Enclosure-VII (A)

Sarvodaya Kelavani Samaj managed,

Shri Manibhai Virani and Smt.NavalbenViraniScience College

(Autonomous)

(Affiliated to SaurashtraUniversity, Rajkot)

Re-Accredited at 'A' Level by NAAC

STAR college Scheme & Status by MST-DBT

UGC-College with Potential for Excellence (CPE)

UGC-DDU KAUSHAL Kendra

GAAA –Grade A-1 by KCG, Government of Gujarat

GPCB-Government of Gujarat approved EnvironmentAuditCenter

Nodal Center for capacity building by GSBTM

DEPARTMENT OF CHEMISTRY

SYLLABI FOR THE COURSES OF

M.Sc. Chemistry

(Specialization in Organic /Analytical Chemistry)

for Students Admitted from A.Y.-2019-20 & Onwards

Semester - I		
Course Code	**Course Title**	**Course Credit and hrs**
19PCECC101	**Core 1:Organic Chemistry**	**4 Credits - 4 hrs / wk**

Course Description:

The course is an introduction to organic chemistry, focusing primarily on the basic principles to understand the structure and reactivity of organic molecules. Emphasis is on various reactive intermediates and some important organic reagents. The course also provides an introduction to the chemistry of aromaticity of organic compounds.

Course Purpose:

- To understand various electronic effects and its applications on Stability, Acidity, Basicity, Nucleophilicity and Aromatic character of molecules.
- To impart knowledge of Reactive intermediates and the Hybridization, Structure, Generation, Stability, Reactivity &Applications of it.
- To familiarize students with, criteria of Aromaticity, Hückel's rule, Aromatic, Anti-aromatic and Non-aromatic compounds.

Course Outcomes: Upon completion of this course, the learner will be able to		
CO No.	**CO Statement**	**Blooms taxonomy Level (K1 to K6)**
CO_1	Understand concept and types of reaction mechanism, draw arrow notation, categorize bond cleavages, and generation of reactive intermediates.	K1, K2
CO_2	Understand the concept of various electronic effect and its applications.	K1, K2
CO_3	Predict the stability of reactive intermediates by applying electronic effect.	K2, K3
CO_4	Calculate aromaticity and differentiate between aromatic, anti-aromatic and non-aromatic compounds	K2, K3
CO5	Illustrate preparation of organic reagents and recognize appropriate reagent for particular reaction.	K1, K2

Prerequisite

Basic concepts of Chemical Bonding, Bonding and antibonding orbitals, Bond strengths (Bond Dissociation Energies), orbital overlap theory, collision theory, conjugation, electron withdrawing & electron donating groups, and Photochemical Activation.

Course Content **Hours**

Module-I: Electronic effects: **12 hrs**

Introduction, Temporary effect: Electromeric (Mesomeric) effect, Permanent Effects: Inductive effect, Resonance effect, Hyperconjugation effect and its applications (Stability, Acidity, Basicity, Nucleophilicity, Aromatic character).

Module-II : Reactive Intermediates-I: **14 hrs**

Homolytic and Heterolytic fission, Different types of arrow notation, concept and examples of Electrophiles and Nucleophiles. Hybridization, structure, generation, stability, reactivity & applications of Carbocation and Carbanion.

Module-III : Reactive Intermediates-II: **14 hrs**

Hybridization, structure, generation, stability, reactivity & applications of Free radicals, Carbenes, Nitrenes, Ylides, Benzyne and Enamines.

Module-IV : Aromaticity: **10 hrs**

Introduction, criteria of aromaticity, Hückel's rule, examples of aromatic, anti-aromatic and non-aromatic compounds. Aromatic character for annulenes, azulenes & heterocycles.

Module-V : Organic reagents: **10 hrs**

Structure, properties, synthesis and applications of:
(1) DDQ, (2) Dicyclohexylcarbodimide (DCC), (3) Lithium diisopropylamide (LDA), (4) $LiAlH_4$ (LAH), (5) *m*-Chloroperbenzoic acid (MCPBA)(6)N-Bromosuccinimide (NBS), (7) TBAB (Quaternary Ammonium salt), (8) Woodward & Prevost Hydroxylation.

Suggested laboratory experiments:

- Note: Included in Practical Core 1 & 2

Pedagogic tools:

- Chalk and Board, Power point presentation, models
- LCD and Videos.

Reference Books:

1. Ahluwalia, V. K. (2011, Fourth edition) *Organic Reaction Mechanism*. New Delhi: Narosa (ISBN: 978-81-8487-115-9).
2. Morrison & Boyd (2009, Sixth edition) *Organic Chemistry*. New Jersey: Pearson Education (ISBN: 978-81-7758-169-0).
3. McMurry, John E. (2011, Eight edition) *Organic Chemistry*. Boston: Cengage

Learning (ISBN: 0840054440).
4. Smith, Michael B.; March, Jerry (2013, Seventh edition) *March's Advanced Organic Chemistry: Reactions, Mechanisms and Structure*. Hoboken: Wiley-Blackwell (ISBN: 978-0-470-46259-1).
5. Bansal, Raj K. (2009, Fifth) *A Textbook of Organic Chemistry*. New Delhi: New Age International (ISBN: 978-81-224-2025-8).
6. T. W. Graham Solomons (2011, 10th edition) *Organic Chemistry*. Hoboken: John Willey & Sons (ISBN: 978-0-470-55659-7).

Laboratory Manual/ Book

- Not applicable.

Suggested reading / E-resources

- Organic Journal

Methods of assessing the Course Outcomes

- Continuous Internal Assessment(CIA)
- Semester End Evaluation (SEE)

Component of CIA

Sr. No	CIA Component	Content	Duration	Marks	Total Marks
1	Test-I	Two Modules	1.5 hrs	5 (Set for 30)	20
	Test-II	All modules	3 hrs	15 (Set for 60)	
2	Assignment	-	-	10	20
3	Class Activity	-	-	10	
Total					**40**

Semester - I		
Course Code	**Course Title**	**Course Credit and hrs**
19PCECC102	**Core 2: Analytical Chemistry**	**3 Credits - 3 hrs / wk**

Course Description:
The course nature is fundamental analytical chemistry, focusing primarily on fundamental of analytical methods, chemical calculations, green analytical techniques, various extraction techniques and Intellectual Property Rights (IPR).

Course Purpose:
- To understand fundamental concepts of classical and instrumental methods of analysis.
- To develop an understanding of different stoichiometric calculations and various extraction techniques.
- To familiarize students with the principle of green chemistry and its application for the sustainable development.

Course Outcomes: Upon completion of this course, the learner will be able to		
CO No.	**CO Statement**	**Blooms taxonomy Level (K1 to K6)**
CO_1	Differentiate basic analytical techniques and apply for various chemical analysis.	K1, K2
CO_2	Calculate modes of concentration for chemical analysis.	K2, K3
CO_3	Apply concept of non aqueous titration for chemical analysis.	K3, K4
CO_4	Understand the different terms and criteria of Intellectual Property right	K1, K2
CO_5	Employ appropriate extraction methods for the chemical separation.	K3, K4

Prerequisite
Basic concepts of types of chemical bonding, dissociation constants, concept of polarity, partition and distribution concept, pH, pKa and pKb values, law of mass conservation, and basics of chemical hazards.

Course Content **Hours**

Module-I : Fundamentals of analytical chemistry: **10 hrs**

Definitions, classification of analytical techniques and its importance. Types and application of quantitative analysis, Selection of analytical method, Gravimetric and volumetric analysis, Classical and instrumental

techniques, Types of Instrumental analysis, Factors affecting the analytical method, Law of mass action, Safety in analytical laboratory

Module-II : Chemical calculations: **10 hrs**

Concentration units, mole calculation, Empirical Formulas,% composition, yield calculations, standardization of solutions.
Statistical data analysis: Errors, types of errors, taste of significance, T test, F test, mean, medium, SD, and RSD.

Module-III : Non-aqueous titrations: **07 hrs**

Role of solvents, properties of solvents, autoprotolysis and dielectric constant, Titration of acids-bases, solvent system, leveling solvents, titrants, standard titration curves, effect of water, end point detection.

Module-IV : Extraction Techniques **08 hrs**

Introduction, theory, types of extraction (LLE, SSE, LSE), Different extraction methods (Maceration, Infusion, Digestion, Decoction, Percolation, Solvent extraction, Soxhlet Extraction, Counter current extraction, Sonication, Supercritical fluid extraction, Steam distillation), Application.

Module-V : Intellectual Property Rights (IPR): **10 hrs**

Introduction, various Technical Terms, Legislation, IPA in India, Criteria for Patent, Non-patentable inventions, Patent for Polymorph, UPOV & Plant patents.

Suggested laboratory experiments:

- Note: Included in Practical Core 1 & 2

Pedagogic tools:

- Chalk and Board, Power point presentation, models
- LCD and Videos.

Reference Books:

1. B. K. Sharma (2014) *Instrumental method of chemical analysis*.Meerut: Krishna Prakashan Media (P) Ltd. (ISBN: 978-8182836730).
2. Stanley Crouch, Donald West, F Holler, Douglas A. Skoog (2013, 9th edition) *Fundamentals of Analytical Chemistry*.Meerut: Brooks/Cole Publishing Company (ISBN: 978-0495558286).
3. B. Sivasankar (2012) *Instrumental Methods of Analysis*. Oxford University Press(ISBN: 978-0198073918).
4. Gary D. Christian, Purnendu K. Dasgupta, Kevin A. Schug (2013, 7th edition)*Analytical chemistry*. John Wiley & sons, Inc. (ISBN: 978-0-470-88757-8).
5. Douglas A. Skoog, F. James Holler, Timothy A. Nieman(1998, 5th edition)*Principles*

of instrumental analysis.HARCOURT ASIA PTE, LTD. (ISBN: 978-0030020780).
6. Gurdeep R. Chatwal, Madhu Arora (2015, 5th edition) *Analytical Chemistry*Himalya Publishing House (ISBN: 978-9352023035).
7. Verma R. M. (2019, 3rd edition) *Analytical ChemistryTheory and Practice*. CBS Publishing (ISBN: 978-8123902661).

Laboratory Manual/ Book

- Not applicable

Suggested reading / E-resources

- E-Journals

Suggested MOOCs

- NA

Methods of assessing the Course Outcomes

- Continuous Internal Assessment(CIA)
- Semester End Evaluation (SEE)

Component of CIA

Sr. No	CIA Component	Content	Duration	Marks	Total Marks
1	Test-I	Two Modules	1.5 hrs	5 (Set for 30)	20
	Test-II	All modules	3 hrs	15 (Set for 60)	
2	Assignment	-	-	10	20
3	Class Activity	-	-	10	
Total					**40**

Semester - I		
Course Code	**Course Title**	**Course Credit and hrs**
19PCECC103	**Core 3: Inorganic Chemistry**	**4 Credits - 4hrs / wk**

Course Description:

The course inorganic chemistry includes stereochemistry and bonding of compounds, introduction of transition elements and theory of Coordination Compounds. It also includes concept of crystal field theory, symmetry and point group theory and basics of organometallic complexes.

Course Purpose:

- To understand the bonding concepts that explains the structures of both main group and transition elements.
- To calculate coordination number and spectral term symbol for coordination compounds.
- To apply the knowledge of CFT for different shapes of complexes and illustrate character table for point groups.

Course Outcomes: Upon completion of this course, the learner will be able to		
CO No.	**CO Statement**	**Blooms taxonomy Level (K1 to K6)**
CO_1	Predict bond order & shapes of covalent compounds using MO & VB theories.	K1, K2
CO_2	Classify coordination compounds & predict isomerism, coordination number, shapes and spectral term symbol for coordination compounds.	K1, K2
CO_3	Understand and apply CFT for splitting of d-orbitals in octahedral, tetrahedral and square planner complexes.	K1, K2
CO_4	Determine symmetry elements and their point groups of molecules by point group theory	K4
CO_5	Recognize bonding, synthesis and application of organometallic complexes.	K1, K2

Prerequisite

Basic concepts of Chemical Bonding, MO, VB, VSEPR theory, shape of molecules, bond length, bond order, bond angle, s, p, d, f-block elements, coordination compounds, multi electron system, d-orbital splitting, and emission spectroscopy.

Course Content **Hours**

Module-I : Stereochemistry and Bonding in compounds **12 hrs**

Valance bond theory, Types of overlapping, Molecular orbital theory, Bond order, Factor affecting on Bond length (Bond strength),

Homonuclear diatomic molecules, Heteronuclear diatomic molecules, Shapes of covalent compounds, VSEPR, Hybridization.

Module-II : Transition Elements & Coordination Compounds **12 hrs**

Classification of Coordination compounds, Werner's theory, Nomenclature, Isomerism, Coordination number, structures and shapes, electronic spectra (spectroscopic terms, term symbols, calculation of spectroscopic terms).

Module-III : Crystal Field Theory **14 hrs**

Concept of crystal field theory, Crystal Field Splitting of d-orbitals (Octahedral, tetrahedral and square planner complexes with CFSE concept), Factors affecting the value of Δ_0, High spin and Low spin complexes, Td distortion, Jahn-Teller effect, splitting of d and f ground terms and its orgel diagram, Example based on CFSE, Pairing energy and magnetic momentum.

Module-IV : Symmetry and Point Group Theory **12 hrs**

Symmetry elements and Operations, Point groups and their symmetry elements, Properties and representation of Groups (Matrices, Representation of point groups, character table). Examples and application of symmetry.

Module-V : Organometallic Complexes **10 hrs**

Introduction, Structure & Classification, 18 electron rule, hepticity, ligands in organometallic chemistry, Metal-Carbonyl and clusters, Organometallic catalysis: Hydroformylation, Monsanto acetic acid process, Wacker (Smidt) process, Wilkinson's catalyst, Mond process.

Suggested laboratory experiments:

- Note: Included in Practical Core 3 & 4

Pedagogic tools:

- Chalk and Board, Power point presentation, models
- LCD and Videos.

Reference Books:

1. Agarwala S. K.; Lal K. (2009), *Advanced Inorganic Chemistry*, Meerut (ISBN: 978-81-8398-773-8).
1. Miessler, G. L; Fischer, P. J.;Tarr, D. A. (2014, sixth edition) *Inorganic Chemistry.* Library of Congress Cataloging-in-Publication Data (ISBN: 978-0-321-81105-9).
2. Prasad, R. K. (2004, Second edition) *Quantum Chemistry*. New Delhi: New Age International (P) Ltd. (ISBN: 81-224-1264-5).
3. Chandra, A. K. (2008, Fourth edition) *Introductory Quantum Chemistry*, New Delhi:

Tata McGraw-Hill. (ISBN: 0-07-462054-1).
4. Singh, A.; Singh, R. (2005) *Textbook of Inorganic Chemistry Vol. I & II*. New Delhi: Campus Books International (ISBN: 8180300714).
5. Mehrotra, R. C. and Singh, A. (2004, Second edition) *Organometallic Chemistry A Unified Approach*, New Delhi: New Age International (P) Ltd. (ISBN: 81-224-1258-05).

Laboratory Manual/ Book

- Not applicable

Suggested reading / E-resources

- NA

Suggested MOOCs

- NA

Methods of assessing the Course Outcomes

- Continuous Internal Assessment(CIA)
- Semester End Evaluation (SEE)

Component of CIA

Sr. No	CIA Component	Content	Duration	Marks	Total Marks
1	Test-I	Two Modules	1.5 hrs	5 (Set for 30)	20
	Test-II	All modules	3 hrs	15 (Set for 60)	
2	Assignment	-	-	10	20
3	Class Activity	-	-	10	
Total					**40**

Semester - I		
Course Code	**Course Title**	**Course Credit and hrs**
19PCECC104	**Core 4: Physical Chemistry**	**3 Credits - 3hrs / wk**

Course Description:
This course provides a basic understanding of the core area of physical chemistry, based around chemical kinetics, properties of solutions, Free Energy and Chemical Reactions, Homogeneous & Heterogeneous Catalysis and polymer chemistry.

Course Purpose:
- To identify the order of reaction by using concepts of chemical kinetics.
- To understand fundamentals of solutions and its deviation from ideal behaviour.
- To apply the concept of catalyst and identify polymers by employing analytical methods.

Course Outcomes: Upon completion of this course, the learner will be able to		
CO No.	**CO Statement**	**Blooms taxonomy Level (K1 to K6)**
CO_1	Recall types & order of chemical reaction	K1
CO_2	Understand properties & behavior of ideal, non-ideal and dilute solutions	K1, K2
CO_3	Distinguish Free energy change and its applications in chemical reactions	K2, K3
CO_4	Classify the types, characteristics and mechanism of homogeneous & heterogeneous catalysis.	K2, K3
CO_5	Derive synthesis of polymers and its identification by different techniques.	K2, K3

Prerequisite
Basic concepts of chemical kinetics, Henry's law, Raoult's law, colligative properties of solution, law of mass, equilibrium constant, and type of catalysis, polymer.

Course Content **Hours**

Module-I : Chemical kinetics: **10 hrs**

- Introduction of Chemical kinetics, Types of reaction: reversible reaction, opposite reaction, successive reaction, consecutive reaction, simultaneous reaction, parallel reaction, order of reaction, zero order, First order reaction in solution, Pseudo unimolecular reaction, Second order reaction, Pseudo Bimolecular reaction, Third order reaction, n^{th} order, molecularity with example, Effect of temperature on rate of reaction, Temperature

coefficient, Arrhenius equation, the temperature dependence reaction rates, Interpretation of Arrhenius parameters, Activation energy, Collision theory.

Module-II : The Properties of Solutions: **10 hrs**

Ideal solutions: Properties, the Duhem-Margules equation, vapour pressure curves. Composition of liquid and vapour in equilibrium influence of temperature on gas solubility and solid-liquid equillibria.

Non ideal solutions: Deviation from ideal behavior, vapour pressure curves, liquid and vapour compositions. General equations for liquid mixtures, partially miscible liquids

Dilute solutions: Henry's law. Determination of molecular weights from freezing and boiling points. Problems.

Module-III : Free Energy and Chemical Reactions **10 hrs**

- Chemical equilibrium and the equilibrium constant: Equilibrium in homogeneous gaseous systems. Homogeneous reactions in liquid solutions. Homogeneous reactions in dilute solutions. Chemical equilibria in heterogeneous systems. Free energy change in chemical reactions: The reaction isotherm, standard free energy of reaction, the direction of chemical variation of equilibrium constant with pressure and temperature. Influence of temperature on heterogeneous reactions. Integration of the Van't Hoff equation. Variation of standard free energy with temperature. Simultaneous equilibria. Formation of standard free energies and entropy changes and their applications, problems.

Module-IV : Homogeneous & Heterogeneous Catalysis **08 hrs**

- Introduction, types of catalysis (Homogeneous & heterogeneous) & their characteristics. Theory of catalysis, autocatalysis, promoters or activators, types of acid base catalysis. Mechanism of acid-base catalysis & catalytic coefficients, Enzyme catalysis.

Module-V : Polymer Chemistry **07 hrs**

- Introduction & classification of polymers, synthesis of some general polymers, identification of polymer: chemical analysis, spectroscopic methods, X-ray diffraction and, thermal analysis.

Suggested laboratory experiments:

- Note: Included in Practical Core 3 & 4

Pedagogic tools:

- Chalk and Board, Power point presentation, models
- LCD and Videos.

Reference Books:

1. Glasstone, Samuel. (2007) *Thermodynamics for Chemists*: Narahari Press (ISBN: 1406773220).
2. Peter Atkins, Julio de Paula (2015) *Physical chemistry*. Thomson Press (ISBN: 019872872-7).
3. Gurdeep Raj (2014, Third edition) *Thermodynamics*. Meerut: GOEL publishing House (ISBN: 8187224886).
4. Gurtu, J. N. Gurtu, A. (2014, Twelfth edition) *Advanced Physical Chemistry*. Meerut: Pragati Prakashan (ISBN: 9350060191).
5. Barrow, Gordon M. (1996, Sixth edition) *Physical Chemistry*. New York: McGraw-Hill International. (ISBN: 0070051119).
6. V R Gowariker, (2012) *Polymer Chemistry*. New age International P limited. (ISBN: 978-0-85226-307-5).

Laboratory Manual/ Book

- Not required

Suggested reading / E-resources

- NA

Suggested MOOCs

- NA

Methods of assessing the Course Outcomes

- Continuous Internal Assessment(CIA)
- Semester End Evaluation (SEE)

Component of CIA

Sr. No	CIA Component	Content	Duration	Marks	Total Marks
1	Test-I	Two Modules	1.5 hrs	5 (Set for 30)	20
	Test-II	All modules	3 hrs	15 (Set for 60)	
2	Assignment	-	-	10	20
3	Class Activity	-	-	10	
Total					**40**

Semester – I		
Course Code	**Course Title**	**Course Credit and hrs**
19PCECC105	**Practical Core 1 & 2: Organic & Analytical Chemistry**	**3 Credits - 5 hrs / wk**

Course Description:
This course provides practicals of separation and qualitative analysis of organic mixtures. The course also includes preparation and calibration of solutions used every day in laboratory.

Course Purpose:
- To separate organic ternary mixtures and identify the unknown compounds by qualitative tests.
- To prepare and standardize solution used in routine laboratory practical.
- To extract and isolate chemical constituents from the mixture.

Course Outcomes: Upon completion of this course, the learner will be able to		
CO No.	**CO Statement**	**Blooms taxonomy Level (K1 to K6)**
CO_1	Perform Qualitative Analysis of a ternary organic mixture	K3,K4
CO_2	Prepare and standardize the solutions.	K2, K3
CO_3	Demonstrate Calibration of glassware and apparatus.	K3
CO_4	Measure the Assay and % Purity of fine chemicals.	K2
CO_5	Employ appropriate extraction methods for the chemical separation	K4,K5

Prerequisite
Chemical nature of compounds, solubility products, mp and bp determination, modes of concentration, calibration of primary apparatus, partition phenomena.

Course Content **Hours 6 hrs / practical**

1. **Organic Chemistry:**
    - Ternary Mixture Separation &Qualitative analysis. (12 exercise)

2. **Analytical Chemistry:**(12 exercise)
    - Preparation and standardization of solutions.
    - Calibration of glassware and apparatus.
    - Assay & % Purity of chemicals.
    - Extraction.

Pedagogic tools:

- NA

Reference Books:

1. Brian S. Furniss (1989, 5th edition) *Vogel's Textbook of Practical Organic Chemistry*. Hoboken: John Willey & Sons (ISBN: 0-582-462363).
2. Jeffery, G. H.; Bassett, J.; Mendham, J.; Denny, R. C. (1989) *Vogel's Textbook of Quantitative Chemical Analysis*. Hoboken: John Willey & Sons (ISBN: 0-582-44693-7).

Laboratory Manual/ Book

- Comprehensive Practical Analytical Chemistry by Dr. H. S. Joshi

Suggested reading / E-resources

- NA

Suggested MOOCs

- NA

Methods of assessing the Course Outcomes

The COs of the course will be assessed through

- CIA and SEE

Component of CIA

Sr. No	CIA Component	Content	Duration	Marks	Total Marks
1	Test	50% to 60 % of Experiment	3 hrs	30	30
2.	Observation book & Record	-	-	10	10
Total					**40**

Semester - I		
Course Code	**Course Title**	**Course Credit and hrs**
19PCECC106	**Practical Core 3 & 4: Inorganic & Physical Chemistry**	**3 Credits - 5hrs / wk**

Course Description:
This course provides qualitative analysis of inorganic mixtures including one less common / rare metal ion. The course also deals with estimation of various physical parameters by instrumental and conventional methods.

Course Purpose:
- To separate and identify inorganic ternary mixtures by qualitative tests.
- To estimate various physical parameters using different instruments and classical titrimetric method.

Course Outcomes: Upon completion of this course, the learner will be able to		
CO No.	**CO Statement**	**Blooms taxonomy Level (K1 to K6)**
CO_1	Perform Qualitative Analysis of an inorganic mixture containing six radicals.	K3, K4
CO_2	Utilize Conductivity meter, pH & Potentiometer, Refractometer, and Ultrasonic instrument for physicochemical analysis.	K2, K3
CO_3	Demonstrate experiments on Partition Co-efficient, First and second order reactions-order determination, energy of activation, Heat of vaporization, Partial molar volume.	K3, K4

Prerequisite
Solubility products, dry and wet test of radicals, calibration of primary instruments, preparation and standardization of solutions.

Course Content **Hours**

1. **Inorganic Chemistry:**(12 exercise) **6 hrs / practical**
   Qualitative Analysis: Analysis of a mixture containing six radicals including one less common / rare metal ion.

2. **Physical Chemistry:**(20 exercise)
   - **Conductometry:** Mono and biprotic acids, mixtures of acids against strong/weak bases, hydrolysis constant, verification of Onsagar's equation
   - **pH metry**: Quantitative drug analysis, Hemmet constant, hydrolysis constant of electrolytes, acid-base titration, pKa of acids.

- **Refractometry**: Molar refraction, refractive index, composition of Binary mixtures.
- **Potentiometry**: Acid-base, normality and dissociation constant, Redox and Argentometric titrations.
- **Ultrasonic**: Acoustical parameters of liquids, compressibility of binary mixture.
- **Partition Co-efficient**: Distribution of Benzoic acid in organic solvent & aqueous phase, equilibrium constant by distribution method.
- **Reaction Kinetics**: First and second order reactions-order determination, energy of activation.
- **Thermodynamics**: Heat of vaporization, Partial molar volume, etc.

Pedagogic tools:

- NA

Reference Books:

1. Svehla, G. (1996, 7th edition) *Vogel's Qualitative Inorganic Analysis*. New Jersey: Pearson Education. (ISBN: 0582218667).
2. Parsania P. H (2005, 1st edition) *Experiments in Physical Chemistry*, Granth Nirman Board.

Laboratory Manual/ Book

- Not applicable.

Suggested reading / E-resources

- NA

Suggested MOOCs

- NA

Methods of assessing the Course Outcomes

The COs of the course will be assessed through

- CIA and SEE

Component of CIA

Sr. No	CIA Component	Content	Duration	Marks	Total Marks
1	Test	50% to 60 % of Experiment	3 hrs	30	30
2.	Observation book & Record	-	-	10	10
Total					**40**

Semester - II		
Course Code	**Course Title**	**Course Credit and hrs**
19PCECC201	**Core 5: Separation Techniques**	**4 Credits - 4 hrs / wk**

Course Description:

Thorough familiarization of students with chromatography as an analytical technique for separation, isolation and identification of organic/natural compound from multi-component mixtures. The course gives a theoretical as well as a practical introduction to principles and techniques of chromatography: adsorption and partition chromatography (normal and reversed-phase systems), thin layer chromatography (TLC), column liquid chromatography including HPLC, gas chromatography, ion exchange and size exclusion chromatography.

Course Purpose:

- To understand concept, types, instrumentation and applications of various planner and column chromatography techniques.
- The course provides hands-on training on TLC and Column.
- Demonstrative training of sophisticated instruments like HPLC and GC.

Course Outcomes: Upon completion of this course, the learner will be able to		
CO No.	**CO Statement**	**Blooms taxonomy Level (K1 to K6)**
CO_1	Understand the principle, fundamental theory and instrumentation of various planar and column chromatographic techniques.	K1, K2
CO_2	Identify the significance, quality, and limitations of the results produced by the various separation techniques.	K2, K3
CO_3	Apply theoretical knowledge to design and develop suitable operating conditions for separation and identification of organic/natural compounds from multi-component mixtures	K4
CO_4	Calculate R_f values and Interpret HPLC and GC chromatograms to perform qualitative analysis of unknown	K3, K4
CO_5	Differentiate various applications of separation techniques to medicinal and pharmaceutical field.	K4

Prerequisite

Basic concepts and terminologies of chromatography, different types of chromatography.

Course Content **Hours**

Module-I: Introduction and Basic Theory of Chromatography: 12 hrs

Introduction, history, principle, different terms in chromatography, basic theory, classification based on SP, MP, and attractive force (adsorption,

partition, ion exchange and size exclusion), plate theory, rate theory& applications.

Module-II: Column Chromatography: **12 hrs**

Principle, basic theory of manual column, Adsorbent, types of column chromatography, manual techniques, Advantage and disadvantage
Ion-exchange chromatography: Principle, Theory, Ion exchangers, Effective parameter and Application
Affinity chromatography: Principle, Theory, Applications.

Module-III: Planar Chromatography (TLC & HPTLC): **12 hrs**

Thin Layer chromatography (TLC):
Principle, basic theory, techniques of TLC, Argentometric chromatography, mode of TLC, 2D-TLC and application
High Performance thin layer Chromatography (HP-TLC):
Principle, Theory, Instrumentation and application

Module-IV: Gas Chromatography (GC): **12 hrs**

Introduction and definition of GC and HSGC
GC: Principle, working theory, instrumentation and applications
GC-MS: Principle, working theory and applications

Module-V:Liquid Chromatography(HPLC): **12 hrs**

Introduction and definition of terms HPLC, UPLC, OPLC
HPLC: Principle, working theory, instrumentation and applications
LC-MS: Principle, working theory and applications

Suggested laboratory experiments:

- **Note:** Included in Practical Core 5 & 6:

Pedagogic tools:

- Chalk and Board, Power point presentation, models
- LCD and Videos.
- Live Demonstration of Instruments

Reference Books:

1. Gary D. Christian, Purnendu K. Dasgupta, Kevin A. Schug (2013, 7th edition) *Analytical chemistry*. John Wiley & sons, Inc. (ISBN: 978-0-470-88757-8).
2. Stanley Crouch, Donald West, F Holler, Douglas A. Skoog (2013, 9th edition) *Fundamentals of Analytical Chemistry*. Meerut: Brooks/Cole Publishing Company (ISBN: 978-0495558286).
3. Sethi, P. D. (2013, 3 Volume Set) *HPTLC: High Performance Thin Layer Chromatography: Quantitative Analysis of Pharmaceutical Formulations*. New Delhi: CBS Publishers & Distributors Pvt. Ltd. (ISBN: 9788123922799).

4. Stahl, E. (1969, 2nd edition) *Thin-Layer Chromatography: A Laboratory Handbook*. New Berlin: Springer. (ISBN: 978-3-642-88488-7).
5. Satinder Ahuza (2002, 4 Volume, 1st Edition) *Chromatography and Separation Science*. Academic Press. (ISBN: 9780080501123).
6. B. K. Sharma (2014) *Instrumental method of chemical analysis*. Meerut: Krishna Prakashan Media (P) Ltd. (ISBN: 978-8182836730).
7. Dr. A. V. Kasture, Dr. S. G. Wadodkar, Dr. K. R. Mahadik, Dr. H. N. More (2008, 7th edition) *Pharmaceutical Analysis Vol.- II*. Nirali Prakashan. (ISBN: 978-8185790084).
8. Gurdeep R. Chatwal (2012) *Instrumental Methods of chemical analysis*. Himalaya Publishing House. (ISBN: 978-9350515310).
9. Howard A. Strobel, William R. Heineman. (1989, 3rd edition) *Chemical instrumentation: Asystematic Approach*. Wiley-Interscience. (ISBN: 978-0471612230).

Laboratory Manual/ Book

- Not applicable.

Suggested reading / E-resources

- http://www.nptel.ac.in/courses/104103069/#
- http://ocw.mit.edu/courses/chemistry/
- Part A (Journal of Chromatography Library). Philadelphia: Elsevier Publishing Company. (ISBN: 0444511075).
- Journal of Planar chromatography (JPC)

Methods of assessing the Course Outcomes

- Continuous Internal Assessment (CIA)
- Semester End Evaluation (SEE)

Component of CIA

Sr. No	CIA Component	Content	Duration	Marks	Total Marks
1	Test-I	Two Modules	1.5 hrs	5 (Set for 30)	20
	Test-II	All modules	3 hrs	15 (Set for 60)	
2	Assignment	-	-	10	20
3	Class Activity	-	-	10	
Total					40

Semester - II		
Course Code	**Course Title**	**Course Credit and hrs**
19PCECC202	**Core 6: Organic Reactions & Rearrangements**	**3 Credits - 3 hrs / wk**

Course Description:

Organic Reaction and Rearrangements is a step by step description of a sequence of basic reactions through which the overall chemical change occurs. Which bonds brakes, which forms, in which sequence, how many steps are involved and relative rates of each such steps are the details one can obtain through the study of reaction mechanism.

Course Purpose:

- To understand concept and types of reaction mechanism.
- To determine the stability of reactive intermediates.
- To understand Principle, plausible reaction mechanism and applications of various organic named reactions.
- To understand concept of molecular rearrangement and its applications in organic synthesis.

Course Outcomes: Upon completion of this course, the learner will be able to		
CO No.	**CO Statement**	**Blooms taxonomy Level (K1 to K6)**
CO_1	Understand concept and types of reaction mechanism draw arrow notation, categorize bond cleavages.	K1, K2
CO_2	Extend concept of molecular rearrangement and describe plausible reaction mechanism mentioning its applications in organic synthesis.	K1, K2
CO_3	Describe Principle, plausible reaction mechanism and applications of various organic reactions.	K2, K3
CO_4	Identify suitable starting material, reagent and reaction condition or product for given organic transformations.	K3
CO_5	Apply concept of various reaction and rearrangements to predict plausible product(s).	K3, K4

Prerequisite

Fundamentals of structure, shapes and reactivity of reactive intermediates like Carbocation, Carbanion, Free radical, Carbene, Nitrene, Ylides, Enamines and Dithioketene acetal. Types of arrows, types of reactions.

Course Content **Hours**

Module-I: Reaction based on Reactive Intermediates-1: **10 hrs**

Principle, mechanism and applications:

- **Carbocation**: Beckmann, Pinacol-Pinacolone, Demjanov rearrangement, Benzilic acid rearrangement.

- **Carbanion**: Aldol condensation, Perkin reaction, Dieckmann condensation, Michael addition, Grignard reaction.
- **Free radical**: Sandmeyer, Wurtz-Fittig, Hunsdiecker reaction.

Module-II : Reaction based on Reactive Intermediates-2: **10 hrs**

Principle, mechanism and applications:

- **Carbene**: Wolf rearrangements, Riemer-Tiemann reaction.
- **Nitrene**: Hoffmann, Curtius, Schmidt rearrangement.
- **Ylides, Enamines and Dithioketene acetal**: Wittig, Stork enamine, Junjappa-Ila reaction.
- **Homologation**: Arndt-Eistert, Corey-Fuchs alkyne synthesis.

Module-III : Reaction based on Cyclization: **10 hrs**

Principle, mechanism and applications:

- **Carbocyclic formation**: Robinson annulation, Danishefsky's diene cycloaddition.
- **Heterocyclic formation**: Fischer indole, Knorr pyrrole, Von Pechman reaction.
- **Pericylic and metathesis**: Diels alder cycloaddition, Hetero Diels alder, Aza-Cope rearrangement, Claisen rearrangement, alkene and alkyne (Enyne) metathesis.

Module-IV : Multicomponent Reactions: **07 hrs**

Principle, mechanism and applications: Ugi, Biginelli, Hantzsch dihydropyridine, Mannich reaction.

Module-V : Cross coupling Reactions: **08 hrs**

Pd-catalyzed cross coupling reaction: Principle, mechanism and applications: Suzuki, Sonogashira, Heck, Negashi, Kumada, Stille, Buchwald-Hartwig reaction.

Suggested laboratory experiments:

- Note: Included in practical Core -5 & 6.

Pedagogic tools:

- Chalk and Board, Power point presentation, models
- LCD and Videos.

Reference Books:

1. Ahluwalia, V. K. (2011, 4thedition) *Organic Reaction Mechanism*. New Delhi: Narosa (ISBN: 978-81-8487-115-9).
2. László Kürtip; Barbara Czakó (2004, 1stedition) *Strategic Applications of Named Reaction in Organic Synthesis*. Philadelphia: Elsevier Publishing company (ISBN: 9780124297852).
3. Morrison Boyd & Bhattacharjee (2010, 7th edition) *Organic Chemistry*. Pearson Education India (ISBN: 978-8131704813).
4. John McMurry (2015, 9thedition) *Organic Chemistry*. CENGAGE Learning Custom Publishing. (ISBN: 9781305080485).

5. Michael B. Smith Jerry March (2006, 6th Edition) *March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure*. John Wiley & Sons, Inc. (ISBN:9780470084960).
6. Raj K. Bansal (2016, 6th Edition) *A text book of Organic Chemistry*. New Age International (P) Ltd. (ISBN: 9788122439670).
7. T. W. Graham Solomons, Craig B. Fryhle, Scott A. Snyder (2016, 7th Edition) *Organic Chemistry*. John Wiley & Sons, Inc. (ISBN: 978-1-118-87576-6).

Laboratory Manual/ Book

- Not applicable.

Suggested reading / E-resources

- https://www.organic-chemistry.org/reactions.htm
- https://www.masterorganicchemistry.com/reaction-guide/

Suggested MOOCs

- Organic Reactions-SWAYAM
- Organic Reactions-NPTEL

Methods of assessing the Course Outcomes

- Continuous Internal Assessment (CIA)
- Semester End Evaluation (SEE)

Component of CIA

Sr. No	CIA Component	Content	Duration	Marks	Total Marks
1	Test-I	Two Modules	1.5 hrs	5 (Set for 30)	20
	Test-II	All modules	3 hrs	15 (Set for 60)	
2	Assignment	-	-	10	20
3	Class Activity	-	-	10	
Total					40

Semester II		
Course Code	**Course title**	**Course Credit and hrs.**
19PCECC203	**Core 7: Stereochemistry**	**3 Credits - 3 hrs./Wk**

Course Description:

Stereochemistry of molecules dictates isomerism, chemical and biochemical reactivity. These days, chiral drugs have become an integral part of pharmaceutical industry. A basic concept on 3D structures, different projection formula, conformations of molecules and asymmetric synthesis and other stereochemical principles and attributes are essential. This course will lay the foundation on to which further advanced topics can be built up.

Course Purpose:

1. To understand and describe Fundamental of Stereochemistry.
2. To discuss Prochirality and Asymmetric Synthesis.
3. To describe Conformational Analysis & Reactivity.
4. To describe Stereochemistry of Substitution, Elimination Reactions and addition reactions.

Course Outcomes: Upon completion of this course, the learner will be able to		
CO No.	**CO Statement**	**Blooms taxonomy Level (K1 to K6)**
CO_1	Understand the fundamentals of stereochemistry and able to draw stereoisomers of organic compounds, and recognize diastereomers, enantiomers, meso compounds and centers of symmetry.	K1, K2
CO_2	Able to discuss the relative stability of conformational isomers of cyclohexanes and related compounds.	K1, K2
CO_3	Recognize and discuss the stereoisomers of chiral compounds that do not contain a stereogenic carbon center and assign the configuration of the stereoisomer.	K2, K3
CO_4	Understand and identify the Substitution Nucleophilic (SN1, SN2, SNi & Mixed SN1 & SN2) and Elimination reaction (E1, E2 and E1cB) mechanism and stereochemistry and Addition Reactions to Carbon-Hetero multiple bond.	K1, K2, K3
CO_5	Apply the stereochemistry concept to identify configuration, conformation, stereochemical notations, Nucleophilic substitution, elimination, reduction and addition reactions to Carbon-Hetero multiple bond.	K2, K3, K4

Prerequisite

Basic concept of optical activity, isomers, chiral center, threo & erythro nomenclature, E & Z and D & L isomers, R & S nomenclature.

Course Content **Hours**

Module-I: Fundamental of Stereochemistry: 10 Hrs

Chirality, Isomers, Classification of stereoisomerism, Optical isomerism, Conventions for D, L and R, S- system, Inter-conversion between Fischer and Three-dimensional formulas with one stereo center, Stereoisomerism for more than one stereogenic unit, Threo & Erythro, Geometrical isomerism, Cis/Trans, E-Z isomerism resulting from double bonds, Oximes, Racemic mixtures and Racemization, Resolution of racemic mixtures, Optical purity & Enantiomeric excess, Formation of diastereomers, Stereoselective and stereospecific reactions, Stereoisomerism without a stereogenic carbon (axial chirality), Planar chirality, Helicity and Molecular stereoisomerism.

Module-II: Prochirality and Asymmetric Synthesis: 08 Hrs

Introduction, Homotopic & Heterotopic ligands and faces, Enantiotopic ligands & faces, Asymmetric synthesis.

Module-III: Conformational Analysis & Reactivity: 10 Hrs

Restricted rotation around single bonds-confirmations of ethane & butane, Origin of conformational energy, Conformations and chemical reactivity of acyclic system, Cycloalkane ring other than cyclohexane, Conformations of substituted cyclohexane, Stereoisomerism in di-substituted cyclohexane, Effect of confirmations on reactivity-cyclic system, Conformation of heterocycles, Conformation of sugars (Fisher, Haworth and chair), Epimers, Anomers, Epimerization and Anomeric effect.

Module-IV: Stereochemistry of Substitution & Elimination Reactions: 08 Hrs

- **Aliphatic Nucleophilic Substitution Reactions**: Introduction, stereochemistry of SN1 & SN2 reaction mechanism, The S_Ni mechanism, Mixed SN1 & SN2 reaction, ambident nucleophile, Regioselectivity, Neighboring group participation.
- **Stereochemistry of Elimination Reactions:** Introduction, Mechanism E1, E2 and E1cB, Stereochemistry of E2-anti-ellimination reaction, E2-syn-elimination, Orientation of the double bond, Pyrolytic elimination.

Module-V: Stereochemistry of Addition Reactions to Carbon-Hetero multiple bonds: 09 Hrs

Introduction, Stereo chemical aspects of addition to carbonyl compounds, Stereochemistry of metal hydride reduction, Cannizzaro reaction, Meerwein-

Ponndorf reduction, Addition of organometallic compounds, Conjugate addition of organocopper reagents.

Suggested laboratory experiments:

- Included in core practical-7

Pedagogic tools:

- Chalk and Board, Stick-ball 3D models, direct explanation.
- Power point presentation, LCD and Videos.

Reference Books:

1. Kalsi, P. S. (2012, 4thedition) *Organic Reactions Stereochemistry and Mechanism (Through Solved Problems)*. New Delhi: New Age International (P) Limited. (ISBN: 9788122417661).
2. Kalsi, P. S. (2011, 7thedition) *Stereochemistry Confirmation and Mechanism*. New Delhi: New Age International (P) Limited. (ISBN: 81-224-2356-6).
3. Nasipuri, D. (2011, 3rdedition) *Stereochemistry of Organic Compounds: Principles and Applications*. New Delhi: New Age International (P) Limited. (ISBN: 978-81-224-3029-5).
4. Finar, I. L. (1989, 5thedition) *Organic Chemistry: Vol -2: Stereochemistry and the Chemistry of Natural Products*. Harlow: Longman. (ISBN: 0-582-05916-X).
5. Clayden Jonathan; Greeves Nick, Warren Stuart (2012, 2ndedition) *Organic Chemistry*. Oxford: Oxford University Press (ISBN: 0199270295).
6. Eliel, Ernest L., Wilen, Samuel H. (1994) *Stereochemistry of Organic Compounds*. Hoboken: Wiley-Blackwell (ISBN: 0471016705).
7. Nogradi, M. (2008, 2ndrevised and updated edition) *Stereoselective synthesis: A practical approach*. Weinheim: Wiley VCH. (ISBN: 978-3-527-61568-1).

Laboratory Manual/ Book

- Not applicable.

Suggested reading / E-resources

- https://www.khanacademy.org/science/organic-chemistry/stereochemistry-topic

Suggested MOOCs

- Stereochemistry- NPTEL
- Stereochemistry- SWAYAM

Methods of assessing the Course Outcomes

- Continuous Internal Assessment (CIA)
- Semester End Evaluation (SEE)

Component of CIA

Sr. No	CIA Component	Content	Duration	Marks	Total Marks
1	Test-I	Two Modules	1.5 hrs	5 (Set for 30)	20
	Test-II	All modules	3 hrs	15 (Set for 60)	
2	Assignment	-	-	10	20
3	Class Activity	-	-	10	
Total					40

SEMESTER II		
Course Code	**Course Title**	**Course Credit and hrs**
19PCECC204	**Core 8: Modern Analytical Techniques**	**3 Credits - 3 hrs / wk**

Course Description:

This course focuses on several topics in Modern analytical techniques and will contain: principles, theory, instrumentation and Identification of molecules and materials with advanced spectroscopy and spectrometry such as UV-Vis spectroscopy, FT-IR spectroscopy, Mass Spectrometry, ^{1}H, ^{13}C NMR and 2D NMR spectroscopy.

Course Purpose:

1. To understand and describe Fundamental of Modern Analytical Techniques.
2. To have a basic understanding of the theoretical background of the measurement principles typically used in spectroscopy and spectrometry.
3. To discuss instrumentation of UV-Vis, FT-IR, NMR Spectroscopy and Mass Spectrometry.
4. To be able to develop an analytical strategy to interpret an unknown organic compounds.

Course Outcomes: Upon completion of this course, the learner will be able to		
CO No.	**CO Statement**	**Blooms taxonomy Level (K1 to K6)**
CO_1	Understand Principle and theory of various spectroscopy. i.e. UV-Vis, FT-IR, NMR Spectroscopy and Mass Spectrometry.	K1, K2
CO_2	Discuss Instrumentation of UV-Vis, FT-IR, NMR Spectroscopy and Mass Spectrometry.	K2, K3
CO_3	Demonstrate competence in collecting and interpreting data in the laboratory.	K4
CO_4	Solve problems related to the saturation, functional group, molecular weight and structure of molecules	K3, K4
CO_5	Analyze and interpret spectroscopic data for structure elucidation.	K4, K5

Prerequisite

Basic concept of Electromagnetic radiation, wavelength and properties of different spectroscopic techniques, sample handling techniques, instrumentation.

Course Content **Hours**

Module-I. Introduction to Spectroscopic Techniques: 09 Hrs

Types of Analytical techniques, Introduction of Instrumental methods and its classification, Overview of spectroscopic methods based on wave length regions of Electromagnetic radiation, Properties of Electromagnetic radiation.

UV-Visible Spectroscopy: Introduction to UV and Visible, Principle & Theory of UV spectrometry, Instrumentation, Interpretation of UV spectra, Applications UV spectroscopy.

Module-II. Infrared Spectroscopy : 07 Hrs

Introduction to IR and FTIR, Principle & Theory of Infrared absorption spectrometry, Infrared sources and transducers, Sample handling, Instrumentation, Interpretation of IR spectra, Applications and limitations of IR spectroscopy.

Module-III. Mass Spectroscopy: 09 Hrs

Introduction, Principle, Theory and components of mass spectrometers, Different ionization and detection techniques, recording and resolution of mass spectrometer, Types of ions produced in mass spectrometer, Interpretation of Mass spectra of selected organic compounds / API, Applications of Mass spectrometry.

Module-IV. Nuclear Magnetic Resonance Spectroscopy-I: 10 Hrs

Introduction, NMR active nuclei, Basic Theory, NMR Spectrometer, internal Standard & solvent; **^{1}H NMR (PMR):** Principle, Number of PMR Signals: Equivalent and Nonequivalent Protons, Shielding, Deshielding and Chemical shift, Magnetic anisotropy, Factors affecting on chemical shift, Peak area and Proton counting, spin-spin coupling (multiplicity), coupling constant (J), Nomenclature of Spin Systems, applications & problems of Nuclear magnetic resonance spectroscopy.

Module-V. Nuclear Magnetic Resonance Spectroscopy-II: 10 Hrs

^{13}C NMR: Introduction, Principle, Chemical shift, Application and Problems of ^{13}C NMR Spectroscopy, DEPT; **2D NMR**: Introduction of Homonuclear Correlation Spectroscopy (COSY, TOCSY, NOESY and INADEQUATE), Heteronuclear Correlation Spectroscopy (HSQC, HMQC and HMBC).

Suggested laboratory experiments:

- Note: Included in core practical-8

Pedagogic tools:

- Chalk and Board, Power point presentation, models
- LCD and Videos.

Reference Books:

1. Savant, M. M, Khistariya, A. V. (2017, 1st edition) *Spectroscopy*. Bharat Publishing House, Rajkot (ISBN: 978-93-5236-290-5).
2. Yadav, L. D. S. (2005) *Organic spectroscopy*. Springer-Science + Business Media, B.V. (ISBN 978-94-017-2508-8).
3. Field, L. D., Li, H. L., Magill, A. M. (2015, 1st edition) *Organic Structures from 2D NMR Spectra.* John Wiley & Sons Ltd,(ISBN: 9781118868942).
4. Jacobsen, N. E. (2017) *NMR Data Interpretation Explained.* John Wiley & Sons Ltd,(ISBN: 9781118370223).
5. Pavia, Donald L., Lampman, Gary M., Kriz, George S. Vyvyan, James A. (2015, 5th edition) *Introduction to Spectroscopy*, Cengage Learning, USA. (ISBN: 9781285460123).
6. Silverstein, Robert M., Webster, Francis X., Kiemle, David J., Bryce, David L. (2014, 8th edition) *Spectrometric identification of Organic Compounds*. John Wiley & Sons Ltd. (ISBN: 978-0-470-91401-4).
7. Williams, D. H., Fleming, I. (2007, 6th edition) *Spectroscopic Methods in Organic Chemistry*. New Delhi: Tata McGraw-Hill. (ISBN: 007711812X).
8. Kalsi, P. S. (2006, 6th edition) *Spectroscopy of Organic Compounds*. New Delhi: New Age International Pvt. Ltd. (ISBN: 8122415431).

Laboratory Manual/ Book

- Not applicable

Suggested reading / E-resources

- E-Journal of spectroscopy
- Libgen
- Khan academy

Suggested MOOCs

- Spectroscopy: SWAYAM portal

Methods of assessing the Course Outcomes

- Continuous Internal Assessment (CIA)
- Semester End Evaluation (SEE)

Component of CIA

Sr. No	CIA Component	Content	Duration	Marks	Total Marks
1	Test-I	Two Modules	1.5 hrs	5 (Set for 30)	20
	Test-II	All modules	3 hrs	15 (Set for 60)	
2	Assignment	-	-	10	20
3	Class Activity	-	-	10	
Total					40

SEMESTER II		
Course Code	**Course Title**	**Course Credit and hrs**
19PCECC205	**Practical Core 5 & 6: Separation Techniques & Organic Synthesis**	**2 Credits - 6 hrs / wk**

Course Description:

Thorough familiarization of students with chromatography as an analytical technique for separation, isolation and identification of organic/natural compound from multi-component mixtures.

Organic synthesis is focusing primarily on the basic principles to understand the structure and reactivity of organic molecules. The purification technique of the obtained crude product is essential to get analytically pure compounds.

Course Purpose:

- To understand techniques of separation using various chromatographic techniques.
- To carry one or multi step reaction for organic transformations.

Course Outcomes: Upon completion of this course, the learner will be able to		
CO No.	**CO Statement**	**Blooms taxonomy Level (K1 to K6)**
CO_1	Design and develop solvent system for separation and identification of organic/natural compounds from multi-component mixtures.	K3, K4
CO_2	Construct manual Thin layer chromatography and Column chromatography and Demonstration of HPLC and GC-Mass spectrometer.	K4
CO_3	Demonstrate laboratory setup for various reactions conditions.	K2
CO_4	Apply understanding of reaction mechanism and reagents to perform organic preparation.	K3, K4
CO_5	Analyze product formation by using physical measurement, separation and purification techniques.	K4

Prerequisite

Fundamentals of chromatography techniques, spraying/dyeing reagents, chemical hazards & Laboratory safety, Chemical calculations, crystallization, MSDS study.

Separation Techniques Practical:

1. **Separation Techniques:**
    - Separation of Amino acid by using Paper Chromatography (05 Exercise)
    - Separation of organic/Natural mixture by using Thin Layer chromatography (04 Exercise)

- Separation of organic/Natural mixture 2D TLC (01 Exercise)
- Separation of Inorganic mixture and Natural product by using Column chromatography (02 Exercise)

2. **Organic Synthesis:** One or Two step organic preparation of important intermediates/privilege scaffolds. (12 Exercise)

Reference Books:

- I. L. Finar, A. I. Vogel

Laboratory Manual/ Book

- Thin-layer chromatography: A laboratory handbook (*Stahl*, Egon).
- Practical organic chemistry by A. I. Vogel.

Suggested reading / E-resources

- Not applicable

Suggested MOOCs

- Not applicable

Methods of assessing the Course Outcomes

- Continuous Internal Assessment (CIA)
- Semester End Examination (SEE)

CIA Component

Sr. No	CIA Component	Content	Duration	Marks	Total Marks
1	Test	50% to 60 % of Experiment	3 hrs	30 (Set for 30)	30
2.	Observation book & Record	-	-	10	10
Grand Total					**40 Marks**

SEMESTER II		
Course Code	**Course Title**	**Course Credit and hrs**
19PCECC206	**Practical Core 7 & 8: Stereochemistry & Modern Analytical Techniques**	**2 Credits - 5 hrs / wk**

Course Description:

The aim of the experiment is to learn concept of stereochemistry and find out optical activity of pure stereoisomer's and racemic mixture. Learn the basic principles of UV-visible spectrophotometry and how to measure wave length and concentration by a UV-visible spectrophotometer. The importance of infrared spectroscopy to find various functional groups encountered in the study of structure of organic compounds

Course Purpose:

1. To understand and apply stereochemistry concept to determine configuration of stereoisomers.
2. To handling polarimeter, UV-visible and IR spectrophotometer.
3. To learn proper sample handling procedures for acquiring infrared and UV spectra.
4. To identify a compound by an investigation of its infrared spectrum
5. To determine the percentage composition of a liquid sample mixture by the application of Beer's law.

Course Outcomes: Upon completion of this course, the learner will be able to		
CO No.	**CO Statement**	**Blooms taxonomy Level (K1 to K6)**
CO_1	Apply the stereochemistry concept to identify optical activity of pure stereoisomers and racemic mixture	K2, K3
CO_2	Calculate enantiomeric excess of racemic mixture.	K3
CO_3	Apply UV Viz. phenomena to find out wavelength, concentration and chemical shifts of organic molecules.	K3, K4
CO_4	Interpret IR spectrum for identification of various functional group in organic molecules.	K3, K4
CO_5	Operate polarimeter, UV Visible and IR spectrophotometer.	K4

Prerequisite

Fundamentals of optical activity, Beer-Lambert law, absorbance and emission, spectroscopic ranges, Instrumentation of various spectrometers.

Stereochemistry

1. Find out optical activity of pure stereoisomers. (04 Exercise)
2. Determination of optical activity of racemic mixture.

- D Glucose and L-Glucose (01 Exercise)
- D-Amino acids and L-Amino acids (04 Exercise)

3. Determination of enantiomeric excess of racemic mixture. (03 Exercise)

Modern Analytical Techniques

1. **UV-VIZ. Spectroscopy:**
    - Find out Wavelength selected Organic molecules/ APIs (02 Exercise)
    - Concentration selected Organic molecules/ APIs (02 Exercise)
    - Shifts of selected Organic molecules/ APIs (02 Exercise)
2. **IR Spectroscopy:**
    - Carry out IR spectrum and interpretation of selected organic molecules / APIs (06 Exercise)

Reference Books:

- I. L. Finar, A. I. Vogel

Laboratory Manual/ Book

- Practical organic chemistry by A. I. Vogel.

Suggested reading / E-resources

- Not applicable

Suggested MOOCs

- Not applicable

Methods of assessing the Course Outcomes

- Continuous Internal Assessment (CIA)
- Semester End Examination (SEE)

CIA Component

Sr. No	CIA Component	Content	Duration	Marks	Total Marks
1	Test	50% to 60 % of Experiment	3 hrs	30 (Set for 30)	30
2.	Observation book & Record	-	-	10	10
Grand Total					**40 Marks**

Semester – III (Organic Chemistry)		
Course Code	**Course Title**	**Course Credit and hrs**
19PCEOCC301	**Core 9:Interpretative Molecular Spectroscopy (Self-study)**	**3 Credits –1 hrs / wk**

Course Description:

This course focuses on interpretation of organic molecules by using modern analytical techniques like UV-Vis spectroscopy, FT-IR spectroscopy, Mass Spectrometry, ^{1}H, ^{13}C NMR and 2D NMR spectroscopy.

Course Purpose:

- To solve simple structural problems efficiently by using combinations of the major techniques (UV, IR, NMR and Mass).
- To impart knowledge of spectroscopic techniques for structural analysis of organic compounds.
- To be able to develop an analytical strategy to interpret an unknown organic compounds.

Course Outcomes: Upon completion of this course, the learner will be able to		
CO No.	**CO Statement**	**Blooms taxonomy Level (K1 to K6)**
CO_1	Calculate wavelength of organic molecules by UV-Vis Spectroscopy	K3, K4
CO_2	Differentiate functional groups based on their frequencies by using IR spectroscopy	K2, K3
CO_3	Analyse molecular structure and its molecular weight by their fragmentation pattern in mass spectroscopy	K4
CO_4	Deduce the chemical structure from ^{1}H NMR, ^{13}C NMR and 2D-NMR spectral data.	K4, K5
CO_5	Analyse data obtained from sophisticated instruments (like UV-Vis, FTIR, NMR, and Mass) for the structure determination and chemical analysis.	K4, K5

Prerequisite

Fundamentals of chemical shifts, fundamental frequencies of various functional groups, fragmentation rules, characteristic signal/peaks of spectrum, electronic effects of functional groups.

Course Content	Hours
Module-I : Problems Solving in UV-Vis Spectroscopy: Interpretation and case study (characteristic absorption, Chemical Shifts, Simple chromophoric groups, conjugated and aromatic systems, effect of acid and base) of UV spectrum of organic compounds.	**02 hrs**
Module-II : Problems Solving in IR Spectroscopy: Interpretation and case study (characteristic frequency, functional group identification) of IR spectrum of organic compounds.	**02 hrs**
Module-III : Problems Solving in MASS Spectroscopy: Interpretation and case study (base peak, molecular ion peak, Fragmentation patterns, isotopic abundance, rearrangement) of Mass spectrum of organic compounds.	**02 hrs**
Module-IV : Problems Solving in NMR Spectroscopy Interpretation and case study (characteristic chemical shift, spin-spin coupling, coupling constant, exchangeable proton, cis-trans isomer, o/m/p substitution pattern, saturated & unsaturated system) of NMR spectrum (PMR & CMR and 2D) of organic compounds.	**04 hrs**
Module-V : General Spectroscopic Problems Structure determination and elucidation using combination of UV, IR, and Mass and NMR spectroscopy.	**05 hrs**

Suggested laboratory experiments:

- Not applicable

Pedagogic tools:

- Chalk and Board, Software, Case study
- LCD and Videos.

Reference Books:

1. L. D. Field, S. Sternhell, J. R. Kalman, (2013). *Organic Structures from Spectra.* (5thedition)John Wiley & Sons, Ltd. (ISBN: 9781118325452).
2. L. D. Field, H. L. Li, A. M. Magill, (2015)*Organic Structures from 2D NMR Spectra*. John Wiley & Sons, Ltd. (ISBN: 9781118868942).
3. L. D. S. Yadav (2005) *Organic Spectroscopy.* Springer Science+Business Media Dordrecht (ISBN 978-1-4020-2574-7)
4. Martin, M. L., Delpuech, J. J. and Martin, G. J. (1980) *Practical NMR Spectroscopy*. Weinheim: John Wiley & Sons Ltd. (ISBN: 0471258652).
5. Silverstein, Robert M., Webster, Francis X., Kiemle, David J., Bryce, David L. (2014,

8th edition) *Spectrometric identification of Organic Compounds*. Weinheim: John Wiley & Sons Ltd. (ISBN: 978-0-470-91401-4).

6. Donald L. Pavia, Gary M. Lampman, George S. Kriz, James R. Vyvyan(2014, 5th edition) *Introduction to Spectroscopy.* (ISBN: 978-1-285-46012-3).

Laboratory Manual/ Book

- Not applicable

Suggested reading / E-resources

- Not applicable

Suggested MOOCs

- Not applicable

Methods of assessing the Course Outcomes

The COs of the course will be assessed through

- Assignment / Seminar
- Continuous Internal Assessment
- Semester End Evaluation

Component of CIA

Sr. No	CIA Component	Content	Duration	Marks	Total Marks
1	Test-I	Two Modules	1.5 hrs	5 (Set for 30)	20
	Test-II	All modules	3 hrs	15 (Set for 60)	
2	Assignment	-	-	10	30
3	Class Activity	-	-	20	
Total					**50**

Semester – III (Organic Chemistry)		
Course Code	**Course Title**	**Course Credit and hrs**
19PCEOCC302	**Core 10: Heterocyclic Chemistry**	**4 Credits - 4hrs / wk**

Course Description:

The subject heterocyclic Chemistry is suitable for PG students in organic chemistry and related areas. The course gives a broad introduction to systematic nomenclature, as well as chemical & physical properties of heterocyclic compounds. Foremost important heterocyclic systems, synthesis and characteristic reactions will be discussed.

Course Purpose:

- To became familiar with the structures of important class of heterocyclic aromatic organic compounds.
- To get familiar with the most important heterocycles as well as different systems of nomenclature.
- To classify simple heterocyclic aromatic compounds as electron deficient or electron rich and explain their reactivity based on these properties.
- To gain fundamental theoretical understanding of heterocyclic chemistry, including alternative general methods for ring synthesis and application of such methods for the preparation of specific groups of heterocyclic systems.

Course Outcomes: Upon completion of this course, the learner will be able to		
CO No.	**CO Statement**	**Blooms taxonomy Level (K1 to K6)**
CO_1	Generate IUPAC nomenclature for heterocyclic systems and vice versa.	K1, K2
CO_2	Predict and describe chemical reactivity of various heterocyclic compounds.	K1, K2
CO_3	Illustrate & Plan synthetic methodology for various heterocycles.	K2, K3
CO_4	Identify suitable starting material, reagent and reaction condition or product for given reaction of heterocyclic compounds.	K3
CO_5	Apply concept of various reaction and rearrangements to predict plausible product(s), and characterize using spectroscopic techniques.	K3, K4

Prerequisite

Fundamentals of organic compounds nomenclature, reaction mechanisms, electronegativity and periodicity of heteroatoms.

Course Content **Hours**

Module-I: IUPAC Nomenclature & 3-membered, and 4-membered **14 hrs**

heterocyclic compounds:

1. **Nomenclature of Heterocyclic compounds.**
2. **3-membered, and 4-membered heterocyclic compounds:**

a. Preparation and properties of aziridine, oxirane, thiirane, Azetidine.

b. Preparation of 1,2-diazetidine, 1,2-dioxetane, 1,3-dithietane.

Module-II : 5-Membered heterocyclic compounds: 12 hrs

- Preparation and properties of pyrrole, furan, thiophene.
- Preparation and properties of indole, benzofuran, benzothiophene.
- Preparation of isoindole, indolizine, isatin.

Module-III : 6-Membered heterocyclic compounds: 12 hrs

a. Preparation and properties of pyridine and pyran.

b. Compounds with Two Heteroatoms in a Six Membered Ring:

Preparation of pyridazine, pyrimidine, pyrazine, thiazine, dioxane, morpholine, phthalazine, quinazoline, quinaxoline, phenothiazine.

Module-IV : Heterocyclic Analogues of Naphthalene: 10 hrs

a. Preparation and properties of quinoline, isoquinoline, acridine.

b. Preparation of benzopyran, benzopyran-2-one and benzopyran-4-one.

Module-V : Compounds with two or more than Two Heteroatoms: 10 hrs

1. **Compounds with two Hetero atoms in a Five Membered Ring:**

a. Preparation & properties of pyrazole, oxazole, thiazole

b. Preparation of, imidazole, isoxazole, isothiazole.

2. **Compounds containing more than Two Heteroatoms:**

Preparation of triazole, oxadiazole, thiadiazole, triazenes.

Suggested laboratory experiments:

- Note: Included in practical Core -10.

Pedagogic tools:

- Chalk and Board, Power point presentation, models
- LCD and Videos.

Reference Books:

1. R. K. Bansal (2017, 5th edition) *Heterocyclic Chemistry*. New Age International Private Limited (ISBN: 8122435858).
2. J. A. Joule, K. Mills (2010, 5th edition) *Heterocyclic chemistry* - Wiley-Blackwell (ISBN: 1405133007).
3. R. M. Acheson (2008, 3rd edition) *An introduction to the chemistry of Heterocyclic compounds*. Wiley India Pvt Ltd; (ISBN: 8126516607).
4. Rakesh Kumar Parashar (2014, 1st edition) *Chemistry of Heterocyclic compounds*- (ISBN 9781466517134).
5. R. R. Gupta, M. Kumar & V. Gupta (2009) *Heterocyclic Chemistry-2 volume*, Springer (ISBN: 978-3-642-72276-9 & ISBN 978-3-662-07757-3).

6. T. Eicher& S. Hauptmann (2013, 3rdCompletely Revised and Enlarged edition,)*The chemistry of Heterocycles* - Wiley-VCH (ISBN 3527327479).
7. A. R. Katritzky & C. W. Rees (1984, 1stedition) *Comprehensive Heterocyclic chemistry* - (Vols 1 - 8) Pergamon; (ISBN 0080262007).
8. T. L. Gilchrist (1997, 3rdedition) *Heterocyclic chemistry* - Prentice Hall; (ISBN 0582278430).

Laboratory Manual/ Book

- Not applicable.

Suggested reading / E-resources

- https://en.wikipedia.org/wiki/Heterocyclic_compound
- https://www2.chemistry.msu.edu/faculty/reusch/virttxtjml/heterocy.htm

Suggested MOOCs

- Heterocyclic Chemistry-SWAYAM
- https://nptel.ac.in/courses/104105034/-NPTEL

Methods of assessing the Course Outcomes

- **Continuous Internal Assessment (CIA)**
- **Semester End Evaluation (SEE)**

Component of CIA

Sr. No	CIA Component	Content	Duration	Marks	Total Marks
1	Test-I	Two Modules	1.5 hrs	5 (Set for 30)	20
	Test-II	All modules	3 hrs	15 (Set for 60)	
2	Assignment	-	-	10	20
3	Class Activity	-	-	10	
Total					**40**

Semester – III (Organic Chemistry)		
Course Code	**Course title**	**Course Credit and hrs.**
19PCEOCC303	**Core 11**: **Organic Synthesis: A Disconnection Approach**	**4 Credits - 4 hrs./Wk**

Course Description:

To extend the ideas of retrosynthetic analysis and synthetic planning that were introduced in previous courses to increasingly complex systems. To be able to recognize synthons in organic molecules, and design syntheses to take advantage of them. To give insight into the strategies of total synthesis, introduce guidelines for analysis of complex target molecules in order to design a suitable synthetic route.

Course Purpose:

- To equip students with the skills to plan how to prepare organic molecules.
- To introduce a range of key reactions for application in organic syntheses.
- Rationalization of the outcome of organic reactions using mechanistic reasoning.

Course Outcomes: Upon completion of this course, the learner will be able to		
CO No.	**CO Statement**	**Blooms taxonomy Level (K1 to K6)**
CO_1	Understand concept of disconnection, synthon and synthetic equivalents and its application in disconnection analysis.	K1, K2
CO_2	Understand concept of functional group interconversion strategy and its application for the aromatic compounds.	K1, K2
CO_3	Recognize disconnection pattern for dicarbonyl compounds including 1-2, 1-3, 1-4, 1-5 and 1-6 dicarbonyl framework and plan synthesis thereof.	K3, K4
CO_4	Apply the stepwise disconnection approach for a range of compounds having different patterns of functionalization to support selected strategic and tactical principles in retrosynthetic analysis of targeted molecules.	K3, K4
CO_5	Analyze published synthetic routes in terms of retrosynthetic strategy, recognize the importance of reagent selection for common transformations and suggest reagents for such transformations in the context of such synthetic routes.	K4

Prerequisite

Knowledge of organic name reactions, rearrangements, & reagents.

Module I. A Disconnection Approach: 12 hrs

Introduction to disconnection, concept of synthon, synthetic equivalent, functional group inter-conversion, concept and design of synthesis, criteria of good disconnection

Module II. One & Two Group Disconnection: 14 hrs

Disconnection and synthesis of alcohols, olefins, simple ketones, acids and its derivatives, Disconnections in 1,3-dioxygenated skeletons, preparation of 8-hydroxy carbonyl compounds, α, β-unsaturated carbonyl compounds, 1,3-dicarbonyls, 1,5-dicarbonyls and use of Mannich Reaction

Module III. Illogical Two Group Disconnections: 11 hrs

Disconnection and synthesis of 2-hydroxy carbonyl compounds, 1,2-diols, 1,4 and 1,6-dicarbonyl compounds.

Module IV. Disconnection & Synthesis of Acyclic, Cyclic Hetero-Compounds: 11hrs

Synthesis of ethers, amines, nitrogen and oxygen containing 5 & 6 membered heterocycles.

Module V. Chemoselectivity& Protecting Groups: 12 hrs

Introduction, three types of control, Chemoselectivity examples and rules, Chemoselectivity by (i) Reactivity (ii) Reagent, Examples of Chemoselectivity in Synthesis. Protection of organic functional groups, protecting reagents and removal of protecting groups.

Suggested laboratory experiments:

- Not applicable

Pedagogic tools:

- Chalk and Board
- LCD and Videos.

Reference Books:

1. Warren, S.; Wyatt, P. (2008, 2nd edition) *Organic Synthesis: The Disconnection Approach*. Weinheim: Wiley. (ISBN: 978-0-470-71236-8).
2. Warren, S. (1978) *Designing Organic Syntheses: A Programmed Introduction to the Synthon Approach*. Weinheim: Wiley. (ISBN: 978-0-471-99612-5).
3. Carruthers, W.; Coldham, Iain (2004, 4thedition) *Modern Methods of Organic Synthesis*. Cambridge: Cambridge University Press. (ISBN: 9780521778305).
4. Fuhrhop, J. -H.; Li, Guangtao; Corey, E. J. (2003, 3rd completely revised and enlarged edition) *Organic Synthesis: Concepts and Methods*. Weinheim: Wiley VCH. (ISBN: 978-3-527-30272-7).

Laboratory Manual/ Book

- Not applicable.

Suggested reading / E-resources

Suggested MOOCs

- NPTEL
- SWAYAM

Methods of assessing the Course Outcomes

The COs of the course will be assessed through

- CIA (Test, Assignment, Seminar, Class Activity)
- SEE

Component of CIA

Sr. No	CIA Component	Content	Duration	Marks	Total Marks
1	Test-I	Two Modules	1.5 hrs	5 (Set for 30)	20
	Test-II	All modules	3 hrs	15 (Set for 60)	
2	Assignment	-	-	10	20
3	Class Activity	-	-	10	
Total					**40**

SEMESTER – III (Organic Chemistry)		
Course Code	**Course Title**	**Course Credit and hrs**
19PCEODC301	**DSE –Core-1 Medicinal Chemistry**	**4 Credits - 4hrs / wk**

Course Description:
The main objective of this course is to familiarize students with the fundamental concepts of medicinal chemistry. Topic includes drug discovery and development, lead modifications, QSAR, pharmacokinetics, pharmacodynamics, prodrug and combinatorial chemistry.

Course Purpose:

- Understand and describe process of drug discovery and development in medicinal chemistry
- Illustrate pharmacokinetics and pharmacodynamic profile for drug & write receptor drug interaction phenomena.
- Predict and describe drug classification, mechanism of action of drugs, adverse effects, therapeutic uses, structure activity relationship (SAR) and synthetic procedures their off.

Course Outcomes: Upon completion of this course, the learner will be able to		
CO No.	**CO Statement**	**Blooms taxonomy Level (K1 to K6)**
CO_1	To understand the chemistry of drugs with respect to their pharmacological activity.	K1, K2
CO_2	Demonstrate an understanding of the steps involved in the drug discovery and design process	K2, K3
CO_3	Understand the background of combinatorial chemistry and role of combinatorial chemistry in drug discovery.	K2
CO_4	Critically analyse biological pathways for their potential as drug targets for a given disease.	K3, K4
CO_5	Describe the role of pharmacodynamic and pharmacokinetic factors as determinants of drug response.	K1, K2

Prerequisite
Basic knowledge of terminologies used in medicinal chemistry, Drug action, dosage forms, Route of drug administration, Properties of drugs.

Course Content

Module-I. Drug design and development **12 hrs**

History and development of medicinal chemistry, drugs and their important, drug discovery, lead discovery, lead discovery from natural sources, lead discovery through random screening, nonrandom (or targeted or focused) screening, drug metabolism studies, clinical observations, rational approaches to lead discovery.

Clinical Studies: Phase 1, 2, & 3 clinical trials, evaluations, post clinical trials, filing of NDA.

Module-II. Lead Modification: Strategies **14 hrs**

Identification of the Active Part: the pharmacophore, functional group modification. Structure–activity relationships, privileged structures and drug-like molecules. Structure modifications to increase potency and the therapeutic index: Homologation, chain branching, ring-chain transformations, bioisosterism.

Clinical Studies: Phase 1, 2, & 3 clinical trials, evaluations, post clinical trials, filing of NDA.

QSAR: Introduction to quantitative structure–activity relationships (QSARs), lipophilicity, partition coefficients (P), lipophilic substitution constants (p), electronic effects, The Hammett constant (s), steric effects, The Taft steric parameter (Es), molar refractivity (MR), other parameters. Hansch analysis, Craig plots, The Topliss decision tree.

Module-III. Pharmacokinetics **14 hrs**

Introduction, Routes of Administration, Drug Absorption: gastrointestinal, Cell membrane (Structure and Physiology), Mechanisms of Drug Absorption Factors affecting drug absorption, Drug Distribution: factor affecting in drug distribution. Drug metabolism: biotransformation of the drug, phase I & II reactions, concept of drug excretion.

Module-IV. Pharmacodynamics **10 hrs**

Receptors and drug action: Types of receptors, theories of drug-Receptor interactions, concept of bioassay and definition of IC_{50}, LD_{50}, ED_{50}, MIC and EC_{50}, GI_{50}.

Module-V. Prodrug & Combinatorial Chemistry **10 hrs**

Prodrug: Concept, structure and classification of prodrug. Use of prodrugs: Masking taste or odor, minimizing pain at site of injection, alteration of drug solubility, overcome absorption problems, prevention of pre-systemic metabolism, longer duration of action diminish local and systemic toxicity.

Combinatorial Chemistry: The principle and design of combinatorial chemistry, pool and split method for peptide synthesis, parallel synthesis, Furka's mix and split technique, Solid support method.

Suggested laboratory experiments:

- Note: Included in practical DSE core

Pedagogic tools:

- Chalk and Board, Power point presentation, models

- LCD and Videos.

Reference Books:

1. BrahmankarJaiswal(2015, New Edition,) *BiopharmacuiticsAnd Pharmacokinetics - A Treatise*.Vallabhaprakashan. (ISBN-13: 978-8185731933).
2. Ed. M. E. Wolff (2010, 7th Edition,) *Burgers Medicinal and Drug Discovery*. John Wiley. (ISBN: 978-0-470-27815-4).
3. Graham L. Patrick (2013, 5th Edition) *An Introduction to Medicinal Chemistry*. Oxford press (ISBN: 9780199697397).
4. Gareth Thomas (2007, 2nd Edition) *Medicinal Chemistry*. (ISBN: 9780470025987).
5. William Foye, Lippincott, William and Wilkins (2012, 7th edition) *Principles of Medicinal Chemistry*. (ISBN: 9781609133450).

Laboratory Manual/ Book

- Not applicable

Suggested reading / E-resources

- SWAYAM course
- NPTEL Course

Suggested MOOCs

- NPTEL

Methods of assessing the Course Outcomes

- Continuous Internal Assessment (CIA)
- Semester End Evaluation (SEE)

Component of CIA

Sr. No	CIA Component	Content	Duration	Marks	Total Marks
1	Test-I	Two Modules	1.5 hrs	5 (Set for 30)	20
	Test-II	All modules	3 hrs	15 (Set for 60)	
2	Assignment	-	-	10	20
3	Class Activity	-	-	10	
Total					**40**

SEMESTER – III (Organic Chemistry)		
Course Code	**Course Title**	**Course Credit and hrs**
19PCEODC302	**DSE –Core-1 Pharmaceutical Technology**	**4 Credits - 4hrs / wk**

Course Description:

This course focuses on several topics in pharmaceutical technology will contain: Various types of drug formulations such as tablet, capsules, sterile dosage form, cosmetology and cosmetic preparations and liquid dosage forms.

Course Purpose:

- Understand & write formulations and evaluations methods for various types tablets & capsules
- Illustrate requirement for preparation of sterile dosages & liquid dosage forms
- Understand and Describe cosmeticology and their preparations

Course Outcomes: Upon completion of this course, the learner will be able to		
CO No.	**CO Statement**	**Blooms taxonomy Level (K1 to K6)**
CO_1	Discuss the fundamental principles for dosage form design, drug release and drug delivery.	K1, K2
CO_2	Classify different dosage forms and apply principles of pharmaceutical science in formulation and dispensing the various dosage forms	K2, K3
CO_3	Apply the engineering principles for formulation of solutions, suspensions and emulsions, granules and tablets	K3
CO_4	Formulate the dosage forms for a given API based on its properties	K3, K4
CO_5	Develop a formulation process for a given API	K4, K5

Prerequisite

Basic knowledge of terminologies used in pharmaceutical chemistry, dosage forms, Properties of drugs, drug excipients, various vehicle used in formulation.

Course Content

Module-I. Tablet: 14 Hrs

(a) Definition, Advantages and disadvantages, Introduction to types of tablets**,** formulation of different types of tablets; excipients, granulation techniques, machinery for large scale granulation and compression, physics of tablet making, In process controls, processing problems and remedies,

(b) Evaluation (Pharmacopoeial and nonpharmacopoeial test) and equipments. Introduction of mouth dissolving tablets, buccal tablets, floating tablets, tablets of colon drug delivery, matrix tablets.

(c) Coating of Tablets: Objectives, types of coating, film forming materials, formulations of coating solution, equipments for coating, coating process, evaluation of coated tablets , coating defects.

Module-II. Capsules : 12 Hrs

Hard Capsules:

Definitions, Advantages, disadvantages, Ideal requirements, Production of Hard capsules (Gelatin and non-gelatin e.g. vegetable), Capsule storage, size of capsules, formulation and methods of capsule filling, problems and remedies, quality control.

Soft Gelatin Capsules:

Formulation of shell and capsule coat, and quality control.

Module-III. Sterile Dosage Forms 12 Hrs

Definitions, Advantages, Disadvantages, Ideal requirements and Formulation of sterile dosage forms, Water for injection-Preparation, Design and requirements for production area- Aseptic techniques, sources of contamination and methods of prevention, design of aseptic area, laminar flow benches, containers and closures, methods of filling including form fill and seal technology. Evaluation of sterile dosage forms.

Module-IV. Cosmeticology and Cosmetic Preparations 11 Hrs

Fundamentals of cosmetic science, formulation, preparation and packaging of cosmetics for skin - Sunscreen, moisturizers, cold cream, and vanishing cream, hair - Shampoo and conditioners, dentifrice- powders, gels, paste and manicure preparations like- nail polish, lipsticks, eye lashes, baby care products, shaving cream, hygienic products.

Module-V. Liquid Dosage Forms 11 Hrs

Introduction, advantages and disadvantages, types of additives used vehicles, stabilizers, preservatives, suspending agents, emulsifying agents, solubilizers, colors, flavors, etc.

Suggested laboratory experiments:

- Note: Included in DSE core practical

Pedagogic tools:

- Chalk and Board, Power point presentation, models
- LCD and Videos.

Reference Books:

1. L Lachman, H Lieberman (2014, 4th Edition) *The Theory and Practice of Industrial Pharmacy*. (ISBN: 9788123922898).
2. Kanig. Gennaro, Alfonso R., Remington: (2005, 21st Revised edition) *The Science and Practice of Pharmacy, Vol-I & II*. Lippincott Williams & Wilkins, New York.

(ISBN: 9780781746731).

3. Ansel (2013, 10th edition) *Pharmaceutical Dosage Forms and Drug Delivery Systems*. (ISBN: 9781451188769).
4. Michael E. Aulton (2001, 2nd edition) *Pharmaceutics: The Science of Dosage Form Design*. (ISBN: 9780443055171).

Laboratory Manual/ Book

- Not applicable

Suggested reading / E-resources

- NA

Suggested MOOCs

- NA

Methods of assessing the Course Outcomes

- Continuous Internal Assessment (CIA)
- Semester End Evaluation (SEE)

Component of CIA

Sr. No	CIA Component	Content	Duration	Marks	Total Marks
1	Test-I	Two Modules	1.5 hrs	5 (Set for 30)	20
	Test-II	All modules	3 hrs	15 (Set for 60)	
2	Assignment	-	-	10	20
3	Class Activity	-	-	10	
Total					**40**

SEMESTER – III (Organic Chemistry)		
Course Code	**Course Title**	**Course Credit and hrs**
19PCEOCC304	**Practical Core 10 & 11: Heterocyclic Chemistry & Organic Synthesis**	**4 Credits - 9hrs / wk**

Course Description:

Organic heterocyclic synthesis is focusing primarily on the basic principles to understand the structure and reactivity of organic molecules. The purification technique of the obtained crude product is essential to get analytically pure compounds.

Thorough familiarization of students with chromatography as an analytical technique for separation, isolation and identification of organic/natural compound from single/multi-step synthesis.

Course Purpose:

- To carry one or single/multi step reactions for organic heterocyclic transformations.
- To understand purification and/or isolation techniques of separation using various chromatographic techniques.

Course Outcomes: Upon completion of this course, the learner will be able to		
CO No.	**CO Statement**	**Blooms taxonomy Level (K1 to K6)**
CO_1	Demonstrate laboratory setup for various reactions conditions.	K2
CO_2	Apply understanding of reaction mechanism and reagents to perform heterocyclic preparation.	K3, K4
CO_3	Analyze product formation by using physical measurement, separation and purification techniques.	K4
CO_4	Design and develop solvent system for separation and identification of organic/natural compounds from single/multi-step reactions.	K3, K4
CO_5	Construct manual Thin layer chromatography and Column chromatography whenever applicable.	K4

Prerequisite

Fundamental knowledge of stoichiometric calculations, reaction mechanism, reaction setup, TLC monitoring, Purification.

Laboratory experiments:

Organic/Heterocyclic Synthesis: Single or multi step preparation of important intermediates (36 Transformation).

- Heterocyclic compounds: pyrazoles, coumarins, pyrimidines, pyridines etc.
- Multistep organic synthesis

Reference Books:

- Not applicable

Laboratory Manual/ Book

1. Vogel's Textbook of Practical Organic Chemistry Prentice Hall; 5thedition 1989
2. Practical organic chemistry by A. I. Vogel.
3. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis by V. K. Ahluwalia, R. Aggarwal

Suggested reading / E-resources

- Not applicable

Suggested MOOCs

- Not applicable

Methods of assessing the Course Outcomes

- Continue Internal Assessment (CIA)
- Semester End Examination (SEE)

Continue Internal Assessment (CIA)

Sr. No	CIA Component	Content	Duration	Marks	Total Marks
1	Test I (01 Exercise from each component)	After completion of 50% to 60 % of the Experiments	3 hrs for each exercise	25 for each exercise	50
2.	Observation book & Record	-	-	5 for Each	10
Total					**60**

SEMESTER – III (Organic Chemistry)		
Course Code	**Course Title**	**Course Credit and hrs**
19PCEODC303	**Practical DSE –Core 1 Medicinal Chemistry**	**2 Credits - 3hrs / wk**

Course Description:
Drug/pharmaceutical intermediate synthesis is focusing primarily on the basic principles to understand the structure and reactivity of organic molecules. The purification technique of drug/pharmaceutical compound is essential to get analytically pure chemical entities.

Course Purpose:

- To carry one or single/multi step reactions for drug/pharmaceutical intermediate synthesis.
- To understand purification and/or isolation techniques of separation using various chromatographic techniques.

Course Outcomes: Upon completion of this course, the learner will be able to		
CO No.	**CO Statement**	**Blooms taxonomy Level (K1 to K6)**
CO_1	Demonstrate laboratory setup for various reactions conditions.	K2
CO_2	Apply understanding of reaction mechanism and reagents to perform drug synthesis/ Important intermediates/ privilege scaffolds.	K3, K4
CO_3	Analyze product formation by using physical measurement, separation and purification techniques.	K4
CO_4	Design and develop solvent system for separation and identification of drug/intermediate compounds from single/multi-step reactions.	K3, K4
CO_5	Construct manual Thin layer chromatography and Column chromatography whenever applicable.	K4

Prerequisite
Fundamental knowledge of stoichiometric calculations, reaction mechanism, reaction setup, TLC monitoring, Purification.

Laboratory experiments: (12 exercises)

- Synthesis and analysis of drugs, privilege scaffolds, and important ingredients: Methyl salicylate, sulphanilamides, benzocaine, etc.

Reference Books:

- Not applicable

Laboratory Manual/ Book

- Practical organic chemistry by A. I. Vogel.
- Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis by V. K. Ahluwalia, R. Aggarwal

Suggested reading / E-resources

- Not applicable

Suggested MOOCs

- Not applicable

Methods of assessing the Course Outcomes

- Continue Internal Assessment (CIA)
- Semester End Examination (SEE)

Component of CIA

Sr. No	CIA Component	Content	Duration	Marks	Total Marks
1	Test	50% to 60 % of Experiment	3 hrs	15 (Set for 15)	15
2.	Observation book & Record	-	-	05	05
Total					**20**

SEMESTER – III (Organic Chemistry)		
Course Code	**Course Title**	**Course Credit and hrs**
19PCEODC304	**Practical DSE –Core-1 Pharmaceutical Technology**	**2 Credits - 3hrs / wk**

Course Description:
This course involves practical and theoretical principles involved in the development and evaluation of industrial formulations including tablet, granules, gelatine capsules, glass vials/ampoules, syrup, power, dry suspension, eye drops and cream form API or cosmetic materials.

Course Purpose:

- To design and prepare various formulation from industrial products.
- Emphasis is placed on developing formulations based on the physical and chemical properties of the drug substance and the intended use of the drug product.

Course Outcomes: Upon completion of this course, the learner will be able to		
CO No.	**CO Statement**	**Blooms taxonomy Level (K1 to K6)**
CO_1	Demonstrate laboratory setup for various reactions conditions.	K2, K3
CO_2	Apply the principles of equipments and instruments with their working and uses in formulation of dosage forms.	K3, K4
CO_3	Formulate and evaluate of solid dosage form such as tablets, tablet coating and capsules.	K5, K6
CO_4	Formulate and evaluate of syrup, emulsion and dry suspension.	K5, K6
CO_5	Formulate and evaluate of injections and eye drops.	K5, K6

Prerequisite
Fundamental knowledge of various formulations used in pharmaceuticals.

Laboratory experiments:

1. Pharmaceutical Technology:

1) **Preparation and evaluation** of effervescent tablet, ferrous sulphate tablet, Paracetamol tablet.
2) Preparation and evaluation of tablets employing direct compression, wet granulation, dry granulation (slugging), compression coating.
3) **Filling** of powder/ granules/ pellets in hard gelatin capsule and its evaluation.
4) Perform **pharmacopoeial test** for given sample of glass vial / ampoule.
5) Preparation and evaluation of face powder, lipstick, cold cream, vanishing cream, tooth paste/ tooth powder.
6) **Formulation and evaluation** of syrup, emulsion (o/w, w/o), turpentine liniment, calamine lotion.

7) **Formulation and evaluation** of milk of magnesia/aluminum hydroxide gel antacid suspension.
8) Formulation and evaluation of dry suspension.
9) Formulation and evaluation of diclofenac sodium gel.
10) Formulation and evaluation of transdermal spray.
11) Formulation and evaluation of calcium gluconate injection, dextrose injection, NaCl injection, dextrose saline injection, menadion injection.
12) Formulation and evaluation of eye drops.
13) Formulation and evaluation of multidose injection of chloroquine phosphate.
14) Formulation and evaluation of metronidazole infusion.

Reference Books:

- NA

Laboratory Manual/ Book

- Practical organic chemistry by A. I. Vogel.

Suggested reading / E-resources

- Not applicable

Suggested MOOCs

- Not applicable

Component of CIA

Sr. No	CIA Component	Content	Duration	Marks	Total Marks
1	Test	50% to 60 % of Experiment	3 hrs	15 (Set for 15)	15
2.	Observation book & Record	-	-	05	05
Total					**20**

SEMESTER – III (Organic Chemistry)		
Course Code	**Course Title**	**Course Credit and hrs**
	Core 12: **Project/Internship/Skill Training/Advance Practical (Research proposal & presentation)**	**3 hrs / wk**

Prerequisite

Literature survey of research publications, data compilation, use of chemical drawing software, basic presentation software operating.

Based on Academic Performance (Merit/Test/Interview) and Interest, students will be allotted Project/Internship/Skill Training/Advance Practical during semester III & IV.

Project:

- The candidates will be given the option of selecting a research problem in a preferred area that falls within the disciplines of courses undertaken.
- Candidates have to present their research outcomes in the Pre-presentation (Internal committee) before final Project thesis/Report & oral presentation.
- At the end of the semester the candidates are required to present their research outcomes in the form of a Project thesis/Report & oral presentation.
- The evaluation (Presentation & Viva) of the Project work (Dissertation) will be carried out at the end of Sem-IV.

Internship/Skill Training:

- An internship is period of work experience offered by an Institution/industries for a limited period of time.
- The evaluation of internship/skill training carried out by Presentation & Vivaduring practical examination.

Advance Practical

- The evaluation of advance practical will be carried out by internal & term end practical examination.

Note: Evaluated at the End of SEM-IV

If the student opts for exit at end of Semester-III; the Core 12: Project/Internship/Skill Training/Advance Practical course will reflected as **19PCEOCC305 in the mark statement** and student will be evaluated for 2 credits.

SEMESTER – IV (Organic Chemistry)		
Course Code	**Course Title**	**Course Credit and hrs**
19PCEOCC401	**Core 12: Project/Internship/Skill Training/Advance Practical**	**12 Credits - 20 hrs / wk**

Course Description:

The aim of the Project/Internship/Skill Training/Advance Practical to enable students to develop deeper knowledge, understanding, capability and attitudes in the context of the programme.

Course Purpose:

- To develop research/practical skills commensurate with the accomplishment of a master degree.
- To develop research proposal/laboratory protocol/ training reports.
- To address issues of research/practical design methodology ethics and theoretical arguments and apply this to research/practical.

Course Outcomes: Upon completion of this course, the learner will be able to		
CO No.	**CO Statement**	**Blooms taxonomy Level (K1 to K6)**
CO_1	Apply critical and analytical skills in a scientific and professional manner.	K3
CO_2	Critically apprising and interpretative published literature	K4
CO_3	Synthesize knowledge and skills previously gained and applied to an in-depth study.	K4, K5
CO_4	Select from different research methodologies, methods and forms of analysis to produce a suitable research method.	K4
CO_5	Present the finding of their project in a written report.	K6

Prerequisite

Literature survey of research publications, data compilation, and understanding of scientific language used in publications, spectroscopic data analysis.

Laboratory experiments:

Project:

- The candidates will be given the option of selecting a research problem in a preferred area that falls within the disciplines of courses undertaken.
- Candidates have to present their research outcomes in the Pre presentation (Internal committee) before final Project thesis/Report & oral presentation.
- At the end of the Semester-IVthe candidates are required to present their research outcomes in the form of a Project thesis/Report & oral presentation.

Internship/Skill Training:

- An internship is period of work experience offered by an Institution/industries for a limited period of time.
- The evaluation of internship/skill training carried out by Presentation & Vivaduring practical examination.

Advance Practical

- Natural Product: Qualitative test/ identification test of phyto-constituents
- Ternary organic mixture separation and chromatographic identification.
- Synthesis, purification and characterization of pharmaceutical drug or intermediates
- Green methods such as Microwave / Mortar pastel / Ionic Liquid / Water mediated / Solid support.

Reference Books:

- NA

Laboratory Manual/ Book

1. Practical organic chemistry by A. I. Vogel.
2. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis by V. K. Ahluwalia, R. Aggarwal
3. Phytochemical Analysis by J. B. Harbone
4. TLC by Stahl

Suggested reading / E-resources

- Not applicable

Suggested MOOCs

- Not applicable

Methods of assessing the Course Outcomes

- Continue Internal Assessment (CIA)
- Semester End Examination (SEE)

Project/Internship/Skill Training:

Component of CIA

Sr. No	CIA Component	Content	Marks	Total Marks
1	Review I (Committee)	Literature search & Presentation	20	80
	Review I (Guide)	Monitoring & Presentation	20	
	Review II (Committee)	Pre presentation of Project	20	
	Review II (Guide)	Monitoring & Presentation	20	
Total				**80**

Advance Practical

Component of CIA

Sr. No	CIA Component	Content	Duration	Marks	Total Marks
1	Test	50% to 60 % of Experiment	6 hrs	60	60
2.	Observation book & Record	-	-	20	20
Total					**80**

Semester - IV (Organic Chemistry)		
Course Code	**Course Title**	**Course Credit and hrs**
19PCEOCC402	**Core 13: Chemistry of Natural Products**	**5 Credits - 5 hrs / wk**

Course Description:

Chemistry of Natural Products is primarily focusing on the basic principles to understand the structure and reactivity of naturally occurring materials. The course is dealing with Classification, extraction, technique of separation, and identification of natural compounds with representative synthesis of the concerned class.

Course Purpose:

- To understand the extraction of metabolites from natural products.
- To state Synthesis, structural significance and importance of representative classes of the alkaloids, vitamins and steroids.
- To carry out phytochemical tests of the metabolites.
- To understand structural significance of Natural product derived drugs.

Course Outcomes: Upon completion of this course, the learner will be able to		
CO No.	**CO Statement**	**Blooms taxonomy Level (K1 to K6)**
CO_1	Understand the concept of identification and isolation of primary and secondary metabolites.	K2, K3
CO_2	Prepare systematic extraction method for the active ingredient.	K3
CO_3	Explain structural significance of the active molecules from the natural resources.	K3, K4
CO_4	To identify active molecules from medicinal plants.	K3, K4
CO_5	Illustrate total synthesis of the selected natural products.	K4

Prerequisite

Basic knowledge of sources, extraction and isolation techniques, solvent properties.

Course Content **Hours**

Module-I: Introduction and History of Natural Products **15 hrs**

Introduction, classification, source, types of extraction, primary and secondary metabolite, extraction and isolation methods of metabolite.

Module-II: Alkaloids **15 hrs**

Introduction, definition, classification, extraction and phytochemical test
Synthesis, structural significance and importance of representative alkaloids: Morphine, Heroin, Codeine, Ricinine, Atropine, Cocaine, Nicotine.

Module-III: Vitamins **15 hrs**

Introduction, History, classification and importance including hyper/hypo

diseases. Synthesis, structural significance and importance of representative Vitamins: Vitamin A , B group (folic acid, niacin, pantothenic acid, riboflavin-B_2, pyridoxine-B_6), C and E (α- and β-tocopherols and tocotrienols).

Module-IV: Steroids **15 hrs**

Introduction, History, classification, and extraction of Steroid and sterol.

- Bile acid: Introduction and its function.
- Steroid Hormones: Introduction, type, synthesis, structural significance and importance of representative steroid hormones: Androsterone, Testosterone, Oestrone, Oestradiol, Oestriol, And Progesterone.

Module-V: Natural product derived drugs **15 hrs**

Introduction, extract based drugs, Herbal formulation, synthesis & structural significance of some representative molecules: 7-Methylomuralide, Agelastatin A, (-)Bursehemin, Carpanone, Chelidonine, Fulvoplumierin, Griseofulvin, Janoxepin, Luotonin A, (-)Mersicarpine, Taxol, (+)Vinblastine.

Suggested laboratory experiments:

- Not applicable

Pedagogic tools:

- Chalk and Board, Power point presentation, models
- LCD and Videos.

Reference Books:

1. Finar, I.L. (1989, 5th edition) *Organic Chemistry: Vol -2: Stereochemistry and the Chemistry of Natural Products*. Harlow: Longman. (ISBN: 0-582-05916-X).
2. Mann, J.; Harborne, J.; Davidson R. S. (1994) *Natural Products: Their Chemistry and Biological Significance*. Harlow: Longman Publishing Group. (ISBN: 0470200022).
3. Hostettmann, Kurt; Gupta, M. P.; Marston A. (1994) *Chemistry, Biological & Pharmacological properties of medicinal plants from the Americas*. Newark: Harwood Academic Publishers. (ISBN: 9057023970).
4. Norman, R. O. C.; Coxon, J. M. (1993, 3rd edition) *Principles of organic synthesis*. New Delhi: CBS Publishers & Distributors. (ISBN: 0748761624).
5. Carey, F. A.; Sundberg, R. J. (2010, 5th edition) *Advanced Organic Chemistry Part B: Reactions and Synthesis.* Berlin: Springer. (ISBN: 0387683542).
   Nogradi, M. (2008, 2nd revised and updated edition) *Stereoselective synthesis: A practical approach*.Weinheim: Wiley VCH. (ISBN: 978-3-527-61568-1).

Laboratory Manual/ Book

- Not applicable

Suggested reading / E-resources

- Not applicable

Suggested MOOCs

- Not applicable

Methods of assessing the Course Outcomes

- Continue Internal Assessment (CIA)
- Semester End Examination (SEE)

Component of CIA

Sr. No	CIA Component	Content	Duration	Marks	Total Marks
1	Test-I	Two Modules	1.5 hrs	5 (Set for 30)	20
	Test-II	All modules	3 hrs	15 (Set for 60)	
2	Assignment	-	-	10	30
3	Class Activity	-	-	20	
Total					**50**

Semester - IV (Organic Chemistry)		
Course Code	**Course Title**	**Course Credit and hrs**
19PCEOCC403	**Core 14: Chemistry of Synthetic Drugs**	**5 Credit -5 hrs/Wk**

Course Description:

This course focuses on types of disease, classification and synthetic methods of known drugs, such like anticancer, infectious diseases, cardiovascular and metabolite disorder diseases, CNS disease, antiparkinson diseases, Analgesic & anti-inflammatory diseases and anesthetic drugs. A short introduction to the biological and pharmacological properties of the drugs will also be included.

Course Purpose:

- Understand and Describe classification & synthesis of anticancer, anti-infectious, cardiovascular and metabolic disorder drugs.
- Understand and illustrate classification & synthesis of CNS acting agents, anti-inflammatory drugs, and anesthetic agents.

Course Outcomes: Upon completion of this course, the learner will be able to		
CO No.	**CO Statement**	**Blooms taxonomy Level (K1 to K6)**
CO_1	Classify type of disease and drugs	K2, K3
CO_2	Employ the core subject knowledge of anticancer and anti-infectious, Cardiovascular and the drugs affecting on metabolic disease.	K2, K3
CO_3	Well acquainted with the synthesis of some important class of drugs.	K4
CO_4	Knowledge about the mechanism pathways of disease and curing by medicinal compounds.	K3, K5
CO_5	Critically evaluate modern methods of functional group transformations and the application of protecting groups in Drug synthesis.	K4, K5

Prerequisite

Awareness about various type of diseases, Drug-receptor interaction, Drug action, SAR, and organic transformations.

Course Content **Hours**

Module-I : Cancer and Infectious Diseases **15 hrs**

Introduction to diseases, classification of anticancer and anti-infectious drugs, synthesis of the following classes of the drugs:

(1) DNA alkylating agents and Aromatase Inhibitors: Anastrozole,

Letrozole, Estramustine, Cisplatin.

(2) Quinolone Antibiotics: Levofloxacin, Moxifloxacin.
(3) Triazole Antifungals: Fluconazole.
(4) Non-Nucleoside HIV Reverse Transcriptase Inhibitors: Nevirapine, DelavirdineMesylate
(5) Neuraminidase Inhibitors For Influenza: Oseltamivir Phosphate (Tamiflu)

Module-II : Cardiovascular and Metabolic Diseases **15 hrs**

Introduction to diseases, classification of drugs acting on Cardiovascular and Metabolic, synthesis of the following classes of the drugs:

Cardiovascular :

(1) Hypertension: Losartan Potassium, Telmisartan.
(2) Calcium Channel Blockers for Hypertension: Nifedipine,
(3) Second-Generation Hmg-CoaReductase Inhibitors: Rosuvastatin, Atorvastatin.

Metabolic diseases:

(1) Type 2 Diabetes: Rosiglitazone, Pioglitazone.

Diuretics:

(1) Thiazides(Benzothiadiazines): Chlorothiazide, Hydrochlorothiazide
(2) Carbonic-Anhydrase Inhibitors: Acetazolamide, Ethoxzolamide
(3) Miscellaneous Sulphonamide Diuretics: Indapamide
(4) Purine or Xanthine Derivatives: Caffeine
(5) Miscellaneous Diuretics- Triamterene

Module-III : Central Nervous System Diseases **15 hrs**

Introduction to diseases, classification of drugs acting on Central Nervous System &Antiparkinsonism, synthesis of the following classes of the drugs:

CNS Diseases:

(1) Antidepressant: Venlafaxine, Duloxetine.
(2) Insomnia: Zolpidem, Zaleplon, Indiplon.
(3) Antiepileptic: Gabapentin.
(4) Attention Deficit Hyperactivity Disorder: Amphetamine.

Module-IV : Analgesic and Anti-Inflammatory Drugs **15 hrs**

Introduction to diseases, classification of Analgesic and Anti-Inflammatory Drugs, synthesis of the following classes of the drugs:

Non-Steroidal Anti-Inflammatory Drugs (NSAIDs):

(1) Heteroarylacetic acid analogues: Indomethacin, Tolmetin sodium.
(2) Arylacetic acid analogues: Ibuprofen, Diclofenac sodium.
(3) Arylpropionic acid analogues: Ketoprofen, Indoprofen.
(4) Naphthalene acetic acid analogues: Naproxen.
(5) Salicylic acid analogues: Aspirin, Benorilate.
(6) Pyrazolones and pyrazolodiones: Phenazone (Antipyrine)

Antipyretic analgesics

(1) Aniline and p-Aminophenol Analogues: Paracetamol, Phenacetin.
(2) Quinoline Derivatives: Cinchophen.
(3) The N-Arylanthranilic Acids: Mefenamic Acid, Flufenamic Acid.

Module-V : Anaesthetics Drugs **15 hrs**

Introduction to diseases, classification of Anasthetic drugs, synthesis of the following classes of the drugs:

General Anaesthetics:

(1) Inhalation Anaesthetics: Halothane, Chloroform.
(2) Intravenous Anaesthetics: Ketamine Hydrochloride, Propanidid.
(3) Basal Anaesthetics: Tribromoethanol, Paraldehyde.

Local Anaesthetic

(1) The Esters: Benzocaine, Procaine Hydrochloride
(2) Piperidine or Tropane Derivatives: α-Eucaine, Benzamine Hydrochloride.
(3) The Amides: Lignocaine Hydrochloride, Pyrrocaine Hydrochloride,
(4) The Quinoline and Iso-quinoline Analogues: Dibucaine Hydrochloride, Dimethisoquin Hydrochloride.
(5) Miscellaneous Type: Phenacaine Hydrochloride

Suggested laboratory experiments:

- Not applicable

Pedagogic tools:

- Chalk and Board, Software, Case study
- LCD and Videos.

Reference Books:

1. Douglas S. Johnson, Jie Jack Li (2007, 1st edition) *The Art of Drug Synthesis*. John Wiley & Sons, Inc., Hoboken, New Jersey (ISBN 978-0-471-75215-8).
2. R. S. Vardanyan and V. J. Hruby (2006) *Synthesis of Essential Drugs*.ElsevierScience (ISBN: 978-0-444-52166-8).
3. Ashutosh Kar (2018, 7th edition) *Medicinal Chemistry*. New Age International (P) Ltd.(ISBN:978-9386649720).
4. Ed. M. E. Wolff (2010, 7thEdition,) *Burgers Medicinal and Drug Discovery*. John Wiley. (ISBN: 978-0-470-27815-4).

Laboratory Manual/ Book

- Not applicable

Suggested reading / E-resources

- Not applicable

Suggested MOOCs

- Not applicable

Methods of assessing the Course Outcomes

The COs of the course will be assessed through

- Assignment / Seminar
- Continuous Internal Assessment
- Semester End Evaluation

Component of CIA

Sr. No	CIA Component	Content	Duration	Marks	Total Marks
1	Test-I	Two Modules	1.5 hrs	5 (Set for 30)	20
	Test-II	All modules	3 hrs	15 (Set for 60)	
2	Assignment	-	-	10	30
3	Class Activity	-	-	20	
Total					**50**

Semester - III (Analytical Chemistry)		
Course Code	**Course Title**	**Course Credit and hrs**
19PCEACC301	**Core 9:Interpretative Molecular Spectroscopy (Self study)**	**3 Credits –1 hrs / wk**

Course Description:

This course focuses on interpretation of organic molecules by using modern analytical techniques like UV-Vis spectroscopy, FT-IR spectroscopy, Mass Spectrometry, ^{1}H, ^{13}C NMR and ^{2}D NMR spectroscopy.

Course Purpose:

- To solve simple structural problems efficiently by using combinations of the major techniques (UV, IR, NMR and MS).
- To impart knowledge of spectroscopic techniques for structural analysis of organic compounds.
- To be able to develop an analytical strategy to interpret an unknown organic compounds.

Course Outcomes: Upon completion of this course, the learner will be able to		
CO No.	**CO Statement**	**Blooms taxonomy Level (K1 to K6)**
CO_1	Calculate wavelength of organic molecules by UV-Vis Spectroscopy	K3, K4
CO_2	Differentiate functional groups based on their frequencies by using IR spectroscopy	K2, K3
CO_3	Analyse molecular structure and its molecular weight by their fragmentation pattern in mass spectroscopy	K4
CO_4	Deduce the chemical structure from ^{1}H NMR, ^{13}C NMR and 2D spectral data.	K4, K5
CO_5	Analyse data obtained from sophisticated instruments (like UV-Vis, FTIR, NMR, and Mass) for the structure determination and chemical analysis.	K4, K5

Prerequisite

Fundamentals of chemical shifts, fundamental frequencies of various functional groups, fragmentation rules, characteristic signal/peaks of spectrum, electronic effects of functional groups.

Course Content **Hours**

Module-I : Problems Solving in UV-Vis Spectroscopy: **02 hrs**

Interpretation and case study (characteristic absorption, Chemical Shifts, Simple chromophoric groups, conjugated and aromatic systems, effect of acid and base) of UV spectrum of organic compounds.

Module-II : Problems Solving in IR Spectroscopy: **02 hrs**

Interpretation and case study (characteristic frequency, functional group identification) of IR spectrum of organic compounds.

Module-III : Problems Solving in MASS Spectroscopy: **02 hrs**

Interpretation and case study (base peak, molecular ion peak, Fragmentation patterns, isotopic abundance, rearrangement) of Mass spectrum of organic compounds.

Module-IV : Problems Solving in NMR Spectroscopy **04 hrs**

Interpretation and case study (characteristic chemical shift, spin-spin coupling, coupling constant, exchangeable proton, cis-trans isomer, o/m/p substitution pattern, saturated & unsaturated system) of NMR spectrum (PMR & CMR and 2D) of organic compounds.

Module-V : General Spectroscopic Problems **05 hrs**

Structure determination and elucidation using combination of UV, IR, and Mass and NMR spectroscopy.

Suggested laboratory experiments:

- Not applicable

Pedagogic tools:

- Chalk and Board, Software, Case study
- LCD and Videos.

Reference Books:

1. L. D. Field, S. Sternhell, J. R. Kalman (2013, 5th edition). *Organic Structures from Spectra.*Weinheim: John Wiley & Sons Ltd. (ISBN: 9781118325452).
2. L. D. Field, H. L. Li, A. M. Magill (2015). *Organic Structures from 2D NMR Spectra*. Weinheim: John Wiley & Sons Ltd. (ISBN: 9781118868942).
3. L. D. S. Yadav (2005) *Organic Spectroscopy.* Springer Science+Business Media Dordrecht (ISBN 978-1-4020-2574-7)
4. Martin, M. L., Delpuech, J. J. and Martin, G. J. (1980) *Martin Practical NMR Spectroscopy*. Weinheim: John Wiley & Sons Ltd. (ISBN: 0471258652).

5. Silverstein, Robert M., Webster, Francis X., Kiemle, David J., Bryce, David L. (2014, 8thedition) *Spectrometric identification of Organic Compounds*. Weinheim: John Wiley & Sons Ltd. (ISBN: 978-0-470-91401-4).
6. Donald L. Pavia, Gary M. Lampman, George S. Kriz, James R. Vyvyan (2014, 5th edition) *Introduction to Spectroscopy.* Cengage Learning India Private Limited(ISBN: 978-1-285-46012-3).

Laboratory Manual/ Book

- Not applicable

Suggested reading / E-resources

- Not applicable

Suggested MOOCs

- Not applicable

Methods of assessing the Course Outcomes

The COs of the course will be assessed through

- Assignment / Seminar
- Continuous Internal Assessment
- Semester End Evaluation

Component of CIA

Sr. No	CIA Component	Content	Duration	Marks	Total Marks
1	Test-I	Two Modules	1.5 hrs	5 (Set for 30)	20
	Test-II	All modules	3 hrs	15 (Set for 60)	
2	Assignment	-	-	10	30
3	Class Activity	-	-	20	
Total					**50**

Semester - III (Analytical Chemistry)		
Course Code	**Course Title**	**Course Credit and hrs**
19PCEACC302	**Core 10: Analytical Method Development & Validation**	**4 Credits - 4 hrs / wk**

Course Description:
This course will provide a broad understanding and "hands-on" knowledge of the method development and validation to comply with today's upgraded FDA and ICH requirements. Analytical methods are intended to establish the identity, purity, physical characteristics and potency of the drugs that we use. Methods are developed to support drug testing against specifications during manufacturing, as well as during long-term stability studies. In Industries, validation is crucial for product approval process at certain stages by regulatory agencies.

Course Purpose: At the successful completion of the course, students will be able to:

- Understand the concepts of process validation, IQ, OQ and PQ.
- Describe importance of Development and Validation of analytical procedures.
- Discuss the concept of ICH guidelines.
- Outline stability and degradation studies.
- Evaluate statistical data elements required for Assay Validation

Course Outcomes: Upon completion of this course, the learner will be able to		
CO No.	**CO Statement**	**Blooms taxonomy Level (K1 to K6)**
CO_1	Understand the latest internationally recognized standards and developments in analytical assurance and their acceptance criteria	K1, K2
CO_2	Gain an understanding of method validation requirements as per ICH guideline and Pharmacopoeia.	K2, K3
CO_3	Identify and classify suitable analytical methods on the basis of various characteristic i.e. accuracy, precision, specificity, etc.	K3
CO_4	Evaluate statistical data Elements for Assay Validation	K3, K4
CO_5	Prepare method validation protocol	K5

Prerequisite
Basic terminology of method development and validation.

Course Content

Hours

Module-I: Introduction: 12 hrs

An Introduction to the Basic Concepts: Calibration, Qualification and Validation

Difference between calibration and validation.

General principles, Scope, Importance and limitation of Analytical Method Development and Validation. Bio-analytical Method Validation, Validation master plan (VMP). Process Validation & How it differs from Qualification, Installation Qualification (IQ), Operational Qualification (OQ) & Performance Qualification (PQ), Selection of method, method transfer. Guidelines Analytical Method Development.

Module-II: Analytical Validation-1: 10 Hrs

Need of analytical validation, Validation of Active Pharmaceutical Ingredients (APIs) and finished products, ICH guidelines on Validation of analytical procedures: text and methodology Q2 (R1).

Module-III: Analytical Validation-2: 14 Hrs

Types of process validation: A Review of Prospective, Concurrent, Retrospective Validation & Revalidation

Cleaning Validation: Validation of effective cleaning. Cleaning of Equipment and Facilities. Validation of Water, Sterile and Non-Sterile Facility.

Impurity profiling and validation – Types and sources of impurities. Validation as per ICH guidelines.

Module-IV: Stability: 12 Hrs

An Introduction to the Basic concept and objectives of stability study, Order of reaction and their applications in predicting shelf life and half-life of pharmaceutical formulations, Importance of accelerated stability study, Effect of various environmental/ processing factors like light, pH, temperature, etc. ICH guidelines on Stability Testing of New Drug Substances and Products, photostability testing.

Module-V: Degradation: 12 Hrs

A Review of accelerated and long term stability studies, stress testing and forced degradation studies. Degradation of products, Degradation Pathways: Study of chemical properties of drugs like hydrolysis, oxidation, reduction, polymorphisms, racemization, polymerization, photolysis, solvolysis and their influence on formulation and stability of products. Outline on Design, Construction and function of stability chambers and stability rooms

Suggested laboratory experiments:

- NA

Pedagogic tools:

- Chalk and Board, Power point presentation, models
- LCD and Videos.
- Practical Demonstration

Reference Books:

1. Robert A. Nash and Alfred H. Wachter. (2003, 3rdedition, Revised and expanded), *Pharmaceutical process validation (Drugs and The Pharmaceuticals Sciences)*, New York: Marcel Dekker Inc.(ISBN: 0-8247-0838-5).
2. Abdou H. M. (1989) *Dissolution, Bioavailability & Bio-Equivalence*.Eastern Pennsylvania: Mack Publishing Company. (ISBN: 978-0912734200).
3. Indian Pharmacopoeia(2018,8th edition, 4 volumes) The Controller of Publications, Govt. of India.
4. Manohar A. Potdar (2007, 2ndedition) *Pharmaceutical Quality Assurance*.Mumbai:NiraliPrakashan(ISBN: 978-81857905965).
5. Milo Gibaldi(2005, 4thedition) *Biopharmaceutics and Clinical Pharmacokinetics*.Pharma Book Syndicate(ISBN: 978-8188449064).
6. *Q2(R1) Validation of Analytical Procedures: Text And Methodology*. ICH Harmonized Tripartite Guideline
7. Sumie Yoshioka, Valentino J. Stella (2000, 2000thedition) *Stability of Drug and Dosage Forms*. Springer(ISBN: 978-0306464041).
8. Jens T. Carstensen (1995, 2ndrevised edition) *Drug stability: Principles and Practices (Drugs and the Pharmaceutical Sciences)*. Marcel Dekker Inc. (ISBN: 978-0824796358).
9. Dr. A. V. Kasturie, Dr. S. G. Wadodkar, Dr. K. R. Mahadik, Dr. H. N. More(2016, 19th edition) *Vol. II: Pharmaceutical Analysis (Instrumental Methods)*.Nirali Prakashan (ISBN: 978-8185790084).
10. D.P.S Kohli and D.H. Shah (2011, 4th edition) *Drug Formulation Manual*. Business Horizons(ISBN: 978-8190646772).
11. Michael E. Swartz, Ira S. Krull (2011, 1st edition) *Analytical Method Development and Validation*. Routledge (ISBN: 978-0824701154).

Laboratory Manual/ Book

- Not applicable.

Suggested reading / E-resources

- https://www.ich.org/fileadmin/Public_Web_Site/ICH_Products/Guidelines/Quality/Q2_R1/Step4/Q2_R1__Guideline.pdf
- Journal of Analytical Chemistry
- Journal of Planner Chromatography

Methods of assessing the Course Outcomes

- Continuous Internal Assessment (CIA)
- Semester End Evaluation (SEE)

Component of CIA

Sr. No	CIA Component	Content	Duration	Marks	Total Marks
1	Test-I	Two Modules	1.5 hrs	5 (Set for 30)	20
	Test-II	All modules	3 hrs	15 (Set for 60)	
2	Assignment	-	-	10	20
3	Class Activity	-	-	10	
Total					**40**

Semester - III (Analytical Chemistry)		
Course Code	**Course Title**	**Course Credit and hrs**
19PCEACC303	**Core 11: Industrial Formulation Development**	**4 Credits - 4 hrs / wk**

Course Description:

The course addresses the whole process pathway of pharmaceutical manufacturing from the identification of suited candidates for drugs until their formulation to the final product. The course is to provide students with an applicable understanding of formulated products, and how such products are designed and manufactured. The course also aims to give the participants new ideas pertaining to development and improvement of formulated products. In this course students knowing the targets, the ingredients available and the selection criteria for ingredients are reviewed.

Course Purpose:

- Methodology for product design, development and management
- Describe the types and excipients of the tablet & Capsules.
- Discuss about various sterile dosage forms.
- Account of cosmetic products.
- Classify and understand formulations of Aerosol formulations.
- Product performance test

Course Outcomes: Upon completion of this course, the learner will be able to		
CO No.	**CO Statement**	**Blooms taxonomy Level (K1 to K6)**
CO_1	Define the components and their functions of product design and development processes	K1, K2
CO_2	Identify and analyze the product design and development processes in manufacturing industry.	K2, K3
CO_3	Gained an understanding of modern formulation technology	K3
CO_4	Design an experimental protocol to investigate selected factors' effects	K3, K4
CO_5	Develop and improve commercial products	K5

Prerequisite

Basic knowledge of terminologies used in pharmaceutical chemistry, dosage forms, Properties of drugs, drug excipients, various vehicle used in formulation.

Course Content

Hours

Module-I: Solid Dosage Forms: 14 Hrs.

- **Tablet** (a) Definition, Advantages and disadvantages, Introduction to types of tablets, formulation of different types of tablets; excipients, granulation techniques, directly compressible excipients, in process controls, processing problems and remedies, Evaluation (Pharmacopoeial and nonpharmacopoeial test).

  (b) The Brief outline on manufacturing method and evaluation of mouth dissolving modified tablets

  (c) Coating of Tablets: Objectives, types, film former, Preparation & evaluation of coated tablets, coating defect.

  Capsules Hard Capsules: Definitions, advantages, disadvantages, Ideal requirements, Production of Hard capsules (Gelatin and nongelatin e.g. vegetable), Capsule storage, and size of capsules, formulation and methods of capsule filling, problems and remedies, quality control, climatic control in capsule department, I.P capsules. Soft Gelatin Capsules: Formulation of shell and capsule coat, quality control with special emphasis on current dissolution testing.

Module-II: Sterile Dosage Forms: 12 Hrs.

- Definitions, Advantages, Disadvantages, Ideal requirements and Formulation of sterile dosage forms, Water for injection-Preparation and quality control, Design and requirements for production area. Methods of filling including form fill and seal technology.
- Evaluation of sterile dosage forms, Parenteral suspensions, Prefilled syringes, Parenteral nutrients, Freeze dried products.
- Ophthalmic preparations: Requirements, formulations, methods of preparations, containers and evaluation.

Module-III: Liquid and Semisolid Dosage Forms: 12 Hrs.

- **Liquid dosage forms:** Introduction, advantages and disadvantages, types of additives. Manufacturing, packaging and evaluation of clear liquids, suspensions and emulsions (including micro emulsion and multiple emulsions) and brief outline of other liquid products.
- **Semisolid dosage forms:** Definition, Advantages and disadvantages, types, mechanisms of drug penetration through skin, factors influencing penetration, semisolid bases, their selection and ideal requirements of bases. General formulation of semisolids, clear gels, suppositories; Manufacturing procedure, evaluation and packaging.

Module-IV: Cosmeticology and Cosmetic Preparations: 12 Hrs.

- Fundamentals of cosmetic science, structure and functions of skin and hair, formulation, preparation and packaging of cosmetics for skin, cosmetics for hair and cosmetics for nail. Brief introduction to cosmeceuticals, baby care products, shaving cream, hygienic products.

Module-V: Pharmaceutical Aerosols **10 Hrs.**

- Brief review on requirements of Aerosols, Advantages, disadvantages and types of it, formulations and packaging components of aerosols, propellants, Pharmaceutical applications of aerosols.

Suggested laboratory experiments:

- NA

Pedagogic tools:

- Chalk and Board, Power point presentation, models
- LCD and Videos.
- Practical Demonstration

Reference Books:

1. Khar R.K., Vyas S. P., Ahmad F. J., Jain G. K.(2020, 4thedition) *Lachman/Lieberman's The Theory and Practice of Industrial Pharmacy*. CBS (ISBN: 978-8123922898).
2. Allen L. V. (Jr.), Ansel H. C. (2013, 10th edition) *Ansel's Pharmaceutical Dosage Forms and Drug Delivery Systems*. Lippincott Williams and Wilkins(ISBN: 978-1451188769).
3. Michael E. Aulton (2001, 2nd edition)*Pharmaceutics: The Science of Dosage Form Design*. Churchill Livingstone (ISBN: 978-0443055171).
4. S. H. Willig and J. R. Storker (2001, 2nd edition)GMP for Pharmaceuticals. Churchill Livingstone (ISBN: 978-0443055171).
5. H. Butler(2000, 10th edition) *Poucher's Perfumes, Cosmetics and Soaps*. Springer (ISBN: 978-0751404791).
6. Latest editions of IP, BP, USP
7. Joseph Price Remington, Alfonso R. Gennaro (2000, 21st edition) *Remington the Science and Practice of Pharmacy*, Vol-I & II, New York:Lippincott Williams & Wilkins(ISBN: 978-0781763783).
8. Herbert Lieberman, Martin Rieger, Gilbert S. Banker (1996, 2nd edition revised and expanded)*Pharmaceutical Dosage Forms: Disperse systems* Vol.1, Vol. 2 and Vol.3, CRC Press.
9. Kenneth E. Avis, Herbert Lieberman, Leon Lachman (1992, 2nd edition revised and expanded)Pharmaceutical Dosage Forms: Parenteral Medication: Vol.1, Vol. 2 and Vol.3, CRC Press.

Laboratory Manual/ Book

- Not applicable.

Suggested reading / E-resources

- NA

Methods of assessing the Course Outcomes

- Continuous Internal Assessment (CIA)
- Semester End Evaluation (SEE)

Component of CIA

Sr. No	CIA Component	Content	Duration	Marks	Total Marks
1	Test-I	Two Modules	1.5 hrs	5 (Set for 30)	20
	Test-II	All modules	3 hrs	15 (Set for 60)	
2	Assignment	-	-	10	20
3	Class Activity	-	-	10	
Total					**40**

Semester-III (Analytical Chemistry)		
Course Code	**Course Title**	**Course Credit and hrs**
19PCEADC301	**DSE –Core-1: Chemistry of Food Analysis**	**4 Credits - 4 hrs / wk**

Course Description:

Food analysis is the discipline dealing with the study and application of analytical procedures for characterizing the properties of foods and their constituents. This course aims to discuss analytical procedures which are used to provide information about a wide variety of different constituents of foods, including their structure, classification, physicochemical properties and possible food additives & adulterations.

Course Outcomes: Upon completion of this course, the learner will be able to:		
CO No.	**CO Statement**	**Blooms taxonomy Level (K1 to K6)**
CO_1	Identify & classify carbohydrates, enzymes, lipids, proteins and vitamins.	K1, K2
CO_2	Appreciate methods of analysis of food carbohydrates and activation & inactivation of enzymes.	K2, K3
CO_3	Choose physical and chemical tests for analysis of oils and fats.	K3
CO_4	Categorize & classify proteins and vitamins with their source & structure.	K3, K4
CO_5	Employ detection methods for food additives and adulterants.	K4, K5

Prerequisite

Basic knowledge of biomolecules, classification, origin and deficiency syndrome.

Course Content **Hours**

Module-I : Carbohydrates & Enzymes: **12 hrs**

Carbohydrates: Chemistry, classification, properties and general methods of analysis of food carbohydrates. Dietary fiber, crude fiber and application of food carbohydrates.

Enzymes: Introduction – Definition, occurrence, classification and chemical nature Properties of enzymes – mechanism of action; methods of assay; specificity; effect of temperature, pH and enzyme-substrate concentrations; activations, inhibition and their kinetics; various methods of inactivation; enzymes as catalysts; isoenzymes and coenzymes Important enzymes of foods Enzymes involved in food deterioration, types/nature of reactions catalyzed and preventive measures.

Module-II : Lipids: **12 hrs**

Introduction and definition of lipids and their classification Various types of lipids – Simple, conjugated, phospholipids and their occurrence in

foods Various fatty acids occurring in fats and oils Fatty acid composition and physical and chemical characteristics of Various fats and oils, Iodine value, saponification value, acid Value, Polenski value, Reichert-Meissel value of important oils Storage changes in fats and oils, antioxidation, effect of various metals, Ions, effects of moisture, surface area and antioxidants Refining of fats and oils; Hydrogenation of vegetable oils. Characteristics tests for various oils. Determination of adulteration in fats and oils. Various methods used for measurement of spoilage of fats and fatty foods.

Module-III : Proteins: **12 hrs**

Chemistry and classification of amino acids and proteins Reaction of amino acids Physico-Chemical properties of protein and their structure Methods of estimation of amino acids and proteins Chromatographic separation of amino acids and proteins Chemical interactions involving amino acids and proteins Nature of food proteins – Plant, animal and other relative merits Digestion, absorption and metabolism of proteins Chemical and biological evaluation of nutritional quality of proteins.

Module-IV : Vitamins: **12 hrs**

Classification of vitamins, Natural sources, Effect of factors like light, heat, pH, redox conditions, etc., on their stability, Chemistry of vitamins, biological Role or Functions of vitamins in body as coenzymes, deficiency of vitamin, Estimation of vitamin in food, Principles of microbial assay of vitamins of B12.

Module-V : Food additives & Adulterants: **12 hrs**

Introduction, types of food additives - preservatives, antioxidants, artificial sweeteners, flavors, flavor enhancers, stabilizers, thickening and jelling agents.

Pesticides: Analysis of organophosphorous and organochlorine pesticides. Determination of pesticide residues in grain, fruits, vegetables, milk and milk products.

Pigments and Synthetic Dyes: Natural pigments - Carotenoids, Anthocyanin, flavone, Chlorophyll - their occurrence, characteristic properties, and methods of detection, Permitted synthetic dyes & Non-permitted synthetic dyes used by industries, Harmful effects of non-permitted dyes.

Suggested laboratory experiments:

- Note: Included in DSE –Core-Practical-1

Pedagogic tools:

- Chalk and Board, Power point presentation, Charts & Models

- Info-graphics and Videos.

Reference Books:

1. Y Picó (2012, 1stEdition) *Chemical Analysis of Food: Techniques and Applications*. Academic Press(ISBN: 978-0123848628).
2. S. Suzanne Nielsen (2010, 4th edition) *Food Analysis (Food Science Text Series)*. Springer (ISBN: 978-1441914774).
3. Peter Belton and Roger Wood*RSC Food Analysis Monographs*. RSC Publication, Print ISSN: 1757-7098.
4. Morris B Jacobs (2006, 3rd edition)*The Chemical Analysis of Foods and Food Products*.CBS Publishers & Distributors Pvt Ltd (ISBN: 978-8123906430).
5. Stanley Crouch, Donald West, F Holler, Douglas A. Skoog (2013, 9th edition) *Fundamentals of Analytical Chemistry*. Meerut: Brooks/Cole Publishing Company (ISBN: 978-0495558286).
6. B. Sivasankar (2012) *Instrumental Methods of Analysis*. Oxford University Press (ISBN: 978-0198073918).
7. Gary D. Christian, Purnendu K. Dasgupta, Kevin A. Schug (2013, 7th edition)*Analytical chemistry*. John Wiley & sons, Inc. (ISBN: 978-0-470-88757-8).
8. Douglas A. Skoog, F. James Holler, Timothy A. Nieman (1998, 5th edition)*Principles of instrumental analysis*. HARCOURT ASIA PTE, LTD. (ISBN: 978-0030020780).
9. Verma R. M. (2019, 3rd edition) *Analytical Chemistry. Theory and Practice*. CBS Publishing (ISBN: 978-8123902661).

Laboratory Manual/ Book

- Not applicable

Suggested reading / E-resources

- One Hundred Years of Progress in Food Analysis, Robert J. Mcgorrin, J. Agric. Food Chem., 2009, 57, 8076–8088, DOI:10.1021/jf900189s
- https://www.augusta.edu/scimath/biology/courses/BIOL_1107/biomolecules.pdf
- Physical Methods in Food Analysis, Editors: Michael H. Tunick and Charles I. Onwulata, Volume 1138, American Chemical Society Publication, DOI: 10.1021/bk-2013-1138
- https://www.sciencedirect.com/topics/chemistry/food-analysis
- https://fssai.gov.in/home

Suggested MOOCs

- NOC: Analytical Chemistry, by Prof. Debashish Ray, IIT-Kharagpur, Course Link: https://nptel.ac.in/courses/104105084/

Methods of assessing the Course Outcomes

- Continuous Internal Assessment(CIA)
- Semester End Evaluation (SEE)

Component of CIA

Sr. No	CIA Component	Content	Duration	Marks	Total Marks
1	Test-I	Two Modules	1.5 hrs	5 (Set for 30)	20
	Test-II	All Modules	3 hrs	15 (Set for 60)	
2	Assignment	-	-	10	20
3	Class Activity	-	-	10	
Total					**40**

SEMESTER-III(Analytical Chemistry)		
19PCEADC302	**DSE – Core 1 Instrumental Methods of Analysis**	**4 Credits - 4 hrs./Wk**

Course Description:

The course will provide students with the knowledge and skills needed to conduct laboratory research, understand instrument design and analyze instrumental results. Over the duration of the course you will be expected to learn the theory behind a range of instrumental techniques, instrumentation hardware and data analysis techniques. The class will cover the theory of instrumental techniques of analysis, atomic emission and absorption, ICP-OES, X-ray analysis, TGA, DTA, DSC, polarimetry, Fluorometry and Phosphorimetry.

Course Purpose:

- To understand and apply the basic concept of instrumental methods of analysis
- To understand instrumental operational methods.
- To able identify the sample for analysis and operate the instrument independently

Course Outcomes: Upon completion of this course, the learner will be able to

CO No.	CO Statement	Blooms taxonomy Level (K1 to K6)
CO_1	Understand the theory and practice of instrumental methods for the emission and absorption spectroscopy, ICP-OES, Thermal techniques etc.	K1, K2
CO_2	Distinguish between qualitative and quantitative measurements and be able to effectively compare and critically select methods for elemental and molecular analyses	K2, K3
CO_3	Demonstrate sampling and sample treatment prior to analysis	K3, K4
CO_4	Assess concepts of availability and evaluation of analytical standards and formulate standard methodology for analysis.	K3, K4
CO_5	Apply the basic phenomena of instrumental techniques to operate instruments and evaluate the experimental data.	K4, K5

Prerequisite

Basic knowledge of absorption and emission spectra, instrumentation of absorption spectrometers & emission spectrometers, diffraction of light, thermal decomposition methods.

Course Content **Hours**

Module-I : Spectroanalytical Techniques **14 hrs**

- Fundamental of spectroscopy, electromagnetic radiations and their properties. Introduction to absorption and emission spectroscopy. Lambert-Beer law.
- Atomic absorption & Emission spectroscopy: Basic principle, theory, instrumentation and applications of AAS & AES.
- Advanced Technique-ICP-OES

Module-II : X-ray diffraction analysis (XRD) **12 hrs**

- Introduction, generation of X-rays, X-ray diffraction, Bragg's law, X-ray powder and single crystal diffraction, Interpretation of diffraction pattern, applications of XRD and numerical.

Module-III : Thermal Methods of Analysis **12 hrs**

- Principle, theory and instrumentation of TGA, DTA and DSC. Factors affecting thermal analysis. Applications of thermal methods in various field of science. Various theories of thermal analysis for evaluation of kinetic parameters and analysis of simple and polymeric compounds.

Module-IV : Spectropolarimetry, Fluorometry and Phosphorimetry **12 hrs**

- Introduction, principle, theory, instrumentation and applications

Module-V : Potentiometry and Conductometry **10 hrs**

- Introduction, principle, Basic scientific theory, instrumentation and applications

Suggested laboratory experiments:

- Not applicable

Pedagogic tools:

- Chalk and Board
- LCD and Videos.
- Instruments

Laboratory Manual/ Book

1. Fundamentals of Analytical Chemistry – Skoog, Harcourt College Publishers.
2. Quantitative chemical analysis – Vogel A. I., Pearson Education.
3. Text Book of Pharmaceutical Analysis – K. A. Connor, John Willey & Sons, New York.
4. Quantitative Chemical Analysis – Ayer by Harper & Row, New York.
5. Instrumental methods of chemical analysis – by B. K. Sharma
6. Concepts, Instrumentation and Techniques in Inductively Coupled Plasma Optical Emission Spectrometry by Charles B. Boss and Kenneth J. Fredeen.

Suggested reading / E-resources

- NA

Suggested MOOCs

- Organic Spectroscopy- NPTEL
- Introduction to Molecular Spectroscopy - COURSERA

Methods of assessing the Course Outcomes

- CIA (Test, Assignment, Seminar, Class Activity)
- SEE

Component of CIA

Sr. No	CIA Component	Content	Duration	Marks	Total Marks
1	Test-I	Two Modules	1.5 hrs	5 (Set for 30)	20
	Test-II	All Modules	3 hrs	15 (Set for 60)	
2	Assignment	-	-	10	20
3	Class Activity	-	-	10	
Total					**40**

Semester - III (Analytical Chemistry)		
Course Code	**Course Title**	**Course Credit and hrs**
19PCEACC304	**Core 10 & 11 Practical: Analytical Method Development &Validation & Industrial Formulations**	**4 Credits - 9 hrs / wk**

Course Description: Thorough Familiarization of students with Method development and validation by chromatography and spectroscopic technique.
The Industrial formulation and Development course addresses the whole process pathway of pharmaceutical manufacturing. The course is to provide students with an applicable understanding of formulated products, and how such products are designed and manufactured.

Course Purpose:

Analytical Method Development, Validation & Stability Studies

- To understand the different techniques of method development and Validation
- To apply practical solutions for determining the validation characteristics
- To become familiar with the various parameters to be applied
- Evaluate statistical data elements required for method development and Validation

Industrial Formulations and Development

- Prepare tablets, capsules, syrup and their evaluation
- To become familiar with the various parameters to be applied
- Evaluate statistical data of analysis.

Course Outcomes: Upon completion of this course, the learner will be able to		
CO No.	**CO Statement**	**Blooms taxonomy Level (K1 to K6)**
CO_1	Understand the latest internationally recognized standards and developments in analytical assurance and their acceptance criteria.	K1, K2
CO_2	Identify and classify suitable analytical methods on the basis of various characteristic i.e.accuracy, precision, specificity, etc.	K2, K3
CO_3	Evaluate statistical data Elements for Validation	K3
CO_4	Define the components and their functions of product design and development processes	K3, K4
CO_5	Develop and improve commercial products	K5

Prerequisite

Fundamental knowledge of, TLC, UV and various formulations used in pharmaceuticals.

Analytical Method Development, Validation & Stability Studies

- Method Development of Different organic compounds by TLC. (05 Exercise)
- Method Development and Validation of Organic compounds by UV spectroscopy (3Exercise)

Industrial Formulation Development Practical

- **Preparation and evaluation** of effervescent tablet, ferrous sulphate tablet, Paracetamol tablet.
- Preparation and evaluation of tablets employing direct compression, wet granulation, dry granulation (slugging), compression coating.
- Filling of powder/ granules/ pellets in hard gelatin capsule and its evaluation.
- Preparation and evaluation of face powder, lipstick, cold cream, vanishing cream, tooth paste/ tooth powder.
- Formulation and evaluation of syrup, emulsion (o/w, w/o), turpentine liniment, calamine lotion.
- Formulation and evaluation of milk of magnesia/aluminum hydroxide gel antacid suspension.
- Formulation and evaluation of dry suspension.
- Formulation and evaluation of diclofenac sodium gel.
- Formulation and evaluation of eye drops.
- Formulation and evaluation of metronidazole infusion.

Laboratory Manual/ Book

- Laboratory Manual.

Suggested reading / E-resources

- NA

Suggested MOOCs

- Organic Spectroscopy- NPTEL
- Introduction to Molecular Spectroscopy - COURSERA

Methods of assessing the Course Outcomes

- Continuous Internal Assessment(CIA)
- Semester End Evaluation (SEE)

Component of CIA

Sr. No	CIA Component	Content	Duration	Marks	Total Marks
1	Test I (01 Exercise from each component)	50% to 60 % of Experiment	3 hrs	25 for each Exercise	50
2.	Observation book & Record	-	-	5 for Each	10
Total					**60**

Semester - III (Analytical Chemistry)		
Course Code	**Course Title**	**Course Credit and hrs**
19PCEADC303	**DSE – Core 1 Practical Chemistry of Food Analysis**	**2 Credits - 3 hrs / wk**

Course Description:

This course aims to perform analytical experiments which are used to provide information about a wide variety of different constituents of foods, including their structure, classification, physicochemical properties and possible food additives & adulterations.

Course Outcomes: Upon completion of this course, the learner will be able to:		
CO No.	**CO Statement**	**Blooms taxonomy Level (K1 to K6)**
CO_1	Choose physical and chemical tests for analysis of oils and fats.	K2, K3
CO_2	Quantify different parameter of Food and Adulterant.	K3, K4
CO_3	Employ different detection methods for food additives and adulterants.	K5

Prerequisite

Fundamental knowledge of various titration methods, spectroscopic methods.

Practicals of Chemistry of Food & Drug Analysis.

- Determination of aqueous acidity and alcoholic acidity of foods
- Saponification value and unsaponifiable matter of fats and oils.
- Refractive index, Iodine value, TBA value, Free fatty acids of fats and oils
- Determination of protein in foods by Folin-Ciocalteau method
- Determination of total and acid insoluble ash
- Spectrophotometric determination of reducing and total sugars
- Determination of sugar by volumetric method.
- Determination of vitamin A by colorimetry
- Spectrophotometric determination of carotenes
- Determination of vitamin C by volumetric method
- Determination of benzoic acid in foods by volumetric method

Laboratory Manual/ Book

- Comprehensive Practical Analytical Chemistry by Dr. H. S. Joshi

Suggested reading / E-resources

- NA

Suggested MOOCs

- NA

Methods of assessing the Course Outcomes

- Continuous Internal Assessment(CIA)
- Semester End Evaluation (SEE)

Component of CIA

Sr. No	CIA Component	Content	Duration	Marks	Total Marks
1	Test	50% to 60 % of Experiment	3 hrs	15 (Set for 15)	15
2.	Observation book & Record	-	-	5	5
Total					**20**

Semester - III (Analytical Chemistry)		
Course Code	**Course Title**	**Course Credit and hrs**
19PCEADC304	**DSE – Core 1 Practical Instrumental Methods of Analysis**	**2 Credits - 3 hrs / wk**

Course Description:

The course will provide students with the practical knowledge and skills needed to conduct laboratory experiment, understand instrument design and analyze instrumental results. The class will cover the Hands on Experiment of instrumental techniques of analysis.

Course Purpose:

- To understand and apply the basic concept of instrumental methods of analysis
- To understand instrumental operational methods.
- To able identify the sample for analysis and operate the instrument independently

Course Outcomes: Upon completion of this course, the learner will be able to		
CO No.	**CO Statement**	**Blooms taxonomy Level (K1 to K6)**
CO_1	Understand the practice of instrumental methods for the absorption spectroscopy.	K1, K2
CO_2	Distinguish between qualitative and quantitative measurements and be able to effectively compare and critically select methods for elemental and molecular analyses	K2, K3
CO_3	Demonstrate sampling and sample treatment prior to analysis	K3, K4
CO_4	Apply the basic phenomena of instrumental techniques to operate instruments and evaluate the experimental data.	K4, K5

Prerequisite

Fundamental knowledge of flame photometry, potentiometry, conductometry and fluorescences.

Practicals: (12 exercise)

- Chemical / Instrumental analysis of different compound by Flame photometer
- Intermediates / Pharmaceutical products analysis by Potentiometer and Conductometer
- Fluorescence measurement of different compounds containing conjugated system

Methods of assessing the Course Outcomes

- Continuous Internal Assessment(CIA)
- Semester End Evaluation (SEE)

Component of CIA

Sr. No	CIA Component	Content	Duration	Marks	Total Marks
1	Test	50% to 60 % of Experiment	3 hrs	15 (Set for 15)	15
2.	Observation book & Record	-	-	05	05
Total					**20**

Semester - III (Analytical Chemistry)		
Course Code	**Course Title**	**Course Credit and hrs**
	Core 12: Project/Internship/Skill Training/Advance Practical (Research proposal & presentation)	**2 Credits - 3 hrs / wk**

Prerequisite

Literature survey of research publications, data compilation, use of chemical drawing software, basic presentation software operating.

Based on Academic Performance (Merit/Test/Interview) and Interest, students will be allotted Project/Internship/Skill Training/Advance Practical during semester III & IV.

Project:

- The candidates will be given the option of selecting a research problem in a preferred area that falls within the disciplines of courses undertaken.
- Candidates have to present their research outcomes in the Pre presentation (Internal committee) before final Project thesis/Report & oral presentation.
- At the end of the semester the candidates are required to present their research outcomes in the form of a Project thesis/Report & oral presentation.
- The evaluation (Presentation & Viva) of the Project work (Dissertation) will be carried out at the end of Sem-IV.

Internship/Skill Training:

- An internship is period of work experience offered by an Institution/industries for a limited period of time.
- The evaluation of internship/skill training carried out by Presentation & Viva during practical examination.

Advance Practical

- The evaluation of advance practical will be carried out by internal & term end practical examination.

Note: Evaluated at the End of SEM-IV

If the student opts for exit at end of Semester-III; the Core 12: Project/Internship/Skill Training/Advance Practical course will reflected as **19PCEOCC305 in the mark statement** and student will be evaluated for 2 credits.

Semester - IV (Analytical Chemistry)		
Course Code	**Course Title**	**Course Credit and hrs**
19PCEACC401	**Core 12: Project/Internship/Skill Training/Advance Practical**	**12 Credits - 20 hrs / wk**

Course Description:

The aim of the Project/Internship/Skill Training/Advance Practical to enable students to develop deeper knowledge, understanding, capability and attitudes in the context of the programme.

Course Purpose:

- To develop research/practical skills commensurate with the accomplishment of a master degree.
- To develop research proposal/laboratory protocol/ training reports.
- To address issues of research/practical design methodology ethics and theoretical arguments and apply this to research/practical.

Course Outcomes: Upon completion of this course, the learner will be able to		
CO No.	**CO Statement**	**Blooms taxonomy Level (K1 to K6)**
CO_1	Apply critical and analytical skills in a scientific and professional manner.	K3
CO_2	Critically apprising and interpretative published literature	K4
CO_3	Synthesise knowledge and skills previously gained and applied to an in-depth study.	K4, K5
CO_4	Select from different research methodologies, methods and forms of analysis to produce a suitable research method.	K4
CO_5	Present the finding of their project in a written report.	K6

Prerequisite

Literature survey of research publications, data compilation, and understanding of scientific language used in publications, spectroscopic data analysis.

Laboratory experiments:

Project:

- The candidates will be given the option of selecting a research problem in a preferred area that falls within the disciplines of courses undertaken.
- Candidates have to present their research outcomes in the Pre presentation (Internal committee) before final Project thesis/Report & oral presentation.

- At the end of the semester IV, the candidates are required to present their research outcomes in the form of a Project thesis/Report & oral presentation.

Internship/Skill Training:

- An internship is period of work experience offered by an Institution/industries for a limited period of time.
- The evaluation of internship/skill training carried out by Presentation & Viva during practical examination.

Advance Practical

- Natural Product: Qualitative test/ identification test of phyto-constituents
- Method development and validation of natural product or synthesized intermediates
- Ternary organic mixture separation and chromatographic identification.
- Food Analysis

Reference Books:

- Not applicable

Laboratory Manual/ Books

1. Practical organic chemistry by A. I. Vogel.
2. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis by V. K. Ahluwalia, R. Aggarwal
3. Phytochemical Analysis by J. B. Harbone
4. TLC by Stahl

Suggested reading / E-resources

- Not applicable

Suggested MOOCs

- Not applicable

Methods of assessing the Course Outcomes

- Continue Internal Assessment (CIA)
- Semester End Examination (SEE)

Project/Internship/Skill Training

Component of CIA

Sr. No	CIA Component	Content	Marks	Total Marks
1	Review I (Committee)	Literature search & Presentation	20	80
	Review I (Guide)	Monitoring & Presentation	20	
	Review II (Committee)	Pre presentation of Project	20	
	Review II (Guide)	Monitoring & Presentation	20	
Total				**80**

Advance Practical

Component of CIA

Sr. No	CIA Component	Content	Duration	Marks	Total Marks
1	Test	50% to 60 % of Experiment	6 hrs	60	60
2.	Observation book & Record	-	-	20	20
Total					**80**

Semester - IV (Analytical Chemistry)		
Course Code	**Course Title**	**Course Credit and hrs**
19PCEACC402	**Core 13: Chemistry of Natural Products**	**5 Credits - 5 hrs / wk**

Course Description:

Chemistry of Natural Products is primarily focusing on the basic principles to understand the structure and reactivity of naturally occurring materials. The course is dealing with Classification, extraction, technique of separation, and identification of natural compounds with representative synthesis of the concerned class.

Course Purpose:

- To understand the extraction of metabolites from natural products.
- To state Synthesis, structural significance and importance of representative classes of the alkaloids, vitamins and steroids.
- To carry out phytochemical tests of the metabolites.
- To understand structural significance of Natural product derived drugs.

Course Outcomes: Upon completion of this course, the learner will be able to		
CO No.	**CO Statement**	**Blooms taxonomy Level (K1 to K6)**
CO_1	Understand the concept of identification and isolation of primary and secondary metabolites.	K2, K3
CO_2	Prepare systematic extraction method for the active ingredient.	K3
CO_3	Explain structural significance of the active molecules from the natural resources.	K3, K4
CO_4	To identify active molecules from medicinal plants.	K3, K4
CO_5	Illustrate synthesis of the selected natural products.	K4

Prerequisite

Basic knowledge of sources, extraction and isolation techniques, solvent properties.

Hours

Course Content

Module-I: Introduction and History of Natural Products **15 Hrs**

Introduction, classification, source, types of extraction, primary and secondary metabolite, extraction and isolation methods of metabolite.

Module-II: Alkaloids **15 hrs**

Introduction, definition, classification, extraction and phytochemical test Synthesis, structural significance and importance of representative alkaloids: Morphine, Heroin, Codeine, Ricinine, Atropine, Cocaine, Nicotine.

Module-III: Vitamins **15 hrs**

Introduction, History, classification and importance including hyper/hypo diseases. Synthesis, structural significance and importance of representative Vitamins: Vitamin A, B group (folic acid, niacin,

pantothenic acid, riboflavin-B_2, pyridoxine-B_6), C and E (α- and β-tocopherols and tocotrienols).

Module-IV: Steroids **15 hrs**

Introduction, History, classification, and extraction of Steroid and sterol.

- **Bile acid**: Introduction and its function.
- **Steroid Hormones**: Introduction, type, synthesis, structural significance and importance of representative steroid hormones: Androsterone, Testosterone, Oestrone, Oestradiol, Oestriol, and Progesterone.

Module-V: Natural product derived drugs **15 hrs**

Introduction, extract based drugs, Herbal formulation, synthesis & structural significance of some representative molecules: 7-Methylomuralide, Agelastatin A, (-)Bursehemin, Carpanone, Chelidonine, Fulvoplumierin, Griseofulvin, Janoxepin, Luotonin A, (-)Mersicarpine, Taxol, (+)Vinblastine.

Suggested laboratory experiments:

- Not applicable

Pedagogic tools:

- Chalk and Board, Power point presentation, models
- LCD and Videos.

Reference Books:

1. Finar, I.L. (1989, Fifth edition) *Organic Chemistry: Vol -2: Stereochemistry and the Chemistry of Natural Products*. Harlow: Longman. (ISBN: 0-582-05916-X).
2. Mann, J.; Harborne, J.; Davidson R. S. (1994) *Natural Products: Their Chemistry and Biological Significance*. Harlow: Longman Publishing Group. (ISBN: 0470200022).
3. Hostettmann, Kurt; Gupta, M. P.; Marston A. (1994) *Chemistry, Biological & Pharmacological properties of medicinal plants from the Americas*. Newark: Harwood Academic Publishers. (ISBN: 9057023970).
4. Norman, R. O. C.; Coxon, J. M. (1993, Third edition) *Principles of organic synthesis*. New Delhi: CBS Publishers & Distributors. (ISBN: 0748761624).
5. Carey, F. A.; Sundberg, R. J. (2010, Fifth edition) *Advanced Organic Chemistry Part B: Reactions and Synthesis.* Berlin: Springer. (ISBN: 0387683542).

   Nogradi, M. (2008, Second revised and updated edition) *Stereoselective synthesis: A practical approach*. Weinheim: Wiley VCH. (ISBN: 978-3-527-61568-1).

Laboratory Manual/ Book

- Not applicable

Suggested reading / E-resources

- Not applicable

Suggested MOOCs

- Not applicable

Methods of assessing the Course Outcomes

- Continue Internal Assessment (CIA)
- Semester End Examination (SEE)

Component of CIA

Sr. No	CIA Component	Content	Duration	Marks	Total Marks
1	Test-I	Two Modules	1.5 hrs	5 (Set for 30)	20
	Test-II	All modules	3 hrs	15 (Set for 60)	
2	Assignment	-	-	10	30
3	Class Activity	-	-	20	
Total					**50**

Semester - IV (Analytical Chemistry)		
Course Code	**Course Title**	**Course Credit and hrs**
19PCEACC403	**Core 14: Regulatory Affairs**	**5 Credits - 5hrs/week**

Course Description:

This course is designed to provide students with a framework necessary to develop an understanding of regulatory affairs. The course focuses on regulatory affairs concept which the pharma companies must comply to sell their drugs both domestically and in the international market. This course covering U.S. and international legislation and regulatory processes guidelines, as well as the crucial role that regulatory affairs play in developing products, navigating the regulatory review and approval process and contributing to keeping products on the market.

Course Purpose:

- To Understand the Regulatory guidance's and guidelines for filing and approval process.
- Able to write Regulatory Documents.
- To provide students with a global knowledge of Regulatory Affairs.
- Enable improvement of the regulatory environment by implementing and upholding good regulatory practices process

Course Outcomes: Upon completion of this course, the learner will be able to		
CO No.	**CO Statement**	**Blooms taxonomy Level (K1 to K6)**
CO_1	Understanding of important regulatory concepts	K1
CO_2	To provide global knowledge of Regulatory Affairs and create Regulatory Strategy	K2, K3
CO_3	Write Regulatory Documents	K3
CO_4	Take independent responsibility for own professional development	K3, K4
CO_5	Evaluate scientific data and conclusions intended for regulatory review	K5

Prerequisite

Fundamentals of documentation, different regulatory authorities, need of quality control for industries.

Course Content

Hours

Module-I: Quality Control and Quality Assurance: 15 Hrs

Basic concept of Quality management, Total quality management (TQM approach), Details of international standards (ICH and ISO 9000).

Quality Assurance: Concept of quality systems – Change control/management, Sampling plans, Packaging and labeling control, Deviations – OOS and OOT, Line clearance, Recall and complaints managements, Finished products release, Quality review, Quality audits, Self-inspection.

Quality Control Laboratory: Responsibilities, Routine controls instruments, Regents, Standard test procedures, Protocols, Non-clinical testing, Data generation and storage, Concept of IPQC, Quality control documents, Retention samples, Records and Audits of quality control facilities.

Module-II: Good Manufacturing Practices (Schedule M): 15 Hrs

- **Concept of GMP and cGMP.**
- **Legal requirement pertaining to GMP and GMP guidelines,**
- **Basic components of GMP -** Organization & Personnel, Training, Premises, Sanitation and hygiene, Equipment, Raw materials, Manufacturing operation & controls, Manufacturing documents, Master formula records, Batch formula records, Batch packaging records, Batch release document, Standard operating procedures, Quality audits of manufacturing processes and facilities.

Module-III: Good Laboratory Practices: 15 Hrs

- **GLP – General introduction & scope**
- **OECD Principles of GLP**: Organization, Personnel & management, Facilities, Equipment, Test items, Test systems, Protocols, Standard operating procedures, Performance of study, Raw data and data collection, Final study report, Archives, Quality assurance programme.
- **Role and responsibilities of GLP.**

Module-IV: Drug Development & Approval Process: 15 Hrs

Drug development stages: Target selection, Pre-clinical development and Clinical development.

New Drug approval process: National drug regulatory requirements, National drug policy, Drugs and Cosmetics Act and its amendments, Overview of schedules -M and Y, FDA guidelines on IND, NDA & ANDA approvals.

Module-V: International Regulatory Agencies: 15 Hrs

General introduction of regulatory affairs, Role and responsibilities in pharma industries, Introduction of various accrediting regulatory agencies in the world: USFDA, MCA, TGA, MHRA, ANVISA, CTD, WHO, ICH, SUPAC, CDSCO etc.

Suggested laboratory experiments:

- NA

Pedagogic tools:

- Chalk and Board, Power point presentation, models
- LCD and Videos.
- Practical Demonstration

Reference Books:

1. Indian Pharmacopoeia (2018, 8th edition, 4 volumes) The Controller of Publications, Govt. of India.
2. Manohar A. Potdar (2007, 2nd edition) *Pharmaceutical Quality Assurance*. Mumbai: Nirali Prakashan (ISBN: 978-81857905965).
3. *Guidelines for Developing National Drug Policies*; WHO Publications, 1998.
4. *Quality Assurance of Pharmaceuticals–A Compendium of Guidelines and Related Materials*, Vol.–1; WHO Publications.
5. Kaushik Maitra and Sedhan K. Ghosh. *A Guide to Total Quality Management* M. PHARM. (PHARMACEUTICAL MANAGEMENT AND REGULATORY AFFAIRS)-R13 Regulations
6. M. L. Mehra(1993) *Good Manufacturing Practice, Quality Control, Guidelines, Basic Standards in the Manufacture of Drugs and Pharmaceuticals*.
7. P.P. Sharma (2015, 7th edition) *How to Practice GMPs*. Vandana Pub (ISBN: 978-8190595797).

8. Sadhan K. Ghosh (2007, 4th edition) Introduction to ISO 9000 and TQM. Oxford Publishing House.

Laboratory Manual/ Book

- Not applicable.

Suggested reading / E-resources

- https://www.ich.org/fileadmin/Public_Web_Site/ICH_Products/Guidelines/Quality/Q2_R1/Step4/Q2_R1__Guideline.pdf

Methods of assessing the Course Outcomes

- Continuous Internal Assessment (CIA)
- Semester End Evaluation (SEE)

Component of CIA

Sr. No	CIA Component	Content	Duration	Marks	Total Marks
1	Test-I	Two Modules	1.5 hrs	5 (Set for 30)	20
	Test-II	All modules	3 hrs	15 (Set for 60)	
2	Assignment	-	-	10	30
3	Class Activity	-	-	20	
Total					**50**