hydrolysis mechanisms.
3. Students will demonstrate knowledge of laboratory safety procedures, including proper handling and disposal of chemicals, use of personal protective equipment, and emergency response protocols.
4. Students will develop skills in analysing experimental results, including yield calculations, melting point determinations, and qualitative analysis of reaction products.
5. Students will gain experience in troubleshooting experimental challenges, such as low yields, side reactions, and impurities, and develop strategies for optimizing reaction conditions and purification techniques.

6. Students will be able to communicate their experimental procedures, results, and conclusions effectively through written reports, oral presentations, and scientific discussions.
7. Students will gain proficiency in quantitative analysis techniques, including stoichiometric calculations, titration methods, and data analysis for estimating the composition of mixtures containing organic compounds.
8. Students will enhance their critical thinking and problem-solving abilities by designing and executing experiments, analyzing data, and making evidence-based conclusions.
9. Through engaging in hands-on laboratory experiments and exploring the principles of organic synthesis, students will develop a curiosity and enthusiasm for further study and research in the field of organic chemistry.

Semester II Practicals – III, PC: 2.08: Bioanalytical techniques

Student Learning Course Outcomes
After successful completion of this course students will be able to : -

1. Students will learn extraction techniques, such as solvent extraction or steam distillation, to isolate caffeine from tea leaves.
2. They will understand the principles of partitioning between immiscible phases and apply them to separate caffeine from other components of the tea.
3. Students will gain experience in extraction and purification techniques to isolate piperine from black pepper.
4. They will learn methods such as Soxhlet extraction, column chromatography, or recrystallization to obtain pure piperine.
5. Students will apply extraction and purification techniques to isolate nicotine from tobacco leaves.
6. They will understand the principles of solvent selection, pH control, and crystallization to maximize yield and purity of nicotine.
7. Students will explore various natural sources and learn to isolate other biologically active constituents, such as alkaloids, flavonoids, or essential oils.
8. They will gain skills in selecting appropriate extraction methods, analyzing extracts for purity, and characterizing isolated compounds using spectroscopic or chromatographic techniques.

Semester III Paper Title PC.HC.3.01: SPECTROSCOPY TECHNIQUES

Student Learning Course Outcomes
After successful completion of this course, students will be able to: -

1. Understanding UV-Visible spectroscopy principles, including instrumentation, Beer's Law, and chromophores, for qualitative and quantitative analysis of organic compounds.
2. Mastery of Optical Rotatory Dispersion fundamentals, Cotton effect curves interpretation, and Circular Dichroism's relation, with practical applications.
3. Grasping IR spectroscopy basics, vibration types, interaction with molecules, and qualitative interpretation techniques including sample preparation and FT-IR instrumentation.
4. Proficiency in analyzing IR spectra, understanding functional group frequencies, and interpreting spectra based on chemical environment variations.
5. Comprehending NMR principles, including nucleus types, excitation, relaxation processes, chemical shift, spin-spin coupling, and FT-NMR principles with C13 nucleus reference.
6. Application of NMR techniques for spectra interpretation, including signal splitting, coupling constants, and understanding 2DNMR principles for structural elucidation.
7. Understanding Mass Spectrometry fundamentals, ion formation, molecular ion peaks, analyzers, fragmentation processes, and ionization techniques like FAB and MALDI.
8. Proficiency in analyzing Mass Spectra, including fragmentation patterns, McLafferty rearrangement, and determining molecular formulas and weights for qualitative and quantitative analysis.

Semester III Paper Title PC.HC.3.02: BIOORGANIC CHEMISTRY

Student Learning Course Outcomes
After successful completion of this course, students will be able to: -

1. Understand the chemistry of amino acids, including synthesis methods, chemical reactions, and primary structure determination, enabling proficient peptide synthesis.
2. Analyze alkaloids, glycosides, anthocyanins, and nucleic acids, including structure elucidation and phytochemical testing for alkaloids and flavonoids.
3. Evaluate the biological significance of steroid hormones, prostaglandins, essential oils, and terpenoids, examining their structures, biosynthesis, and pharmacological properties.
4. Interpret enzyme kinetics, including the Michaelis-Menten equation, Vmax, Km, and bisubstrate reactions, to quantitatively analyze enzyme-catalyzed reactions.
5. Perform experiments to elucidate enzyme inhibition mechanisms using reversible and irreversible inhibitors, interpreting data to determine enzyme kinetics parameters.
6. Demonstrate practical skills in the extraction, isolation, and structural elucidation of natural products such as alkaloids, glycosides, essential oils, and terpenoids.
7. Apply stereochemistry principles for the protection and deprotection of amino groups, activation of carboxylic groups, and synthesis of dipeptides and tripeptides.

8. Assess the occurrence, synthesis, and classification of alkaloids, glycosides, anthocyanins, and nucleic acids, and perform phytochemical tests for alkaloids and flavonoids.
9. Understand enzyme classification, characteristics, and kinetics, including enzyme-substrate complex formation, factors affecting reaction rates, and enzyme inhibition mechanisms.
10. Critically analyze the structures, occurrence, and pharmacological properties of steroid hormones, prostaglandins, essential oils, and terpenoids in biological systems.

Semester III Paper Title PC. SC. 3.21: SEPARATION TECHNIQUES

Student Learning Course Outcomes
After successful completion of this course, students will be able to: -

1. Understand the principles and terminology of chromatographic methods, including paper chromatography and thin-layer chromatography (TLC), and their applications in qualitative analysis.
2. Explore the various methods of paper chromatography, such as ascending, descending, and 2D techniques, along with their practical applications in separating and identifying components.
3. Examine the principles and techniques of thin-layer chromatography, including types of adsorption, preparation methods, and mobile phase selection, and compare its advantages with paper chromatography.
4. Investigate column chromatography and high-performance thin-layer chromatography (HPTLC), focusing on adsorption phenomena, packing techniques, and their applications in pharmaceutical analysis.
5. Learn the principles and instrumentation of gas chromatography (GC), including column types, efficiency parameters, and detector types, and understand its derivatization methods and interfacing with mass spectrometry.
6. Explore the principles and instrumentation of high-performance liquid chromatography (HPLC), emphasizing reverse-phase HPLC, column selection, and detectors such as UV-visible, refractive index, and mass detectors.
7. Compare the efficiency, retention, resolution, and selectivity parameters of GC and HPLC, highlighting their respective strengths and limitations in pharmaceutical analysis.
8. Understand the significance of mobile phase selection and packing materials in HPLC, including standard columns, narrow bore columns, and guard columns, for optimizing separation and detection.
9. Learn about the resolution equation and efficiency parameters in gas chromatography, along with the practical applications of GC in pharmaceutical analysis.
10. Explore advanced techniques in chromatography, including derivatization methods, such as acylation and esterification, and the use of electron capture detectors (ECD) in gas chromatography for sensitive detection of analytes.

Semester III Paper Title PC. SC. 3.22: PHARMACEUTICAL ANALYSIS

Student Learning Course Outcomes
After successful completion of this course, students will be able to: -

1. Understand the principles, specifications, and performance of automated methods of analysis.
2. Identify automation strategies and analyze the advantages and disadvantages of automated techniques.
3. Familiarize with various automated chemical analyzers, including infrared process analyzers, on-line potentiometric analyzers, chemical sensors, discrete analyzers, and continuous analyzers.
4. Demonstrate knowledge of thermal methods of analysis, including thermogravimetric analysis (TGA), differential thermal analysis (DTA), and differential scanning calorimetry (DSC).
5. Explain the theory, working principles, and instrumentation of capillary supercritical fluid chromatography, gel chromatography, and size exclusion chromatography.
6. Analyze cyclic voltammetry principles, instrumentation, and applications, along with electrogravimetry theory and applications.
7. Define and describe ion-exchange chromatography (IEC), including ion-exchange mechanisms, factors affecting equilibrium, instrumentation, and applications.
8. Understand the principles and applications of affinity chromatography, exclusion chromatography, and supercritical fluid chromatography.
9. Explain the basis and applications of electrophoresis techniques, including moving boundary electrophoresis, zone electrophoresis, isotachophoresis, isoelectric focusing, immunoelectrophoresis, and capillary electrophoresis.
10. Demonstrate practical skills in performing experimental techniques related to the discussed analytical methods.

Semester III Paper Title PC.SC.3.23: DRUG DISCOVERY AND DEVELOPMENT

Student Learning Course Outcomes
After successful completion of this course, students will be able to: -

1. Understand the historical context and processes involved in drug discovery, including lead discovery, modification, and the pharmaceutical phases, emphasizing natural product sources and enzyme inhibition.
2. Analyze drug design principles, including physicochemical properties, stereochemistry, and 3D database searches, employing computational methods like docking and molecular modeling.
3. Evaluate the relationship between molecular structure and pharmacological activity, focusing on solubility, functional group modification, and drug-receptor interactions in lead compound refinement.
4. Examine the classification, properties, and biological significance of vitamins, exploring their synthesis, chemical properties, and physiological roles in health and disease prevention.
5. Investigate the nomenclature, classification, and structural characteristics of lipids, emphasizing the biological importance of lipids such as phospholipids, sphingolipids, and oils in cellular function.
6. Apply drug discovery methods, including random screening, lead compound refinement, and functional group modification, to identify potential drug candidates and improve pharmacological activity.

7. Discuss the significance of drug action in terms of ADME processes, bioavailability, pharmacodynamics, and drug routes of administration, ensuring effective drug development and delivery.
8. Explore the concept of selectivity in drug action and drug-receptor interactions, elucidating how specific molecular structures influence target specificity and therapeutic efficacy.
9. Investigate the synthesis, biological roles, and consequences of deficiency or excess of essential vitamins such as retinal, thiamine, ascorbic acid, and vitamin K in human health.
10. Examine the structural diversity, purification methods, and physiological functions of lipids, highlighting their roles as structural components, energy sources, and signaling molecules in biological systems.

Semester III Paper Title PC 3.03: ELECTIVE: DRUG DESIGN AND METABOLISM

Student Learning Course Outcomes
After successful completion of this course, students will be able to: -

1. Understand the principles of drug design and development, exploring lead discovery methods like random and non-random screening, and rational approaches to lead modification for improved potency and therapeutic index.
2. Analyze physicochemical properties of drugs, including solubility, partition coefficient, protein binding, and chelation, and their impact on biological activity and drug metabolism.
3. Investigate drug metabolism pathways, including phase I (oxidation-reduction, hydrolysis) and phase II (conjugation reactions), and the role of Cytochrome P-450 enzymes in biotransformation.
4. Examine the identification of pharmacophores and functional group modifications in lead compounds, emphasizing structure-activity relationships (SAR) and strategies to enhance potency and safety profiles.
5. Discuss the significance of drug metabolism in terms of site-specific biotransformation, highlighting major conjugation reactions such as glucuronidation, sulfation, methylation, and acetylation.
6. Explore the factors influencing drug metabolism, including enzyme induction/inhibition, genetic polymorphisms, age, gender, and disease states, and their implications for drug efficacy and toxicity.
7. Evaluate the role of isosterism, geometrical, and optical isomerism in drug design and metabolism, considering their impact on drug-receptor interactions and pharmacokinetic properties.
8. Investigate the importance of steric effects and ionization in drug molecules, elucidating their influence on drug distribution, metabolism, and excretion processes *in vivo*.
9. Discuss clinical observations and experimental approaches in drug discovery, emphasizing the integration of *in vitro* and *in vivo* studies to optimize lead compounds for therapeutic use.
10. Analyze the role of drug metabolism studies in preclinical and clinical drug development, focusing on the assessment of metabolic stability, metabolite identification, and drug-drug interactions for safe and effective pharmacotherapy.

Semester III Practical-I, PC: 3.04: Synthesis of drugs and drug intermediates-I

Student Learning Course Outcomes
After successful completion of this course, students will be able to: -

1. Students will develop practical skills in synthetic organic chemistry, including reaction setup, purification techniques, and product characterization.
2. Students will gain a deeper understanding of reaction mechanisms involved in the synthesis of drugs and drug intermediates, enabling them to predict reaction outcomes and troubleshoot experimental challenges.
3. Students will learn about the synthesis and properties of pharmaceutically important compounds, including their biological activity, pharmacokinetics, and therapeutic uses.
4. Students will acquire proficiency in interpreting UV, IR, NMR, and mass spectra, allowing them to identify functional groups, determine molecular structures, and assess compound purity.
5. Students will develop critical thinking and problem-solving abilities by analyzing spectral data, proposing structural assignments, and making evidence-based conclusions.
6. Students will understand the importance of ethical conduct and safety protocols in pharmaceutical research, including the responsible handling and disposal of hazardous materials.
7. Students will learn to effectively communicate their experimental procedures, results, and interpretations through written reports, oral presentations, and scientific discussions, fostering collaboration and teamwork.

Semester III Practical-II, PC: 3.05: Separation techniques:

Student Learning Course Outcomes
After successful completion of this course, students will be able to: -

1. Develop practical skills in various chromatography methods including TLC, column, and paper chromatography for qualitative and quantitative separations in analytical chemistry laboratories.
2. Gain a deep understanding of partitioning, adsorption, and separation mechanisms underlying chromatographic processes, enabling efficient compound separation and analysis.
3. Interpret chromatographic data including retention times, peak shapes, and resolutions to identify and quantify compounds in complex mixtures with accuracy.
4. Optimize experimental conditions such as stationary/mobile phase selection, flow rates, and detection methods to achieve optimal chromatographic separations for diverse compound classes.
5. Develop proficiency in quantitative analysis techniques using peak areas, calibration curves, and standard solutions to determine compound concentrations in chromatographic fractions reliably.
6. Learn to troubleshoot chromatographic challenges such as poor resolution or peak shape, and develop strategies to address issues for successful chromatographic separations.

Semester III Practical- III, PC: 3.06: Assay of drugs by titrimetric and instrumental methods – I

Student Learning Course Outcomes
After successful completion of this course, students will be able to: -

1. Students will develop practical skills in performing titrimetric and instrumental assays for the quantitative determination of drug concentrations in pharmaceutical formulations.
2. Gain a deep understanding of the principles underlying titrimetric and instrumental assays, including acid-base, redox, and complexometric reactions used in pharmaceutical analysis.
3. Interpret assay data obtained from titrations and instrumental measurements, including calculation of drug concentrations and assessment of assay accuracy and precision.
4. Learn to develop and validate assay methods for pharmaceutical analysis, including optimization of experimental conditions and assessment of method performance parameters.
5. Understand the importance of quality control in pharmaceutical analysis, including adherence to regulatory guidelines and validation requirements for assay methods.

Semester IV Paper Title PC.HC. 4.01: MEDICINAL CHEMISTRY-I

Student Learning Course Outcomes
After successful completion of this course, students will be able to: -

1. Understand the classification and mechanism of action of local anti-infective agents, including nitrofurazone and furazolidone, and their synthesis and structure-activity relationship (SAR).
2. Explore the mechanism of action and SAR of sulfonamides, such as sulfisoxazoles and sulfamethoxazoles, and their synthesis for combating bacterial infections.
3. Study the classification, mechanism of action, and synthesis of major antibiotics like Penicillin G, cephalosporins, and tetracyclins, highlighting their SAR.
4. Analyze the mechanism of action and synthesis of antitubercular and antileprotic agents like isoniazid, ethambutol, and clofazimine, focusing on their efficacy in treating mycobacterial infections.
5. Investigate the mechanism of action and synthesis of analgesic and anti-inflammatory agents like Ibuprofen, phenylbutazone, and diclofenac sodium, and understand their pharmacological properties.
6. Explore the synthesis and mode of action of anticancer, antiviral, and hypoglycemic agents, including 5-fluorouracil, azidothymidine, and tolbutamide, emphasizing their therapeutic potential.
7. Examine the classification, mechanism of action, and synthesis of antihistamines like pheniramine maleate, pyrilamine, and histamine receptor antagonists such as ranitidine and cimetidine.
8. Study the synthesis and mechanism of action of cardiovascular agents, including antiarrhythmic agents like verapamil and antihypertensive agents like clonidine and hydralazine derivatives.

9. Explore the mechanism of action and synthesis of psychopharmacological agents like benzodiazepines (e.g., diazepam), phenothiazines (e.g., chlorpromazine), and tricyclic antidepressants (e.g., amitriptyline).
10. Analyze the mechanism of action and synthesis of antimalarials like chloroquine, mefloquine, and primaquine, focusing on their efficacy against Plasmodium species, and SAR considerations.
11. Investigate the mechanism of action and synthesis of antiamoebic agents like metronidazole and iodoquinol, highlighting their use in treating amoebic infections.
12. Study the mechanism of action and synthesis of anticonvulsants like phenytoin sodium and carbamazepine, focusing on their role in managing epileptic seizures.
13. Explore the mechanism of action and synthesis of sedatives and hypnotics like phenobarbital and chlordiazepoxide, emphasizing their pharmacological effects on the central nervous system.
14. Analyze the mechanism of action and synthesis of general anesthetics like halothane and methohexital sodium, focusing on their use in inducing and maintaining anesthesia during surgical procedures.

Semester IV Paper Title PC.HC:4.02: MEDICINAL CHEMISTRY-II

Student Learning Course Outcomes
After successful completion of this course, students will be able to: -

1. Understand the historical evolution and basic considerations in medicinal chemistry, including drug forms, applications, and biological actions, and factors influencing drug metabolism and interactions.
2. Explore drug classification, nomenclature, and the selection of essential drugs, along with physicochemical properties affecting biological activity like solubility, partition coefficient, and ionization.
3. Delve into Structure-Activity Relationships (SAR) and Quantitative Structure-Activity Relationships (QSAR), focusing on substituent effects, lipophilicity, electronic effects, and steric parameters in drug design.
4. Investigate prodrugs and their utility in enzyme activation, including various types and mechanisms of drug activation, such as carrier-linked prodrugs and bioprecursor prodrugs.
5. Analyze examples of drug action targeting cell membranes, walls, enzymes, receptors, and nucleic acids, including mechanisms of action and classes of drugs affecting each target area.
6. Examine the principles and techniques of combinatorial chemistry in drug synthesis, including solid support methods, parallel synthesis, and encoding methods for library generation and screening.
7. Explore drug metabolism processes, including phase-I and phase-II reactions, the role of Cytochrome P-450 enzymes, and factors influencing drug biotransformation in the body.

Semester IV Paper Title PC.SC.4.21: GENERAL PHARMACOLOGY

Student Learning Course Outcomes
After successful completion of this course, students will be able to: -

1. Understand the basics of pharmacology including drug sources, routes of administration, distribution, metabolism, and excretion, along with factors influencing drug effects and toxicity.
2. Explore sterilization methods and screening techniques for drug discovery, including bioassays, *in vitro* and *in vivo* studies, and methodologies for microbial assays.
3. Investigate drug-receptor interactions, affinity, and mechanisms of drug action, along with adverse drug reactions and the concept of drug allergy.
4. Examine microbial drug development, including microbiology fundamentals, fermentation processes, antimicrobial assays, and downstream processing.
5. Gain insights into immunology and immunopharmacology, covering the immune system, immune response mechanisms, hypersensitivity, immunodeficiency, and immunomodulation techniques.

Semester IV Paper Title PC.SC.4.22: DOSAGE FORMS AND REGULATORY ASPECTS

Student Learning Course Outcomes
After successful completion of this course, students will be able to: -

1. Learn about various dosage forms, including oral solids, liquids, suspensions, and emulsions, along with their production methods and quality control measures.
2. Understand the principles of stability in medicinal products, covering chemical and physical stability factors, such as hydrolysis, oxidation, and changes in crystal properties.
3. Explore current good manufacturing practices (GMP) and quality management requirements, including guidelines for manufacturing premises, equipment, documentation, and quality control.
4. Gain insights into process development for solid dosage forms and granulation, including validation of equipment, batch size definition, and regulatory aspects of process development.
5. Study novel drug delivery systems (NDDS) fundamentals, including sustained/controlled release mechanisms, factors influencing design, and pharmacokinetic/pharmacodynamic basis.
6. Explore the theory of mass transfer and Fick's law in the context of novel drug delivery systems, along with the assessment of bioavailability in controlled-release systems.
7. Understand the role of polymers in controlled release, including classification, properties of biocompatible/biodegradable polymers, and modeling drug release from different polymer matrices.

Semester IV Paper Title PC.SC. 4.23: BIOPHARMACEUTICS

Student Learning Course Outcomes
After successful completion of this course, students will be able to: -

1. Understand the structure of cell membranes and the mechanisms of gastrointestinal absorption of drugs.
2. Analyze the factors affecting drug absorption including biological, physiological, physico-chemical, and pharmaceutical factors.
3. Evaluate methods for determining drug absorption such as in-vitro, in-situ, and in-vivo methods.
4. Define and measure bioavailability, including the concept of equivalents and bioequivalence studies.
5. Demonstrate knowledge of dosage regimen principles including multiple dosing, loading dose, maintenance dose, and adjustment of dosage in renal and hepatic impairment.
6. Apply therapeutic drug monitoring concepts for individualization of therapy.
7. Demonstrate understanding of scale-up and pilot plant techniques in pharmaceutical production.
8. Analyze pharmaceutical production planning and control, including large-scale manufacturing techniques for solids, liquids, semisolids, and parenteral dosage forms.
9. Evaluate pre-approval inspections and post-operational activities including FDA evaluation, risk-based approach to inspections, and quality by design concepts.
10. Understand equipment cleaning procedures and their importance in pre-approval inspections.
11. Analyze distribution processes, handling of recalled and returned products, and management of complaints and adverse effects.
12. Understand the regulatory framework governing drug product design, manufacture, and distribution in India, including the Drugs and Cosmetics Act 1940 and its rules, National Pharmaceutical Pricing Authority (NPPA), and Intellectual Property Rights.
13. Evaluate registration requirements and regulatory procedures for various drug categories including new drugs, generics, medical devices, biologics, herbals, cosmetics, and fixed-dose combinations.
14. Analyze regulatory requirements for clinical trial registration, test license, commercial import license, manufacture license, and certificate of pharmaceutical product (CoPP).
15. Understand the organization and structure of the FDA and its regulatory processes in the USA including the Federal Register, CFR, FDC Act, Hatch-Waxman Act, and Orange Book.
16. Analyze regulatory approval processes for IND, NDA, ANDA, orphan drugs, and combination products.
17. Understand the organization of the EMA and marketing authorization procedures in the European Union, including variations, extensions, and IMPD requirements.
18. Evaluate regulatory requirements for generic drug registration, new drugs, and post-approval requirements in emerging markets such as BRICS countries and Egypt.

Semester IV Practical –I, PC: 4.03: Synthesis of Drugs and Drug intermediates-II

Student Learning Course Outcomes
After successful completion of this course, students will be able to: -

1. Students will develop practical skills in organic synthesis techniques, including reaction setup, monitoring, workup, and purification of synthesized compounds.
2. Students will gain a deep understanding of the reaction mechanisms underlying the synthesis of drugs and drug intermediates, including condensation, cyclization, and functional group transformations.
3. Learn to purify synthesized compounds using techniques such as recrystallization, column chromatography, and spectroscopic methods for compound characterization.
4. Apply knowledge of synthetic routes and transformations to design and execute efficient strategies for the synthesis of specific drug molecules and intermediates.
5. Adhere to safety protocols in laboratory practices, including proper handling of reagents, waste disposal, and ethical conduct in synthetic chemistry research.
6. Develop problem-solving skills to address challenges encountered during synthetic reactions, such as low yields, side reactions, and purification issues.
7. Effectively document experimental procedures, results, and observations through laboratory notebooks, reports, and presentations, fostering clear communication and record-keeping practices in synthetic chemistry research.

Semester IV Practical-II, PC: 4.04: Assay of drugs by titrimetric and instrumental methods – II

Student Learning Course Outcomes
After successful completion of this course, students will be able to: -

1. Students will develop practical skills in performing titrimetric and instrumental assays for the quantitative determination of drug concentrations in pharmaceutical formulations.
2. Gain a deep understanding of the principles underlying titrimetric and instrumental assays, including acid-base, redox, and complexometric reactions used in pharmaceutical analysis.
3. Interpret assay data obtained from titrations and instrumental measurements, including calculation of drug concentrations and assessment of assay accuracy and precision.
4. Learn to develop and validate assay methods for pharmaceutical analysis, including optimization of experimental conditions and assessment of method performance parameters.
5. Understand the importance of quality control in pharmaceutical analysis, including adherence to regulatory guidelines and validation requirements for assay methods.

Semester IV Practical-III, PC: 4.05: Project Work

Student Learning Course Outcomes
After successful completion of this course, students will be able to: -

1. Students will be able to design a research project in Pharmaceutical Chemistry, considering objectives, methodologies, and timelines for completion.
2. Develop proficiency in conducting multistage synthesis or isolation of active molecules from medicinal plants, employing appropriate laboratory techniques and equipment.
3. Conduct comprehensive literature reviews to gather relevant information on the chosen topic, including background information, previous research findings, and current trends in Pharmaceutical Chemistry.
4. Gain experience in using analytical techniques such as spectroscopy, chromatography, and spectrophotometry for compound characterization and evaluation of biological activities.
5. Analyze experimental data obtained from multistage synthesis, isolation, or pharmacokinetic studies, and interpret the results to draw meaningful conclusions.
6. Develop critical thinking skills to address research challenges and troubleshoot experimental issues encountered during the project work.
7. Effectively communicate research findings, methodologies, and conclusions through the preparation of a dissertation, adhering to appropriate scientific writing conventions and standards.
8. Present the research project findings during a viva voce examination, demonstrating the ability to articulate ideas, respond to questions, and defend the validity of the research conducted.
9. Understand and adhere to ethical principles in Pharmaceutical Chemistry research, including integrity in data collection, proper attribution of sources, and respect for human and animal subjects in pharmacokinetic studies.
10. Develop project management skills to organize research activities, allocate resources effectively, and meet project deadlines within the allotted timeframe.
11. Gain insight into the professional aspects of Pharmaceutical Chemistry research, including collaboration with peers, mentorship opportunities, and potential avenues for future research or career advancement.