गोंय विद्यापीठ
ताळगांव पठार,
गोंय – ४०३ २०६
फोन : +९१-८६६९६०९०४८

(Accredited by NAAC)

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GU/Acad –PG/BoS -NEP/2025-26/227 Date: 04.07.2025

CIRCULAR

The Academic Council & Executive Council of the University has approved Ordinance OA-35A relating to PG Programmes offered at the University campus and its affiliated Colleges based on UGC 'Curriculum and Credit Framework for Postgraduate Programmes'. Accordingly, the University has proposed introduction of Ordinance OA-35A from the Academic year 2025-2026 onwards.

The Programme structure and syllabus of Semester I & II of the **Master of Science in Pharmaceutical Chemistry** Programme approved by the Academic Council in its meeting held on 13th & 14th June 2025 is attached.

The Dean & Vice-Dean (Academic) of the School of Chemical Sciences and the Principals of affiliated Colleges offering the **Master of Science in Pharmaceutical Chemistry** are requested to take note of the above and bring the contents of the Circular to the notice of all concerned**.**

ASHWIN VYAS LAWANDE
Digitally signed by ASHWIN VYAS LAWANDE
Date: 2025.07.04 17:04:22 +05'30'

(Ashwin V. Lawande)
Deputy Registrar – Academic

To,
1. The Dean, School of Chemical Sciences, Goa University.
2. The Vice-Dean (Academic), School of Chemical Sciences, Goa University.
3. The Principals of affiliated Colleges offering the Master of Science in Pharmaceutical Chemistry Programme.

Copy to:
1. Chairperson, BoS in Chemistry, Goa University.
2. Programme Director, M.Sc. Pharmaceutical Chemistry, Goa University.
3. Controller of Examinations, Goa University.
4. Assistant Registrar Examinations (PG), Goa University.
5. Director, Directorate of Internal Quality Assurance, Goa University for uploading the Syllabus on the University website.

GOA UNIVERSITY

MASTER OF SCIENCE IN PHARMACEUTICAL CHEMISTRY

(Effective from the Academic Year 2025-26)

ABOUT THE PROGRAMME

The M.Sc. Pharmaceutical Chemistry program is a two-year postgraduate course designed to provide an in-depth understanding of the chemical and analytical aspects of drug development and pharmaceutical sciences. The course integrates key concepts from organic, inorganic, medicinal, and analytical chemistry with pharmaceutical applications to equip students with the knowledge and skills required in modern drug discovery, development, and quality control. Emphasis is placed on the synthesis of medicinal compounds, structure-activity relationships, pharmacokinetics, drug formulation, and regulatory affairs. The curriculum includes theoretical instruction, laboratory training, and a research-based dissertation project to foster critical thinking, scientific inquiry, and technical proficiency. This program prepares graduates for careers in the pharmaceutical industry, research and development laboratories, regulatory agencies, and academic institutions, while also serving as a strong foundation for pursuing doctoral studies in related fields.

OBJECTIVES OF THE PROGRAMME

1. To provide fundamental and advanced knowledge of pharmaceutical chemistry.
2. To develop skills in drug synthesis, analysis, and formulation.
3. To enhance laboratory techniques and research capabilities.
4. To prepare students for careers in pharmaceutical industries and research.

Approved by: Academic Council on 13th & 14th June 2025

PROGRAMME SPECIFIC OUTCOMES (PSO)	
PSO 1.	Demonstrate a comprehensive understanding of pharmaceutical chemistry, including drug design, synthesis and evaluation.
PSO 2.	Apply advanced knowledge of organic, inorganic, medicinal, and analytical chemistry in pharmaceutical research and development.
PSO 3.	Utilize modern techniques and instruments for the synthesis, analysis, and quality control of pharmaceutical products.
PSO 4.	Analyze the structure-activity relationships (SAR) and pharmacokinetic properties of pharmaceutical compounds.
PSO 5.	Conduct independent research and critically evaluate scientific literature to support drug discovery and development.
PSO 6.	Apply regulatory standards, ethical guidelines, and safety protocols in pharmaceutical practices and laboratory work.
PSO 7.	Communicate research findings, experimental results and technical information clearly and effectively in written and oral formats.
PSO 8.	Prepare for professional roles in pharmaceutical industries, research organizations, regulatory agencies, and academia.

PROGRAMME STRUCTURE

Master of Science in Pharmaceutical Chemistry

Effective from the Academic Year 2025-2026

Bridge Course			
Sr. No.	**Course Code**	**Title of the Course**	**Credits**
1	CHC-1000	Bridge Course in mathematical concepts for chemistry	1
2	CHC-1001	Bridge Course in organic chemistry	1

SEMESTER I				
Discipline Specific Core (DSC) Courses (16 credits)				
Sr. No.	**Course Code**	**Title of the Course**	**Credits**	**Level**
1	CHO-5000	Fundamental Concepts in Organic Chemistry	4	400
2	CHH-5000	Basics of Pharmaceutical Chemistry	4	400
3	CHP-5000	Fundamentals of Physical Chemistry	4	400
4	CHA-5000	Analytical Chemistry Techniques	4	400
Total Credits for DSC Courses in Semester I			**16**	
Discipline Specific Elective (DSE) Course (4 credits)				
Sr. No.	**Course Code**	**Title of the Course**	**Credits**	**Level**
1	CHH-5201	Pharmaceutical Chemistry Practical - I	2	400
2	CHH-5202	Pharmaceutical Chemistry Practical - II	2	400
3	CHO-5201	Organic Chemistry Practical - I	2	400
4	CHO-5202	Organic Chemistry Practical - II	2	400
5	CHP-5201	Physical Chemistry Practical - I	2	400
6	CHP-5202	Physical Chemistry Practical - II	2	400
7	CHA-5201	Analytical Chemistry Practical - I	2	400
8	CHA-5202	Analytical Chemistry Practical - II	2	400
Total Credits for DSE Courses in Semester I			**4**	
Total Credits in Semester I			**20**	

SEMESTER II				
Discipline Specific Core (DSC) Courses				
Sr. No.	**Course Code**	**Title of the Course**	**Credits**	**Level**
1	CHH-5001	Advance Pharmaceutical Chemistry	4	500
2	CHH-5002	Drugs: Product Development, Formulation and Manufacture	4	500
3	CHH-5003	Drugs: Discovery, Design and Development	4	500
4	CHH-5004	Pharmacokinetics and Biopharmaceutics	4	500
Total Credits for DSC Courses in Semester II			**16**	
Discipline Specific Elective (DSE) Courses (4 credits)				
Sr. No.	**Course Code**	**Title of the Course**	**Credits**	**Level**
1	CHH-5201	Pharmaceutical Chemistry Practical - I	2	400
2	CHH-5202	Pharmaceutical Chemistry Practical - II	2	400
3	CHO-5201	Organic Chemistry Practical - I	2	400
4	CHO-5202	Organic Chemistry Practical - II	2	400
5	CHP-5201	Physical Chemistry Practical - I	2	400
6	CHP-5202	Physical Chemistry Practical - II	2	400
7	CHA-5201	Analytical Chemistry Practical - I	2	400
8	CHA-5202	Analytical Chemistry Practical - II	2	400
Total Credits for DSE Courses in Semester II			**4**	
Total Credits in Semester II			**20**	

Blooms Taxonomy Cognitive Levels	
Cognitive Level	**Notations**
K1	Remembering
K2	Understanding
K3	Applying
K4	Analyzing
K5	Evaluating
K6	Create

BRIDGE COURSES

Title of the Course	Bridge Course in Mathematical Concepts for Chemistry
Course Code	CHC-1000
Number of Credits	1
Theory/Practical	Theory
Level	400
Effective from AY	2025-26
New Course	No
Bridge Course/ Value added Course	Yes
Course for advanced learners	No

Pre-requisites for the Course:	NIL			
Course Objectives:	To introduce mathematical concepts to the students of MSc Part-I (Chemistry).			
Course Outcomes:	Students will be able to solve problems based on:		**Mapped to PSO**	
	CO 1. Matrices in M.Sc. Chemistry		PSO1	
	CO 2. Determinants in M.Sc. Chemistry		PSO1	
	CO 3. Differential calculus in M.Sc. Chemistry		PSO1	
	CO 4. Integral calculus in M.Sc. Chemistry		PSO1	
Content:		**No of**	**Mapped**	**Cognitive**

		hours	to CO	Level
Module 1:	1. Calculus for thermodynamics and kinetics a. Introduction to Differentiation: Notation, Differentiating various f functions, Differentiating a Sum, Product Rule, Quotient Rule, Chain Rule, Partial Differentiation: exact and inexact differentials. b. Introduction to Integration: Notation, Rules for Integrals, Integrating various functions, Definite and indefinite Integrals.	**8**	CO3, CO4	K5
Module 2:	2. Matrices, Determinants and vector algebra: a. Types of Matrices: Identity, reflection, rotation, inversion, distance matrix, Matrix Algebra, Matrix similarity transformation. b. The Determinant, Minors and Cofactors, Inverse of a Matrix, Character of a matrix, Linear algebra. c. Vectors and molecular structure.	**7**	CO1, CO2	K5
Pedagogy:	Mainly lectures and tutorials. Seminars/assignments/presentations/self-study or a combination of some of these can be used. ICT mode should be preferred. Sessions can preferably be interactive to enable peer group learning.			
Texts:	Robert G. Mortimer, Mathematics for Physical Chemistry, Elsevier, New York. 4th ed., 2013			
References/ Readings:	James R. Barrante, Applied Mathematics for Physical Chemistry, 3rd ed., Prentice-Hall, New Jersey, 1998			

Title of the Course	Bridge Course in Organic Chemistry
Course Code	CHC-1001
Number of Credits	1
Theory/Practical	Theory
Level	400
Effective from AY	2025-26
New Course	No
Bridge Course/ Value added Course	Yes
Course for advanced learners	No

Pre-requisites for the Course:	NIL			
Course Objectives:	• To understand various principles of organic chemistry. • To apply the importance of chirality in organic syntheses. • To analyse stereoselective reactions. • To interpret oxidation and reduction reactions.			
Course Outcomes:	Students will be able to:		**Mapped to PSO**	
	CO 1. understand knowledge of basic reaction mechanisms in organic transformation.		PSO2	
	CO 2. apply chirality in organic synthesis.		PSO2	
	CO 3. compare configurations/ conformations of organic molecules.		PSO2	
	CO 4. assess oxidizing and reducing reagents in organic synthesis.		PSO2	
Content:		**No of**	**Mapped**	**Cognitive**

		hours	to CO	Level
Module 1:	1. Fundamentals of organic chemistry: Electron movement with arrows, half and double headed arrows (Cleavage of bonds: homolysis and heterolysis) in organic reaction mechanisms; inductive effect, electromeric effect, resonance and hyperconjugation, steric hindrance, hydrogen bonding; reactivity of organic molecules: nucleophiles and electrophiles; reactive intermediates: carbocations, carbanions and free radicals; strength of organic acids and bases, aromaticity, benzenoids and Huckel's rule.	**8**	CO1	K1, K2
Module 2:	2. Stereochemistry: Conformations with respect to butane and cyclohexane; interconversion of wedge formula, Newmann, Sawhorse and Fischer representations; CIP Rules: R/S configurations.	**3**	CO2, CO3	K2, K3, K4
Module 3:	3. Substitution, elimination and addition reactions: Substitution and elimination reactions (SN1, SN2, E1 and E2), addition of different groups on olefins.	**2**	CO1	K2, K3
Module 4:	4. Oxidation and reduction reactions: Basic concepts, oxidizing and reducing reagents and some examples.	**2**	CO4	K3, K4
Pedagogy:	Mainly lectures and tutorials. Seminars/assignments/presentations/self-study or a combination of some of these can be used. ICT mode should be preferred. Sessions can preferably be interactive to enable peer group learning.			
Texts:	1. D. Nassipuri, Stereochemistry of Organic compounds - Principles and Application, 4th ed., Wiley Eastern Limited, New Academic Science Limited, Lucknow, India, 2013 2. E. L. Eliel, Stereochemistry of carbon compounds, Tata MacGraw Hill Publishing Company Ltd., New Delhi, 1990. 3. J. March, Advanced Organic Chemistry: Reaction, Mechanism and Structure, 4th ed., Wiley, USA, 2010. 4. J. Clayden, N. Greeves, S. Warren & Wothers, Organic Chemistry, 2nd ed., Oxford University Press, Oxford, 2012 5. I. L. Finar Stereochemistry and Chemistry of Natural products, Vol. 2, 3rd ed., , Longmans, ELBS London, 1963 6. F. A. Carey and R.J. Sundberg, Advanced Organic Chemistry, Vol. I & II. Plenum Press, New York, 1977 7. E. S. Gould et al., Mechanism and structure in Organic Chemistry, Holt, Rinehart And Winston, New York, 1965 8. F. A. Carey, Organic Chemistry, 4th ed., McGraw-Hill Higher Education, USA, 2000			

	9. S. H. Pine, Organic Chemistry, 5th ed., McGraw-Hill International Education, New York, 2010
References/ Readings:	1. V. M. Potapov, Stereochemistry, MIR Publishers, Moscow, 1979 2. J. M. Harris & C.C. Wamser, Fundamentals of Organic Reaction Mechanisms, John Wiley & Sons. Inc. New Jersey, 1976. 3. F. M. Menger, D.J. Goldsmith & L. Mendell, Organic Chemistry, A concise approach, 2nd ed., Addison Wesley Longman, Boston 1975.

SEMESTER I

Discipline Specific Core Courses

Title of the Course	Fundamental Concepts in Organic Chemistry
Course Code	CHO-5000
Number of Credits	4
Theory/Practical	Theory
Level	400
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	NIL	
Course Objectives:	• To study the various concepts based on molecular orbital theory, Aromaticity, Acids and bases. • To understand the concepts of stereochemistry and their significance in determining the structure, reactivity, and properties of organic molecules • To understand the mechanistic aspects of various type of reactions in organic synthesis and the use of selective reagents in organic transformations.	
Course Outcomes:	Students will be able to:	**Mapped to PSO**

	CO 1. Understand the effect of delocalization of electrons & presence or absence of aromaticity in organic compounds.		PSO1, PSO 2	
	CO 2. Apply various concepts in stereochemistry to understand stereochemical outcome in a reaction.		PSO1, PSO 2	
	CO 3. Evaluate plausible mechanisms of organic reactions.		PSO1, PSO2, PSO3	
	CO 4. Apply various reagents for desired organic transformations.		PSO1, PSO2, PSO3, PSO4	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**1.1 Molecular orbitals and delocalized chemical bonding** a. Qualitative description of molecular orbitals of simple acyclic and monocyclic systems, frontier molecular orbitals. b. Conjugation, cross conjugation, hyperconjugation and tautomerism (types and examples). c. Aromaticity: Origin of Huckel's rule, examples of aromatic, non-aromatic and antiaromatic compounds; concept of Mobius aromaticity. **1.2 Structure & Reactivity** a. Acidity, basicity and pKa of organic compounds; Acid and base strengths; HSAB concept & Factors affecting it, effect of structure & medium on acid and base strength. b. Concept of superacids and superbases. c. Electrophilicity & nucleophilicity, examples of ambident nucleophiles & electrophiles. (Including revision of aromatic electrophilic and nucleophilic substitution)	**15**	CO1	K1, K2, K3, K4,K5
Module 2:	**2. Stereochemistry** a. Brief revision of configurational nomenclature: R & S; D & L; E & Z; cis & trans and *syn* & *anti* nomenclature. Chirality in molecules with two and more chiral centers. b. Conformational analysis of open chain compounds (Butane, 2, 3-butane	**15**	CO2, CO3	K1, K2, K3, K4, K5

	diol, 2,3-dibromobutane etc.). *Erythro* and *threo* nomenclature. c. Topicity and Prostereoisomerism: Topicity of ligands and faces-homotopic, enantiotopic and diastereotopic, ligands and faces. d. Chemoselective, regioselective and stereoselective reactions with examples. e. Conformation and reactivity of cyclohexane and substituted cyclohexanes, cyclohexene / cyclohexanone. Conformational isomerism and analysis in acyclic and simple cyclic systems substituted ethane, cyclopentane, cyclohexane. f. Optical isomerism - optical activity - molecular dissymmetry and chirality - elements of symmetry. optical isomerism in biphenyls, allenes and spirans - optical isomerism of nitrogenous compounds racemisation and resolution.			
Module 3:	**3.1 Reaction Mechanism** a. Structure, stability and reactivity of reactive intermediates (carbocations, carbanions, free radicals, carbenes, arynes and nitrenes) b. Types of mechanisms, types of reactions, thermodynamic and kinetic control. c. Methods of determining reaction mechanisms: i. Identification of products. ii. Determination of the presence of intermediates (isolation, detection, trapping and addition of suspected intermediate. iii. Isotopic labelling. iv. Stereochemical evidence. v. Kinetic evidence and Isotope effect. (at least two examples to be covered for above methods) **3.2 Selective reagents for Organic transformation** a. Oxidation of organic compounds: PCC, PDC and MnO_2, ozonolysis,	**15**	CO2, CO3	K1, K2, K3, K4, K5

	peracids. b. Reduction of organic compounds: $NaBH_4$, LAH, DIBAL reduction and reduction with borane and dialkylboranes. Clemmensen reduction, Birch reduction and Wolff-Kishner reduction			
Module 4:	**4.1 Aliphatic Nucleophilic substitution** a. Nucleophilic substitutions with respect to mechanism and various factors affecting such reactions. b. The Neighbouring Group Participation (NGP)/ Anchimeric assistance: General approach to various NGP processes; NGP by unshared/lone pair of electrons; NGP by π-electrons; NGP by aromatic rings (formation of phenonium ion intermediate); NGP by sigma bonds with special reference to bornyl and nor- bornyl system (formation of nonclassical carbocation) **4.2 Elimination reactions** a. The E2, E1 and E1cB mechanisms. Orientation of the double bond, Saytzeff and Hofmann rule. b. Effects of substrate, base, leaving group and medium on: i. Overall reactivity ii. E1 vs. E2 vs. E1cB iii. Elimination vs substitution, mechanism and orientation in pyrolytic *syn* elimination (various examples involving cyclic and acyclic substrates to be studied).	**15**	CO3. CO4	K1, K2, K3, K4, K5
Pedagogy:	Mainly lectures and tutorials. Seminars / term papers /assignments / presentations / self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning.			
Texts:	1. R. T. Morrison, R. N. Boyd, S. K. Bhattacharjee, Organic Chemistry, 7th ed. Pearson Education, New Delhi, 2010 2. D. Nassipuri, Stereochemistry of Organic Compounds: Principles and Applications, 4th ed. New Age International, New Delhi, 2020 3. J. Clayden, N. Greeves, S. Warren, P. Wothers, Organic Chemistry, 2nd ed. Oxford University Press, Oxford, 2012			

	4. J. March, Advanced Organic Chemistry: Reactions, Mechanisms and Structure, 4th ed. Wiley Student Edition, New York, 2003. 5. P. S. Kalsi, Stereochemistry: Conformation and Mechanism, 11th ed. New Age International, New Delhi, 2022 6. E. L. Eliel, S. H. Wilen, Stereochemistry of Organic Compounds, 1st ed. John Wiley and Sons, New York, 1994 7. H. O. House, Modern Synthetic Reactions, 2nd ed. W. A. Benjamin, New York, 1965 8. F. A. Carey, R. J. Sundberg, Advanced Organic Chemistry, 5th ed. Springer India Private Limited, New Delhi, 2007
References/ Readings:	1. R. Bruckner, Advanced Organic Chemistry: Reaction Mechanisms, 1st ed. Harcourt/Academic Press, San Diego, 2002. 2. P. Y. Bruice, Organic Chemistry, 8th ed, Pearson, New Delhi, 2020

Title of the Course	Basics of Pharmaceutical Chemistry
Course Code	CHH-5000
Number of Credits	4
Theory/Practical	Theory
Level	400
Effective from AY	2025-2026
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	• To get introduced to pharmaceutical chemistry and terms involved. • To understand the various classes of drugs with examples. • To learn the Structure, IUPAC name and Mechanism of action of drugs. • To acquire knowledge of structure activity relationships and synthesis.	
Course Outcomes:	Students will be able to:	**Mapped to PSO**
	CO 1. Explain the various categories of drugs and their physico-chemical properties, metabolism and assay.	PSO 1
	CO 2. Explain the structures, synthesis and mechanism/mode of action of drugs.	PSO 2, PSO 3
	CO 3. Analyze the drugs based on nature, structure, bioactivity and its SAR.	PSO 4

	CO 4. Evaluate the case study of drugs for a particular disease.		PSO 6, PSO 8	
Content:	**Pharmaceutical chemistry, physicochemical properties of drugs, drug metabolism and assay of drugs:**	**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	Role of chemistry in pharmacy: Introduction to pharmaceutical chemistry. Need to study pharmaceutical chemistry. Important terminologies: pharmacodynamics, pharmacokinetics, pharmacognosy, materia medica, toxicology, pharmacopoeia, pharmacophore, effect of functional groups on physiological activity of drugs: hydroxy, acidic, alkyl, aldehyde, ketone, cyano, halogens, ether and ester groups with examples. Physicochemical properties of drugs: effect of solubility, partition coefficient, ionization constant, surface active agents, chelation, hydrogen bonding, stereoisomers on the pharmacological action of drugs (specific example of API to be given). Drug action, drug metabolism-significance of drug metabolism. phase I, phase II pathways with reactions. Factors on which drug metabolism depends. Assay of drugs-chemical, biological and immunological assay.	**12**	CO1, CO2, CO3	K1, K2, K3, K4
Module 2:	**Classification of chemotherapeutic drugs: Development of the following drugs including structure activity relationship (SAR), mechanisms of action (MA), chemical nomenclature, generic names (GN) and side effects (SE).** **Note: outline of synthesis ($) of the selected drugs.** **Anti-Infective agents-I:** **Antiseptics and Disinfectants**: Alcohols, substituted phenols, Methenamine Mandelate, Chloramine-T, 8-hydroxy quinoline derivatives, Acridine derivatives, Mercurials like (Mercurochrome, Thiomersal) and Nitrofurantoin derivative, Triclosan$. **Antitubercular agents**- Aminosalicylic acid, PAS, Pyrazinamide$, Ethambutol$, Clofazimine, **Antimalarials**: Life cycle of parasite, drug acting on different stages- Quinine, Chloroquine$, Primaquine, Trimethoprim, Proguanil (MA), Cycloguanil, Drug combinations. **Antiamoebics**: General aspect of infection, Life cycle of parasite, Hydroxyl quinolines, Metronidazole$, Lucanthone, **Anthelmentics**:	**12**	CO1, CO2	K2, K3, K4, K5

	Diethylcarbamazine, Niclosamide, Mebendazole$, Oxamniquine.			
Module 3:	**Anti-Infective agents-II** Antivirals including drugs acting on HIV Idoxuridines, Amantadine Hydrochloride$, Acyclovir. **Antineoplastics**: 6- Mercaptopurine, Thiotepa$, Chlorambucil, Taxol. **Antifungal**: Antibiotics like Nystatin, Tolnaflate$, Clotrimazole$. **Sulfonamides and other antifolics**: Sulfonamides and other para-aminobenzoic acid antagonist, Sulfacetamide$, Sulfamethoxazole, **Newer antibacterial agents**: Quinoline carboxylic acids such as Ciprofloxacin, Temafloxacin. **Hypoglycemics**: Insulin and various sulfonyl ureas like tolbutamide$, Tolazamide, phenformin, Glipizide.	**12**	CO2, CO3, CO4	K3, K4, K5, K6
Module 4:	**Anti-lipidemics, Diuretics, and diagnostic agents:** Anti-lipidemics: Clofibrate$, nicotinic acid, boxidine. **Diuretics**: Acid forming osmotic diuretics, Mercurials-Meralurides, Sulfonamides-Acetazolamide$, Chlorothiazide$, Hydrochlorothiazide, Ethacrynic acid. **Synthetic sweetener**: Diagnostic agents Inorganic compounds- Iodoxyl, Iodophendylate. **Dyes**: Rose Bengal, Fluorescein, Aminohippuric acid$.	**12**	CO2, CO3, CO4	K2, K3, K4, K5
Module 5:	**Hypotensive agents, General and Local Anaesthetics:** **Hypotensive agents** acting on vascular smooth muscles: Nitrites, Amylnitrites, Glyceryl nitrite$, Pentaerythritol tetranitrate, Isosorbide dinitrate. **General anaesthetics**: Ether, Nitrous oxide, Halothane$, Ultra short acting Barbiturates-Thiopental sodium $. **Local anaesthetics**: Cocaine, Benzocaine$, Procaine (MA), Lidocaine$, Purgatives and cathartics: Phenolphthalein, Castor oil.	**12**	CO2, CO3, CO4	K3, K4, K5
Pedagogy:	Mainly lectures and tutorials. Seminars / term papers /assignments / presentations / self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning.			
Texts:	1. Williams, D. A., & Lemke, T. L. (2006). Foye's Principles of Medicinal Chemistry, 5th ed., Philadelphia, PA: Lippincott Williams & Wilkins. 2. Beale, J. M., & Block, J. H. (2004). Wilson and Gisvold's Textbook of Organic Medicinal and Pharmaceutical			

	Chemistry, 11th ed., Philadelphia, PA: Lippincott Williams & Wilkins. 3. Abraham, D. J., & Rotella, D. P. (2010). Burger's Medicinal Chemistry, Drug Discovery and Development, 7th ed., Vols. 1–6, Hoboken, NJ: John Wiley & Sons. 4. Shriram, D., & Yogeshwari, P. (2007). Medicinal Chemistry, 1st ed., New Delhi: Pearson Education. 5. Patrick, G. L. (2017). An Introduction to Medicinal Chemistry, 6th ed., Oxford, UK: Oxford University Press. 6. Lednicer, D., & Mitscher, L. A. (2005). The Organic Chemistry of Drug Synthesis, Vol. III, 1st ed., Hoboken, NJ: John Wiley & Sons. 7. Singh, H., & Kapoor, V. K. (2010). Medicinal and Pharmaceutical Chemistry, 2nd ed., New Delhi: Vallabh Prakashan. 8. Chatwal, G. R. (2002). Medicinal Chemistry (Organic Pharmaceutical Chemistry),1st ed., Mumbai: Himalaya Publishing House.
References/ Readings:	1. National Center for Biotechnology Information (NCBI) – PubChem 2. Royal Society of Chemistry (RSC) - Chemical Biology 3. ScienceDirect - Pharmaceutical Chemistry journals 4. Wiley Online Library - Pharmaceutical Chemistry books and journals 5. US Pharmacopeia (USP) - official standards for pharmaceuticals
Web Resources:	1. https://www.pharmaguideline.com/2021/08/introduction-classification-dosage-forms.html 2. https://www.upm-inc.com/preformulation-in-drug-studies 3. https://www.ncbi.nlm.nih.gov/books/NBK518682/ 4. https://www.ncbi.nlm.nih.gov/books/NBK568677/

Title of the Course	Fundamentals of Physical Chemistry
Course Code	CHP-5000
Number of Credits	04
Theory/Practical	Theory
Level	400
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	NIL	
Course Objectives:	• To introduce various mathematical and computational concepts of chemistry • To gain knowledge of core concepts of physical chemistry i.e. thermodynamics, kinetics, quantum chemistry and electrochemistry • To inculcate critical thinking and apply the knowledge of physical chemistry concepts in problem solving • To understand and apply physical chemistry principles to other areas of chemistry	
Course Outcomes:	Students will be able to:	**Mapped to PSO**
	CO 1. Explain various concepts in physical chemistry.	PSO1, PSO2
	CO 2. Utilise concepts of electrochemistry and their applications in renewable energy generation and storage.	PSO1, PSO6

	CO 3. Demonstrate the concepts during the lab course in physical chemistry.		PSO3, PSO4, PSO5	
	CO 4. Apply fundamentals of chemical kinetics and thermodynamics for understanding reaction processes and mechanisms		PSO3, PSO7	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**1. Mathematical Preparations** a. Introduction to various functions and function plotting (exponential, logarithmic, trigonometric etc.), functions of many variables. complex numbers and complex functions. b. Linear equations, vectors, matrices and determinants. c. Basic rules of differentiation and integration, Partial differentiation, location and characterization of critical points of a function, Regression methods, curve fitting. d. Introduction to series, convergence and divergence, power series, Fourier series e. Probability (permutations and combinations).	**10**	CO1, CO3	K1, K2, K3
Module 2:	**2. Quantum Chemistry** a. Operators, Functions, Eigen value equations, Postulates. b. Schrödinger equation, application to simple system viz. free particle, particle in one dimensional, two dimensional and three-dimensional box (quantization, separation of variables, degenerate wave functions). c. Hydrogen like atoms, Schrödinger equation and its solutions, atomic orbital wave functions and interpretation. d. Hückel MO theory, Secular equations, Secular determinant, delocalization energy, charge density, π-bond order, free valence, applications to C_2H_4, C_3H_5 (radical), C_4H_6, C_4H_4, C_6H_6, C_6H_8.	**20**	CO1, CO3	K1, K2, K5
Module 3:	**3. Thermodynamics** a. Thermodynamic properties: Gas laws, real gases, Boyle temperature, critical temperature, state and path properties. Intensive and extensive properties. Exact and inexact differentials. Internal energy, enthalpy, entropy, free energy	**12**	CO1, CO3, CO4	K1, K2, K3, K5

	and their relations and significances. Maxwell relations. Thermodynamic equations of state. b. Joule-Thomson effect. Joule-Thomson coefficient for van der Waals' gas. Joule-Thomson effect and production of low temperature, adiabatic demagnetization, Joule-Thomson coefficient, inversion temperature. c. The third law of thermodynamics. Need for the third law. Apparent exceptions to third law. Application of third law. Use of thermodynamic functions in predicting direction of chemical change. Entropy and third law of thermodynamics. d. Phase equilibria: Phase rule, Discussion of two component systems forming solid solutions with and without maximum or minimum in freezing point curve. Systems with partially miscible solid phases. e. Three component systems: Graphical representation. Three component liquid systems with one pair of partially miscible liquids. Influence of temperature. Systems with two pairs and three pairs of partially miscible liquids. The role of added salts.			
Module 4:	**4. Electrochemistry** a. EMF series, cell potential: Nernst equation, Cells at equilibrium. Determination of thermodynamic functions. b. Decomposition potential and overvoltage, electronegativity, basic principles, completeness of deposition, separation with controlled potentials, constant current electrolysis, composition of electrolyte, potential buffers, physical characteristics of metal deposits. c. Electroplating and electroless plating, electrosynthesis. d. Concepts of acid-base aqueous and non-aqueous solvents, hard and soft acid-base concept and applications.	**9**	CO1, CO2, CO3	K1, K2, K3, K5, K6
Module 5:	**5. Chemical Kinetics** a. General introduction to various types of order of reaction including fractional order, molecularity of the reaction. b. Introduction to reversible and irreversible reactions and reactions leading to equilibrium. van't Hoffs equation and analysis of Gibbs free energy of	**9**	CO1, CO3, CO4	K1, K2, K3, K4, K5

	equilibrium reactions. c. Collision theory and Maxwell Boltzmann distribution of energies of colliding molecules. The concept of collisional cross section and reactive cross section and its significance. d. Comparative study of transition state and collision state theory. e. Reaction Mechanisms: elementary reactions, consecutive elementary reactions, steady state approximation, the rate determining step and pre-equilibria. f. Free radical reactions, complex reactions such as acetaldehyde decomposition and reaction between H_2 and Br_2. Homogeneous reactions and acid-base catalysis. g. Elementary enzyme reactions. Lineweaver-Burk plot and its analysis.			
Pedagogy:	Mainly lectures and tutorials. Seminars / term papers /assignments / presentations / self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning.			
Texts:	1. P. W. Atkins and J. D. Paula, Physical Chemistry, 8th ed., Oxford University Press, New Delhi. 2007 2. G. M. Barrow, Physical Chemistry, 5th ed., Tata McGraw Hill, New Delhi. 2016 3. J. E. House, Principles of Chemical Kinetics, 2nd ed., Academic Press, Elsevier Burlington, USA, 2007 4. I. N. Levine, Quantum Chemistry, 7th ed., Prentice-Hall, New Delhi. 1999. 5. S. Glasstone, Text Book of Physical Chemistry, D. Van Nostrand Company, New York, Reprint 1942.			
References/ Readings:	1. B. R. Puri, L. R. Sharma and M. S. Pathania, Principles of Physical Chemistry, 49th ed., Vishal Publishing Co., New Delhi, 2020 2. A. Saggion, R. Faraldo, M. Pierno, Thermodynamics - Fundamental Principles and Applications, Springer, Switzerland, 2019 3. J. Bockris, A. K.N. Reddy, M. E. Gamboa-Aldeco, Modern Electrochemistry: Fundamentals of Electrodics, Vol. 2A, 2nd ed., Kluwer Academic Publishers, New York, 2002 4. J. Bockris, A. Reddy, Modern Electrochemistry: Ionics, Vol. 1, 2nd ed., , 2nd Ed., Kluwer Academic Publishers, New York, 2002 5. J. E. House, Principles of Chemical Kinetics, 2nd ed., Academic Press, Burlington MA, 2007 6. J. P. Lowe, K. Peterson, Quantum Chemistry, 3rd ed., Elsevier, Burlington MA, 2006			

	7. R. G. Mortimer, Physical Chemistry, 3rd ed., Elsevier, Burlington MA, 2008

Title of the Course	Analytical Chemistry Techniques
Course Code	CHA-5000
Number of Credits	4
Theory/Practical	Theory
Level	400
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	NIL	
Course Objectives:	• To learn various methods of data handling in analysis. • To explain the significance of sampling and calibration techniques. • To understand principles and applications of various types of techniques • To train the students to deduce structures based on IR, NMR, MS combined data.	
Course Outcomes:	Students will be able to:	**Mapped to PSO**
	CO 1. Analyze the role of statistical tools for determination of error and organize data management for systematic interpretation.	PSO1
	CO 2. Apply the sampling and calibration methods for obtaining reliable results.	PSO1
	CO 3. Explain basic principles and scope of different methods of separation and Techniques of analysis	PSO2

	CO 4. Solve problems based on IR, NMR, MS combined spectral data.		PSO3, PSO5	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	1.1. Analytical Objectives and Data Handling: Importance of analytical chemistry in research and industry; statistics and data handling in analytical chemistry, standard operating procedures, good laboratory practices: quality assurance, method validation and quality control.	**5**	CO1	K4
	1.2. Sampling and Calibration Techniques: Sampling and sample preparation, general steps in chemical analysis, calibration of glassware. Finding the best straight line - least square regression, correlation coefficient; Calibration curves, standard addition, external standards and internal standards. Chemical concentrations. Classical methods of Analysis: Gravimetry and Titrimetric methods: Principle, methodology, advantages & disadvantages over instrumental methods.	**5**	CO2	K3
	1.3. Introduction to Thermoanalytical techniques: Principle, instrumentation and applications of Thermogravimetric Analysis (TGA), Differential Thermal Analysis (DTA), and Differential Scanning Calorimetry (DSC). Numericals based on TGA.	**5**	CO3	K2
Module 2:	2.1. Introduction to Chromatographic Techniques: Principles of chromatography, classification of chromatographic techniques based on mechanism of retention, configuration, mobile and stationary phase. Efficiency of separation- plate theory (theoretical plate concept) and rate theory (van Deemter equation).	**4**	CO3	K2
	2.2. Principles and applications of Paper chromatography, thin layer chromatography, HPTLC, Size exclusion and Ion exchange chromatography. Counter-current chromatography for isolation of natural products.	**4**	CO3	K2
	2.3. Gas and Liquid Chromatography: Introduction; Instrumental Modules; Separation System; Choice of Conditions of Analysis; Sample Inlet Systems;	**7**	CO3	K2

	Detectors; Practical Considerations in Qualitative and Quantitative Analysis; Coupled Systems-introduction to GCMS, GCIR, LCMS: Applicability, interpretation and numericals.			
Module 3:	3.1. Introduction to Spectroscopic Techniques: Interaction of Electromagnetic Radiation with Matter, Electromagnetic spectra, regions of spectrum, numericals. Ultraviolet and visible Spectroscopy: Electronic spectra and Molecular structure: types of electronic transition, Chromophore and auxochrome, absorption by isolated chromophore, conjugated chromophores, aromatic compounds, inorganic chelates. Choices and effect of solvents on UV-Vis. Quantitative Calculations: Beer-Lambert Law; Mixtures of absorbing species-laws of additivity of absorbance; calibration curve for calculation of unknown; Spectrometric errors in measurement; Deviation from Beer-Lambert Law - chemical deviation, instrumental deviation; Numericals for quantitative analysis using UV-Vis spectroscopy. Infrared Spectroscopy: Infrared absorption and molecular structures, molecular vibrations, types of vibrations, IR spectra, overtones and bands-basis of NIR absorption. Spectrometric instrumentation of UV-Vis and IR: Sources, monochromators, sample cells, detectors, instrumental wavelength and absorption calibration.	**10**	CO4	K5
	4.2. Applications of UV-Vis spectroscopy for qualitative analysis: Calculating λmax for Conjugated Dienes, Trienes, polyenes, α,β-unsaturated carbonyl compounds, Numericals. Applications of IR spectroscopy for qualitative analysis: Spectra interpretation, Frequencies of functional group, Spectral Databases, Identification of unknown compounds.	**5**	CO4	K5
Module 4:	4.1. Raman Spectroscopy: Theory, Basic instrumentation and Structural analysis using Raman Spectra. Mass Spectrometry: Principle, Instrumentation and various fragmentation patterns.	**5**	CO3, CO4	K2, K5
	4.2. Proton and Carbon NMR Spectroscopy: Theory of NMR, Instrumentation,	**5**	CO4	K5

	Chemical shift, factors influencing chemical shift, solvents used in NMR, spin-spin splitting, coupling constant calculation, factors influencing coupling constant.			
	4.3. Conjoint spectrometry problems: Structural elucidation of organic molecules using IR, UV, NMR and MS.	**5**	CO4	K5
Pedagogy:	Mainly lectures and tutorials. Seminars / term papers /assignments / presentations / self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning.			
Texts:	1. G. D. Christian, Analytical Chemistry, 6th ed., Wiley, Singapore, 2004. 2. G. W. Ewing, Instrumental Methods of Chemical Analysis, 5th ed., McGraw- Hill Int., New York, 1985. 3. W. Kemp, Organic Spectroscopy, 3rd ed., Palgrave, New York, 1991. 4. D. A. Skoog, D. M. West, F. J. Hollar, S. R. Crouch, Fundamentals of Analytical Chemistry, 9th ed., Cengage learning, USA, 2014. 5. R. M. Silverstein, F. X. Webster, Spectrometric identification of Organic Compounds, 6th ed., Wiley, USA, 1998. 6. J. Mendham, R. C. Denney, J. D. Barnes, M. Thomas, B. Sivasankar, Vogel's Text Book of Quantitative Chemical Analysis, 6th ed., Pearson, New Delhi, 2009 7. F. J. Holler, D. A. Skoog, S. R. Crouch, Principles of Instrumental Analysis, 6th ed., Thomson Books, London, 2007. 8. H. Willard, L. L. Merritt, J. A. Dean, F. A. Settle, Instrumental methods of Analysis, 7th ed., HCBS Publishing, India, 2004. 9. C. N. Banwell, E. M. McCash, Fundamentals of Molecular Spectroscopy, 4th ed., Tata McGraw- Hill, India, 2006. 10. P. S. Kalsi, Spectroscopy of Organic Compounds, 2nd ed., New Age International, New Delhi, 2000.			
References/ Readings:	1. J. H. Kennedy, Analytical Chemistry: Principles, 2nd ed., Saunders College Publishing, Philadelphia, 1990. 2. H. Gunzler, A. Williams, Handbook of Analytical Techniques, 1st ed., Wiley, Germany, 2001. 3. E. Pretsch, P. Buhlmann, C. Affolter, Structural Determination of Organic Compounds, 2nd ed., Springer, Germany, 2005. 4. L. D. Field, S. Sternhell, J. R. Kalman; Organic Structures from Spectra, 4th ed., Wiley, Singapore, 2007. 5. R. A. Day, A. L. Underwood, Quantitative Analysis, 6th ed., Prentice Hall, USA, 2001. 6. B. K Sharma, Instrumental methods of chemical analysis, Goel Publishing House, Meerut, 2004. 7. K. Nakamoto, Infrared and Raman Spectra of Inorganic and Coordination Compounds, 6th ed., Wiley, USA, 2009. 8. P. J. Larkin, Infrared and Raman Spectroscopy: principles and spectral interpretation, 2nd ed., Elsevier, Netherlands,			

	2018.

SEMESTER II

Discipline Specific Core Courses

Title of the Course	Advance Pharmaceutical Chemistry
Course Code	CHH-5001
Number of Credits	4
Theory/Practical	Theory
Level	500
Effective from AY	2025-2026
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Should have studied Pharmaceutical Chemistry at Semester I of level 400.	
Course Objectives:	• To learn major classes of drugs w.r.t. IUPAC nomenclature, structure andfunctional groups. • To understand the SAR of selected drugs and their Mechanism of action. • To get acquainted with the synthesis of selected drug molecules. • To evaluate biological response of the drugs	
Course Outcomes:	Students will be able to:	**Mapped to PSO**
	CO 1. Explain the differences between drug molecules and their application by IUPAC name, physical and chemical properties.	PSO 1

	CO 2. Distinguish the structures, synthesis, reactions and reactivity of substitution reactions.		PSO 2, PSO 3	
	CO 3. Relate structural features in drugs to its biological activity.		PSO 4, PSO6	
	CO 4. Illustrate the application of drug molecules toward human and the environment.		PSO 6, PSO 8	
Content:	**Classification of Chemotherapeutic Drugs: Development of the following drugs including structure activity relationship (SAR), mechanisms of action (MA), chemical nomenclature, generic names (GN) and side effects (SE).** **Note: Outline of synthesis ($) of the selected drugs.**	**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Cholinergic and adrenergic agents, general anaesthetics and hypotensive agents** Classification of cholinergic agents: Drugs acting on cholinergic nervous system: Bethanechol$, Methacholine$, Neostigmine, Pyridostigmine, Parathion, Malathion, Atropine, Dicyclomine$,Tropicamide$, Papaverine. Classification of adrenergic agents, drugs acting on adrenergic nervous system: Methyldopa$, Guanethidine, Ephedrine, Amphetamine, Tranylcypromine, Pargyline, Norepinephrine, Epinephrine, Pronethalol, Propranolol$, Atenolol$, Metoprolol.	**12**	CO1, CO2	K1, K2, K3, K4
Module 2:	**Drugs acting on the central nervous system**: **Hypnotics and Sedatives**: Chloral hydrate, Phenobarbital$, Secobarbital, Thiopental$, Nitrazepam. **Drugs acting as anticonvulsants**: Phenytoin$, phenacemide, Clonazepam, Phensuximide, Phenobarbital, (classification of barbiturates), Primidone, Carbamazepine$. **Psychotherapeutic agents**: Phenothiazines such as Chlorpromazine, Chlordiazepoxide$, Oxazepam, Diazepam$, Imipramine, Nialamide, Tranylcypromine, Pargyline. **CNS stimulants**: Phenmetrazine, Nikethamide$, Iproniazid, Picrotoxins, Tetrazole, Amphetamine.	**12**	CO1, CO2	K2, K3, K4, K5
Module 3:	**Antihistaminic, antiemetic, antiulcer drugs, Drugs used in parkinsonism and Alzheimer's** Diphenhydramine, Triprolidine, Cyclizine, Promethazine$, Cimetidine, Omeprazole, Ranitidine, Sumatriptan, Ondansetron. **Drugs used in Parkinsonism**: Benztropine mesylate, Levodopa, Carbidopa, Amantadine hydrochloride **Drugs for Alzheimer's diseases**: Serine, Velnacrine, Aniracetam.	**10**	CO2, CO3	K3, K4, K5

Module 4:	**Cardiovascular drugs, antihypertensive agents, and antibiotics:** Digitoxin, Quinidine, Procainamide, Verapamil. Antihypertensive agents which elicit their action through autonomous nervous system previously described under 1 and 2, Clonidine, Hydralazine, ACE inhibitors- Enalapril and related drugs vasodilators such as Nitroglycerine, Isoxsuprine, Nylidrin. **Antibiotics**: Penicillin and semisynthetic penicillin and Cephalosporins, Amoxicillin, Cloxacillin, Streptomycin, Chloramphenicol, Tetracycline and derivatives, Erythromycin.	**10**	CO3, CO4	K4, K5
Module 5:	**Analgesic, Antipyretic and Inflammatory agents:** Analgesics, antipyretics and anti-inflammatory agents: Sodiumsalicylate, Acetaminophen$, Phenacetin, Phenylbutazone, Oxyphenbutazone$, Naproxen$, Probenecid, Allopurinol, Ibuprofen, Diclofenac$. **Narcotic analgesic agents**: Morphine, Codeine, Meperidine, Methadone, Dextropropoxyphene. **Non-narcotic analgesic agents**: Dextropropoxyphene, Levallorphan.	**10**	CO3, CO4	K3, K4, K5
Module 6:	**Neglected Tropical diseases**. Background, overview of neglected tropical diseases, (poverty diseases) Human schistosomiasis, african trypanosomiasis (chagas), leishmaniasis, sleeping sickness. Nitroheterocycles, Benznidazole, Nifurtimox$.	**06**	CO2 CO3	K3, K4
Pedagogy:	Mainly lectures and tutorials. Seminars / term papers /assignments / presentations / self-study or a combination of some of these can also be used. ICT mode should be preferred. sessions should be interactive in nature to enable peer group learning.			
Texts:	1. Williams, D. A., & Lemke, T. L. (2006). Foye's Principles of Medicinal Chemistry (5th ed.). Philadelphia, PA: Lippincott Williams & Wilkins. 2. Beale, J. M., & Block, J. H. (2004). Wilson and Gisvold's Textbook of Organic Medicinal and Pharmaceutical Chemistry (11th ed.). Philadelphia, PA: Lippincott Williams & Wilkins. 3. Abraham, D. J., & Rotella, D. P., (2010). Burger's Medicinal Chemistry, Drug Discovery and Development (7th ed., Vol. 1–6). Hoboken, N. J: John Wiley & Sons.			
References / Readings:	1. Shriram, D., & Yogeshwari, P. (2007). Medicinal Chemistry (1st ed.). New Delhi: Pearson Education. 2. Patrick, G. L. (2017). An Introduction to Medicinal Chemistry (6th ed.). Oxford, UK: Oxford University Press. 3. Lednicer, D., & Mitscher, L. A. (2005). The Organic Chemistry of Drug Synthesis (Vol. III). Hoboken, N. J: John			

	Wiley & Sons. 4. Singh, H., & Kapoor, V. K. (2010). Medicinal and Pharmaceutical Chemistry (2nd ed.). New Delhi: Vallabh Prakashan. 5. Chatwal, G. R. (2002). Medicinal Chemistry (Organic Pharmaceutical Chemistry) (1st ed.). Mumbai: Himalaya Publishing House. 6. Wang, Yanli, Evan Bolton, Svetlana Dracheva, Karen Karapetyan, Benjamin A. Shoemaker, Tugba O. Suzek, Jiyao Wang, Jewen Xiao, Jian Zhang, and Stephen H. Bryant. "An overview of the PubChem BioAssay resource." Nucleic acids research 38, no. suppl_1 (2010): D255-D266. 7. Campbell, I. B., Macdonald, S. J., & Procopiou, P. A. (2018). Medicinal chemistry in drug discovery in big pharma: past, present and future. *Drug Discovery Today*, *23*(2), 219-234. 8. Beale JM, Block J, Hill R. Organic medicinal and pharmaceutical chemistry. Philadelphia: Lippincott Williams & Wilkins; 2010. 9. Williams, Roger L., Project Team, and U. S. P. Staff. "Official USP Reference Standards: Metrology concepts, overview, and scientific issues and opportunities." *Journal of pharmaceutical and biomedical analysis* 40.1 (2006): 3-15.
Web Resources:	1. https://www.pharmaguideline.com/2021/08/introduction-classification-dosage-forms.html 2. https://www.upm-inc.com/preformulation-in-drug-studies 3. https://www.ncbi.nlm.nih.gov/books/NBK518682/ 4. https://www.ncbi.nlm.nih.gov/books/NBK568677/

Title of the Course	Drugs: Product Development, Formulation and Manufacture
Course Code	CHH-5002
Number of Credits	4
Theory/Practical	Theory
Level	500
Effective from AY	2025-2026
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Should have studied Pharmaceutical Chemistry at Semester I of Level 400.	
Course Objectives:	• To understand the basic principles of drug development process. • To study the concept of pilot plant & scale-up techniques and manufacturing methods for dosage forms. • To learn the key unit operations, biopharmaceutical manufacturing, and Quality by Design (QbD). • To examine the dosage forms, their manufacturing processes, administration routes, and quality control.	
Course Outcomes:	Students will be able to:	**Mapped to PSO**
	CO 1. Explain the concepts related to drug development, preformulation and the regulatory aspects of pharmaceutical products.	PSO 1
	CO 2. Classify the scale-up techniques, pilot plant benefits, and industrial manufacturing methods for various dosage forms.	PSO 2, PSO 3
	CO 3. Illustrate key unit operations, biopharmaceutical manufacturing techniques, and the	PSO 4

	fundamentals of Quality by Design (QbD) in pharmaceutical productions			
	CO 4. Evaluate the different types of dosage forms, their manufacturing processes, routes of administration, and quality control evaluation.		PSO 6, PSO 8	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Introduction and classification**: Introduction to drugs, dosage forms & drug delivery system: definitions of common terms. development of dosage forms: four stage development including preformulation. Preformulation studies, objectives, factors to be considered, study protocol, including prototype development, scale up studies and commercialization. For example, analyzing polymorphs using ultraviolet, infra-red, solid-state NMR, DSC-DTA and X-ray crystallography. Drug regulation and control, pharmacopoeias-formularies, sources of drug, drug nomenclature, routes of administration of drugs products their advantages and disadvantages, need for a dosage form, classification of dosage forms & brief description, study of excipients.	**15**	CO1, CO2	K1, K2, K3
Module 2:	**Pilot plant** Scale up techniques, benefits of pilot plant- broad guidelines of process development and general consideration. Industrial manufacturing method and flow charts of Sulfamethoxazole, Rifampicin, Chloramphenicol maleate, Actinobolin, BTZO43, Piperaquine, Propranolol hydrochloride.	**15**	CO1, CO2	K2, K3, K4
Module 3:	**Pharmaceutical manufacturing operations** Brief discussion on unit operations and types of equipments/machines used. Unit operations like size reduction, mixing/blending, drying, compression, granulation, coating etc. Three most frequently used unit operations within biopharmaceutical manufacturing, that includes chromatography, virus filtration, and tangential flow filtration (TFF). Quality by design (QbD): Fundamentals of pharmaceutical quality by design, identification of critical quality attributes, critical material attributes, critical process parameters and quality risk management.	**15**	CO2, CO3	K3, K4

Module 4:	**Dosage forms-formulation components, manufacturing and quality control evaluation, routes of drug administration.** Types of dosage forms: Liquids-monophase & biphase including ENT preparation, sprays. Semisolid eg. ointment, creams, gels, liniment, paste, lotion etc. Solid dosage forms: Tablets-Types of tablets, capsules, granules, powders, pastilles, lozenges. Sterile dosage forms: Injectables and ophthalmic preparations, Suppositories etc.	**15**	CO3, CO4	K3, K4, K5
Pedagogy:	Mainly lectures and tutorials. Seminars / term papers /assignments / presentations / self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning.			
Texts:	1. Allen, L. V. Jr., Popovich, N. G., & Ansel, H. C. (2005). Ansel's Pharmaceutical Dosage Forms and Drug Delivery Systems (8th ed.). Philadelphia, PA: Lippincott Williams & Wilkins. 2. Khar, R. K., (2020). Lachman/Lieberman's The Theory and Practice of Industrial Pharmacy (4th ed.). New Delhi: CBS Publishers & Distributors Pvt. Ltd. 3. Banker, G. S., & Rhodes, C. T. (2002). Modern Pharmaceutics (4th ed.). New York, NY: Marcel Dekker, Inc.			
References/ Readings:	1. Carter, S. J. (2007). Dispensing for Pharmaceutical Students (12th ed.). New Delhi: CBS Publishers & Distributors Pvt. Ltd. 2. Remington, J. P. (1990). Remington's Pharmaceutical Sciences (18th ed.). Easton, PA: Mack Publishing Company. 3. Aulton, M. E., & Taylor, K. (2001). Aulton's Pharmaceutics: The Science of Dosage Form Design (2nd ed.). Edinburgh: Churchill Livingstone, Elsevier Health Sciences Division. 4. Thunga, Girish, Sudeep Kumar Agrawal, Mahendra Joshi, Muddukrishna Badamane Sathyanarayana, Vamshi Krishna Tippavajhala, and Girish Pai Kulyadi. "Solid Dosage Forms: A Detailed Research on Non-conforming Product Quality." *Indian Journal of Pharmaceutical Education & Research* 54 (2020). 5. Ahirwar, Kailash, and Rahul Shukla. "Preformulation studies: a versatile tool in formulation design." In *Drug Formulation Design*. IntechOpen, 2023. 6. Shah, Gourav, Piyush Kamble, Rohini Shinde, and Kanchan Ghatge. "Advances in Technology Transfer for the Pharmaceutical Industries: An Overview." *Research Journal of Pharmacy and Technology* 7, no. 6 (2014): 719-726. 7. Djuris, Jelena, Svetlana Ibric, and Zorica Đurić. "Quality by design in the pharmaceutical development." *Computer-aided applications in pharmaceutical technology*. Woodhead Publishing, 2024. 1-21.			

Web Resources:	1. https://www.pharmaguideline.com/2021/08/introduction-classification-dosage-forms.html 2. https://www.upm-inc.com/preformulation-in-drug-studies 3. https://www.ncbi.nlm.nih.gov/books/NBK518682/ 4. https://www.ncbi.nlm.nih.gov/books/NBK568677/

Title of the Course	Drugs: Discovery, Design and Development
Course Code	CHH-5003
Number of Credits	04
Theory/Practical	Theory
Level	500
Effective from AY	2025-26
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Should have studied Pharmaceutical Chemistry at Semester I of Level 400.	
Course Objectives:	• To introduce the various theories of drug action. • To understand the Structure ActivityRelationship studies citing various examples. • To acquaint the concepts of drug designing bymolecular modelling. • To learn various terms involved in patenting and IPR.	
Course Outcomes:	Students will be able to:	**Mapped to PSO**
	CO 1. Describe the various methods and types of drug designing, QSAR and enzyme inhibitors	PSO1, PSO2
	CO 2. Differentiate physio-chemical properties, enzyme inhibitors and IPR	PSO1, PSO2

	CO 3. Illustrate the drug designing process, QSAR methods and intellectual property rights.		PO3, PO4	
	CO 4. Design new drugs using molecular modelling software.		PO4, PO5	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Introduction to drug design, lead compounds and pro-drugconcept** Development of new drugs: Introduction, procedure followed in drug design, the search for lead compounds, molecular modification of lead compounds, prodrugs and soft drugs. Prodrug; introduction, prodrug formation of compounds containing various chemical groups, multiple prodrug formation, soft drugs; design of soft drugs.	**12**	CO1, CO3	K2. K3. K4
Module 2:	**SAR and QSAR Studies in drug discovery** Structure-activity relationship (SAR): Factors effecting bioactivity, resonance, inductive effect, isosterism, bioisosterism, spatial considerations, biological properties of simple functional groups. 4-5 illustrative examples depicting structural activity relationship studies. Theories of drug activity, occupancy theory, rate theory, induced-fit theory. Quantitative structure-activity relationship (QSAR): history and development of QSAR, drug receptor interactions, the additivity of group contributions, physico-chemical parameters, lipophilicity parameters, electronic parameter, ionization constants, steric parameters, chelation parameters, redox potential, indicator-variables, quantitative models.	**12**	CO1, CO2, CO3	K2, K3, K4, K5
Module 3:	**QSAR approaches in drug designing and modern methods in discovery** Hansch analysis- Advantages and drawbacks. Free- Wilson analysis, Advantages and drawbacks. Their application, relationship between Hansch and Free-Wilson analysis (the mixed approach), non-linear relationship, Introduction to other QSAR approaches- free topliss method-postulates and illustration. Introduction to molecular modelling using computers and docking using software's (Hex, Autodock).	**12**	CO1, CO3	K2, K3, K4, K5
Module 4:	**Designing of enzyme inhibitors as drugs**	**12**	CO1,	K2, K3,

	Structure-based drug design: Process, deactivation of certain drugs necessary for T-cell functioning, determination of the active site with reference to chymotrypsin and inhibitors such as 9-alkylpurines, 9-mercaptopurines and allopurines. Active site directed irreversible and suicide enzyme inactivators.		CO2 CO3.	K4
Module 5:	**Development of new drugs** High throughput screening, drug design software's (Hex, Autodock) and its applications. Intellectual property rights, patents, industrial designs, geographical indications, trademarks, trade secrets. Patentable inventions and importance of patents in pharmaceutical industry, eg: Pembrolizumab. Trade related aspects of intellectual property rights (TRIPS), international & regional agreements. Patent writing for different types of inventions (formulations, synergic, process, technology, polymorph and biotechnology).	**12**	CO2, CO3, CO4	K2, K3, K4
Pedagogy:	Mainly lectures and tutorials. Seminars / term papers /assignments / presentations / self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning.			
Texts:	1. Pandeya, S. S., & Dimmock, J. R. (2007). An Introduction to Drug Design (1st ed.). New Delhi: New Age International (P) Ltd. Publishers. 2. Wolff, M. E., (1997). Burger's Medicinal Chemistry and Drug Discovery, Vol. I (Chapters 9 & 14). New York, N. Y: John Wiley & Sons. 3. Gringauz, A. (1997). Introduction to Medicinal Chemistry: How Drugs Act and Why (1st ed.). New York, NY: Wiley-VCH. 4. Lednicer, D., & Mitscher, L. A. (2005). The Organic Chemistry of Drug Synthesis, Volumes I–V. Hoboken, NJ: John Wiley & Sons.			
References/ Readings:	1. Silverman, R. B. (2014). The Organic Chemistry of Drug Design and Drug Action (3rd ed.). London: Academic Press. 2. Leach, A. R. (2001). Molecular Modelling: Principles and Applications (2nd ed.). Delhi: Pearson Education India. 3. Bailey, N. T. J. (1995). Statistical Methods in Biology (3rd ed.). Cambridge, UK: Cambridge University Press. 4. Krogsgaard-Larsen, P., Madsen, U., & Liljefors, T. (1996). A Textbook of Drug Design and Development (2nd ed.).			

	Boca Raton, FL: CRC Press. 5. Jolles, G., & Wooldridge, R. H. (1984). Drug Design: Fact or Fantasy (1st ed.). London: Academic Press. 6. Roche, E. B. (1977). Design of Biopharmaceutical Properties Through Prodrugs and Analogs. Washington, DC: American Pharmaceutical Association, Academy of Pharmaceutical Sciences. 7. Patrick, G. L. (2001). An Introduction to Medicinal Chemistry, 2nd Indian ed., New Delhi: Oxford University Press. 8. Subbaraman, N. R. What Everyone Should Know About Patent. Mumbai: Pharma Book Syndicate. 9. Grubb, P. W. (2005). Patents for Chemicals, Pharmaceuticals & Biotechnology, 4th ed., Oxford, UK: Oxford University Press. 10. Current Patent Acts of Various Countries.
Web Resources:	1. https://pubchem.ncbi.nlm.nih.gov/ 2. https://go.drugbank.com/ 3. https://www.chemspider.com/structuresearch 4. https://www.bindingdb.org 5. https://onlinelibrary.wiley.com/

Title of the Course	Pharmacokinetics and Biopharmaceutics
Course Code	CHH-5004
Number of Credits	04
Theory/Practical	Theory
Level	500
Effective from AY	2025-26
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Should have studied Pharmaceutical Chemistry at Semester I of Level 400.	
Course Objectives:	• To learn the principles of pharmacokinetics (absorption, distribution, metabolism, and excretion) and biopharmaceutics. • To understand pharmacokinetic models to predict drug concentrations and optimize dosing regimens. • To analyze the impact of biopharmaceutical properties on drug absorption and bioavailability. • To evaluate the role of pharmacokinetics and biopharmaceutics in drug development and therapy.	
Course Outcomes:	Students will be able to:	**Mapped to PSO**
	CO 1. Explain the drug absorption mechanism, drug excretion with the bioavailability and bioequivalence interaction with drugs.	PSO1, PSO2
	CO 2. Describe the various types of drug metabolism and drug excretion, linear and non-	PSO1, PSO2

	linear pharmacokinetics using different methods			
	CO 3. Illustrate the different classes of drug molecules using equations/methods.		PSO2, PSO3	
	CO 4. Analyze the application of pharmacokinetics models for drug molecules		PSO4, PSO6	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Introduction to biopharmaceutics and pharmacokinetics:** Definitions, ADME, concentration time profile, plotting the data, different fluid compartments and blood flow rate compartment models, biological half-life, elimination rate constant. Drug research.	**8**	CO1, CO2	K1, K2, K3, K4
Module 2:	**Drug Absorption, Dissolution and Distribution.** GIT absorption of drugs: Techniques, mechanisms of drug absorption, factors affecting drug absorption: Biological, physiological, physico-chemical and pharmaceutical. Noyes-study of various approaches to improve dissolution of poorly soluble drugs, In-vitro dissolution testing models, In-vitro and in-vivo correlation. Factors affecting drug distribution; volume of distribution, protein binding factors affecting, significance and kinetics of protein binding.	**12**	CO1, CO2	K2, K3, K4
Module 3:	**Drug Metabolism and Excretion** Metabolism of drugs, Xenobiotics, Drug metabolizing organs and enzymes (microsomal & non-microsomal), Chemical pathways - Phase I reactions (Oxidative, reductive and hydrolytic reactions) and Phase II reactions (Conjugation reaction: Glucuronidation, aminoacid, methylation, sulphonation). Significance of cytochrome P450 oxidation reduction cycle, factors affecting biotransformation of drugs. Renal excretion glomerular filtration, active tubular secretion, active (or) passive tubular reabsorption. Factors affecting renal excretions of drugs. Non renal excretions biliary, pulmonary, salivary, mammary, skin/dermal, gastrointestinal and genital excretions of drugs such as Fluconazole, carbamazepine, phenytoin, lead.	**12**	CO1, CO2	K3, K4, K5
Module 4:	**Bioavailability and Bioequivalence studies**	**12**	CO1,	K2, K3,

	Objectives and considerations in bioavailability studies: Definitions, federal requirements, methods of determination of bioavailability using blood and urinary excretion data. Protocol design for bioavailability assessment. Concept of equivalence. Methods for bioequivalence determination: Measurements of bioavailability, determination of the rate of absorption, bioequivalence studies and its importance. Biopharmaceutical classification of drugs, importance of biopharmaceuticals.		CO2, CO3	K4
Module 5:	**Pharmacokinetics:** Pharmacokinetic characterization of drugs: Pharmacokinetics of drugs following one/two compartment open models with first order elimination kinetics as applied to rapid intravenous injection, intravenous transfusion and oral administration. Determination of absorption rate constant using Wagner- Nelson, Loo Riegelman methods. Non-Linear pharmacokinetics: Various causes of non-linearity, Michaelis-Menten kinetics, In- vivo estimation of Km and Vm. Case studies on Amoxcillin, Rifampicin, intravenous Verapamil. Physiologic pharmacokinetics models: Mean Residence Time; Statistical moment theory; application and limitations of physiologic pharmacokinetic models. Chronopharmacokinetics, drug toxicity and forensic pharmacokinetics, kinetics of maternal-fetal drug transfer, pharmacokinetics v/s pharmacological/ clinical response, metabolic kinetics.	**16**	CO2, CO3, CO4	K3, K4, K5
Pedagogy:	Mainly lectures and tutorials. Seminars / term papers /assignments / presentations / self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning.			
Texts:	1. Gibaldi, M. (1991). Biopharmaceutics and Clinical Pharmacokinetics (4th ed.). Philadelphia, PA: Lea & Febiger. 2. Brahmankar, D. M., & Jaiswal, S. B. (1998). Biopharmaceutics and Pharmacokinetics: A Treatise (1st ed.). New Delhi: Vallabh Prakashan. 3. Shargel, L., & Yu, A. B. C. (1985). Applied Biopharmaceutics and Pharmacokinetics (2nd ed.). Norwalk, CT: Appleton-Century-Crofts.			

	4. Swarbrick, J. (1970). Current Concepts in Pharmaceutical Sciences: Biopharmaceutics (1st ed.). Philadelphia, PA: Lea & Febiger.
References/ Readings:	1. Abdou, H. M. (1989). Dissolution, Bioavailability and Bioequivalence (1st ed.). Easton, PA: Mack Publishing Company. 2. Notari, R. E. (1987). Biopharmaceutics and Clinical Pharmacokinetics: An Introduction (4th ed.). New York, NY & Basel, Switzerland: Marcel Dekker Inc. 3. Wagner, J. G., & Pernarowski, M. (1971). Biopharmaceutics and Relevant Pharmacokinetics (1st ed.). Hamilton, IL: Drug Intelligence Publications. 4. Swarbrick, J., & Boylan, J. C., (2002). Encyclopedia of Pharmaceutical Technology, Vol. I (2nd ed.). New York, NY: Marcel Dekker Inc. 5. Niazi, S. K. (2010). Textbook of Biopharmaceutics and Clinical Pharmacokinetics (1st ed.). Hyderabad: BSP Books Pvt. Ltd. 6. Niazi, S. K. (2007). Handbook of Bioequivalence Testing (1st ed.). Boca Raton, FL: CRC Press. 7. Jaiswal, S. B., & Bramhankar, D. M. (2006). Biopharmaceutics and pharmacokinetics a treatise. *IstEdn*, *VallabhPrakashan*, 296-297. 8. Bollish, S. J. (1981). Applied biopharmaceutics and pharmacokinetics. 9. Biopharmaceutics and Clinical Pharmacokinetics by Milo Gibaldi, 4th ed., 1991.
Web Resources:	1. https://accesspharmacy.mhmedical.com/book.aspx?bookid=1592. 2. https://link.springer.com/chapter/10.1007/978-3-319-99593-9_1 3. https://pharmdbm.com/biopharmaceutics-and-pharmacokinetics-6th-semester/ 4. https://www.scribd.com/document/329195113/BHRAMANKAR-Biopharmaceutics.

SEMESTER I & II

Discipline Specific Elective Courses

Title of the Course	Pharmaceutical Chemistry Practical - I
Course Code	CHH-5201
Number of Credits	2
Theory/Practical	Practical
Level	400
Effective from AY	2025-2026
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	• To learn synthesis of medicinal compound. • To understand application of drug molecules in human beings and animals. • To evaluate biological response of the drugs towards human bodies. • To acquire hands on training in laboratory techniques.	
Course Outcomes:	Students will be able to:	**Mapped to PSO**
	CO 1. Explain working principle and handling techniques of instruments.	PSO 1, PSO 3
	CO 2. Distinguish the qualitative and quantitative tests of the drug molecule.	PSO 2, PSO 4

	CO 3. Develop the synthesis method/route and characterization of the drug compounds.		PSO 5, PSO 6	
	CO 4. Apply and validate the analytical method of drugs towards industrial or research purpose.		PSO 7, PSO 8	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**1) Qualitative and Quantitative tests of (Any 1)** 1. Purified Water as per IP Monograph 2. Ibuprofen as per IP Monograph	**10**	CO1, CO2	K1, K2, K3
Module 2:	**2) Titrimetric Assay of the following bulk drugs:(4 x 2 = 8) (Any2)** 1. Pheniramine Maleate 2. Salbutamol 3. Ofloxacin	**08**	CO2, CO3	K2, K3, K4
Module 3:	**3) UV Spectrophotometric Assay of the following drugs (in different dosage forms): (4 x 4= 16) (Any 4)** Rifampicin, Meloxicam, Salbutamol, Ofloxacin, Isoniazid, Diazepam, Acyclovir, Bisacodyl, Tinidazole	**16**	CO2, CO3	K2, K4, K5
Module 4:	**4) Synthesis of following bioactive or drug molecules (2x3 = 6 hours) Any 2** 1. 3-Acetylcoumarin 2. 2-Phenylbenzimidazole 3. 2,3-Diphenyl Quinoxaline	**06**	CO2, CO3	K3, K4
Module 5:	**5) Multistep synthesis (Any one)** 1. Flavone from 2-hydroxyacetophenone 2. Paracetamol from Acetanilide	**08**	CO2, CO3	K3, K5
Module 6:	**6) Dissolution experiment:** To study the dissolution rate of sustained release Theophylline tablets IP.	**06**	CO3, CO4	K3, K5

Module 7:	**7) High Performance liquid Chromatographic experiment:** To separate a mixture of Paracetamol and Caffeine using reverse phase high performance liquid chromatography.	**06**	CO3, CO4	K5, K6
Pedagogy:	Pre-lab and Post-lab exercises. Demonstrations of experiments. Explanation of Procedures.			
Texts:	1. Vogel, A. I., Tatchell, A. R., & Hannaford, B. S. F. (2011). Vogel's Textbook of Practical Organic Chemistry, 5th ed., Harlow, England: Prentice Hall. 2. Connors, K. A. (1990). Textbook of Pharmaceutical Analysis, 3rd ed., New York, NY: Wiley-Inter science. 3. Bassett, J., Mendham, J., & Denny, R. C. (Revised by G. H. Jeffery). (2007). Vogel's Textbook of Quantitative Chemical Analysis, 6th ed., New Delhi, India: Pearson Education.			
References/ Readings:	Pharmacopoeias: 1. Indian Pharmacopoeia, 9th ed., Ghaziabad: Indian Pharmacopoeia Commission. 2. United States Pharmacopeia (USP-NF, Issue 1, May 2024) Rockville, MD: United States Pharmacopeial Convention. 3. British Pharmacopoeia (BP 2025, Jan. 2025), London: Medicines and Healthcare Products Regulatory Agency (MHRA). 4. European Pharmacopoeia (Ph. Eur.), 11th ed., 2022, Strasbourg: European Directorate for the Quality of Medicines & HealthCare (EDQM), Council of Europe. 5. Reynolds, J. E. F., (1993), Martindale: The Extra Pharmacopoeia, 30th ed., London, The Pharmaceutical Press. 6. Moini, J. (2010). Pharmaceutical Laboratory Procedures,1st ed., New Delhi: Cengage Learning India Pvt. Ltd.			
Web Resources:	1. https://qps.nhsrcindia.org/sites/default/files/2022-01/INDIAN%20PHARMACOPOEIA%202010%20Volume%201.pdf 2. https://docsdrive.com/pdfs/insightknowledge/IPHARMA-IK/2018/1-12.pdf 3. https://www.sciencedirect.com/science/article/pii/S1878535222007882 https://assets.thermofisher.cn/TFS-Assets/CMD/Application-Notes/an-72709-lc-ibuprofen-drug-products-an72709-en.pdf. 4. Indian Pharmacopoeia (IP) – 2010 Vol.2 (PDF)			

	https://qps.nhsrcindia.org/sites/default/files/2022-01/INDIAN%20PHARMACOPOEIA%202010%20Volume%202.pdf. 5. Acid-Base Titrimetric Assay - https://www.researchgate.net/publication/286194403. 6. UV Spectrophotometric Estimation -https://www.researchgate.net/publication/340052113. 7. Dissolution Testing-https://www.pharmaguideline.com/2010/02/dissolution-testing-of-tablets.html

Title of the Course	Pharmaceutical Chemistry Practical - II
Course Code	CHH-5202
Number of Credits	2
Theory/Practical	Practical
Level	400
Effective from AY	2025-2026
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	• To acquire hands on training in laboratory techniques. • To learn organic synthesis of medicinal compound. • To understand application of drug molecules in human beings and animals. • To evaluate biological response of the drugs towards human bodies.	
Course Outcomes:	Students will be able to:	**Mapped to PSO**
	CO 1. Explain working principle and handling techniques of instruments.	PSO 1, PSO 3
	CO 2. Distinguish the qualitative and quantitative tests of the drug molecule.	PSO 2, PSO 4
	CO 3. Develop the synthesis method/route and characterization of the drug compounds.	PSO 5, PSO 6
	CO 4. Apply and validate the analytical method of drugs towards industrial or research	PSO 7, PSO 8

	purpose.			
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**1) Qualitative and Quantitative tests of (Any 1)** 1. Paracetamol as per IP Monograph 2. Aspirin as per IP Monograph	**10**	CO1, CO2	K1, K2, K3
Module 2:	**2) Titrimetric Assay of the following bulk drugs: (4 x 2 = 8) (Any 2)** 1. Furosemide injection IP 2. Ketoprofen 3. Phenytoin	**08**	CO2, CO3	K2, K3, K4
Module 3:	**3) UV Spectrophotometric Assay of the following drugs (in different dosage forms): (4 x 2= 8)** **(Any 2)** 1. Mefenamic acid, 2. Furosemide, 3. Chloramphenicol	**08**	CO2, CO3	K2, K4, K5
Module 4:	**4) Synthesis of following bioactive or drug molecules (2x4 = 8 hours) (Any 2)** 1. Warfarin 2. 2-(p-Chlorophenyl)benzoxazole 3. Monastrol 4. Nitazoxanide	**08**	CO2, CO3	K3, K4
Module 5:	**5) Dissolution experiment:** Dissolution rate study of sustained release Diclofenac tablets IP	**06**	CO2, CO3	K3, K5
Module 6:	**6) Thin Layer Chromatographic experiments on pharmaceuticals (Any 1)** 1. To identify the given drug amongst the Paracetamol, Aspirin and Caffeine	**04**	CO3, CO4	K3, K5

	citrate with the help of thin layer chromatography and calculate its Rf value. 2. To identify the given sulpha drug among the sulphadiazine, Sulfamethoxazole and Trimethoprim with the help of thin layer chromatography and calculate its Rf value.			
Module 7:	**7) High Performance liquid Chromatographic experiment:** To separate a mixture of Ibuprofen and Acetylsalicylic acid using reverse phase high performance liquid chromatography.	**06**	CO3, CO4	K5, K6
Module 8:	**8) Separation of mixture** of o-Nitroaniline and p- Nitroaniline using column chromatography.	**06**	CO1, CO2, CO3	K1, K2, K3
Module 9:	**9) Infrared spectroscopic analysis demonstration of instrumentation and interpretation of representative spectrum (Any 1)** a) To differentiate between analgesic NSAIDs: Aspirin, Ibuprofen, Paracetamol. b) To differentiate between Acetophenone, p-Nitroacetophenone, Benzamide.	**04**	CO1, CO2, CO3	K1, K2, K3
Pedagogy:	Pre-lab and Post-lab exercises. Demonstrations of experiments. Explanation of Procedures.			
Texts:	1. Vogel, A. I., Tatchell, A. R., & Hannaford, B. S. F. (2011). Vogel's Textbook of Practical Organic Chemistry, 5th ed., Harlow, England: Prentice Hall. 2. Connors, K. A. (1990). Textbook of Pharmaceutical Analysis, 3rd ed., New York, NY: Wiley-Interscience. 3. Bassett, J., Mendham, J., & Denny, R. C. (Revised by G. H. Jeffery). (2007). Vogel's Textbook of Quantitative Chemical Analysis, 6th ed., New Delhi, India: Pearson Education.			
References/ Readings:	Pharmacopoeias: 1. Indian Pharmacopoeia, 9th ed., Ghaziabad: Indian Pharmacopoeia Commission. 2. United States Pharmacopeia (USP-NF, Issue 1, May 2024) Rockville, MD: United States Pharmacopeial Convention. 3. British Pharmacopoeia (BP 2025, Jan. 2025), London: Medicines and Healthcare Products Regulatory Agency			

	(MHRA). 4. European Pharmacopoeia (Ph. Eur.), 11th ed., 2022, Strasbourg: European Directorate for the Quality of Medicines & Health Care (EDQM), Council of Europe. 5. Reynolds, J. E. F., (1993), Martindale: The Extra Pharmacopoeia, 30th ed., London, The Pharmaceutical Press. 6. Moini, J. (2010). Pharmaceutical Laboratory Procedures,1st ed., New Delhi: Cengage Learning India Pvt. Ltd.
Web Resources:	1. https://pharmaguideline.com/2020/01/assay-of-paracetamol-by-non-aqueous-titration. html 2. https://www.ijpsr.com/bft-article/uv-spectrophotometric-determination-of-chloramphenicol-in-pharmaceutical-formulation/ 3. https://www.researchgate.net/publication/290861264_Synthesis_of_Warfarin 4. https://www.omicsonline.org/open-access/hplc-method-for-determination-of diazepam.pdf 5. https://www.chemistrysteps.com/separation-of-o-and-p-nitroaniline-by-column-chromatography/

Title of the Course	Organic Chemistry Practical - I
Course Code	CHO-5201
Number of Credits	2
Theory/Practical	Practical
Level	400
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	NIL	
Course Objectives:	• To understand essential laboratory equipment, safety protocols, and fundamental experimental purification techniques • To create practical skills in basic organic synthesis through key reactions, including electrophilic substitution and other important transformations. • To understand the methods of isolation and purification of naturally occurring organic compounds.	
Course Outcomes:	Students will be able to:	**Mapped to PSO**
	CO 1. Understand stoichiometric requirements during organic syntheses.	PSO1, PSO3, PSO4
	CO 2. Apply safe and good laboratory practices and develop skills in handling laboratory glassware, equipment and chemical reagents.	PSO1, PSO3, PSO4

	CO 3. Create the practical knowledge to perform experiments involving common laboratory techniques like reflux, distillation, steam distillation, vacuum distillation, aqueous extraction, thin layer chromatography (TLC).		PSO1, PSO3, PSO4	
	CO 4. Assess their expertise in isolation of some important natural products.		PSO1, PSO2, PSO3, PSO4	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**1.1 Introduction to laboratory equipment, apparatus and safety** a. Use of common laboratory equipment like fume hood, vacuum pump, weighing balance. b. Introduction to various types of quick fit joints and apparatus. c. Safety Techniques: i. Disposal of chemicals ii. Personal Protective Equipment (PPE) iii. First aid iv. Fire extinguishers, types of fire v. Chemical hazards and risk assessment **1.2 Laboratory Techniques-I** a. Simple distillation (any one): i. Toluene-dichloromethane mixture using water condenser. ii. Nitrobenzene and aniline using air condenser. b. Steam distillation (any one): i. Separation of o- and p- nitrophenols. ii. Naphthalene from its suspension in water. iii. Clove oil from cloves. c. Crystallisation: Concept of induction of crystallization (any one) i. Crystallisation of phthalic acid from hot water using fluted filter paper and stemless funnel. ii. Acetanilide from boiling water iii. Naphthalene from ethanol.	**16**	CO1, CO2, CO3, CO4	K1, K2, K3, K4, K5

	iv. Decolorisation and crystallization of brown sugar (sucrose) with animal charcoal using gravity filtration.			
Module 2:	**2 Laboratory Techniques-II** a. Sublimation: Simple or vacuum sublimation of camphor, naphthalene, anthracene or succinic acid (any one).Vacuum distillation (any one): o-dichlorobenzene, diphenyl ether. Explanation of use of nomograph. b. Thin layer Chromatography (any one): i. Separation of o and p-nitroanilines. ii. Separation of analgesic drugs (ibuprofen/paracetamol) iii. Separation of o and p-nitrophenols	**12**	CO1, CO2, CO3, CO4	K1, K2, K3, K4, K5
Module 3:	**3. Organic synthesis (Any Four experiments)** a. Aliphatic electrophilic substitution: Preparation of iodoform from ethanol & acetone. b. Aromatic electrophilic substitution (any one): i. Preparation of p-bromoacetanilide. ii. Bromination of acetophenone to phenacyl bromide iii. Nitration of napththalene to 1-nitronaphthalene iv. Nitration of benzaldehyde to 3-nitrobenzaldehdye. c. Oxidation (any one) i. Benzoic acid from toluene. ii. Cyclohexanone from cyclohexanol. iii. Isoborneol to camphor using Jones reagent. d. Reduction (any one) i. Reduction of o-nitroaniline to o-phenylenediamine using Sn/HCl ii. Reduction of p-nitro benzaldehyde to p-nitrobenzyl alcohol using $NaBH_4$. e. Bromination of an alcohol using CBr_4/ triphenylphosphine. f. Grignard reaction: Triphenylmethanol from benzoic acid ester or benzophenone. g. Aldol condensation: Dibenzalacetone from benzaldehyde h. Acetoacetic ester condensation: Preparation of ethyl n-butylacetoacetate	**16**	CO1, CO2, CO3, CO4	K1, K2, K3, K4, K5

	or ethyl acetoacetate.			
Module 4:	**Organic synthesis and synthetic reagents (Any two)** a. Cannizzaro reaction using 4-chlorobenzaldehyde as substrate. b. Friedel Craft's reaction i. using toluene and succinic anhydride ii. Resorcinol to resacetophenone, benzene and maleic anhydride to benzoylacrylic acid. c. Solvent free preparation of coumarin by the Knoevenagel condensation under MW irradiation. d. Preparation of oxidizing agent (any one): Pyridinium chlorochromate-silica, pyridinium chlorochromate-alumina, MnO_2. e. Preparation of cuprous chloride. **Isolation from natural sources (Any two)** i. Caffeine from tea powder. ii. Piperine from pepper. iii. Cinnamaldehyde from cinnamon iv. Lemongrass oil from lemongrass	**16**	CO1, CO2, CO3, CO4	K1, K2, K3, K4, K5, K6
Pedagogy:	Students should be given suitable pre- and post-lab assignments and explanation revising the theoretical aspects of laboratory experiments prior to the conduct of each experiment.			
Texts:	1. A. I. Vogel, A. R. Tatchell, B. S. Furniss, A. J. Hannaford, Vogel's Textbook of Practical Organic Chemistry, 5th ed. Prentice Hall, New Delhi, 2011 2. K. Tanaka, Solvent-Free Organic Synthesis, 2nd ed, Wiley-VCH, Weinheim, 2009. 3. L. F. Fieser, K. L. Williamson, Organic Experiments, 7th ed. D. C. Heath, Lexington, 1992. 4. K. L. Williamson, K. M. Masters, Macroscale and Microscale Organic Experiments, 6th ed. Cengage Learning, Boston, 2010 5. R. K. Bansal, Laboratory Manual in Organic Chemistry, 5th ed. New Age International, New Delhi, 2016 6. O. R. Rodig, C. E. Bell Jr., A. K. Clark, Organic Chemistry Laboratory: Standard and Microscale Experiments, 3rd ed. Saunders College Publishing, Philadelphia, 2009			

References/ Readings:	1. S. Delvin, Green Chemistry, 1st ed. Sarup & Sons, New Delhi, 2005 2. J. Mohan, Organic Analytical Chemistry, 1st ed. Narosa Publishing House, New Delhi, 2014 3. T. Laue, A. Plagens, Named Organic Reactions, 1st ed. John Wiley and Sons, Inc., Hoboken, 2005

Title of the Course	Organic Chemistry Practical - II
Course Code	CHO-5202
Number of Credits	2
Theory/Practical	Practical
Level	400
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	NIL	
Course Objectives:	• To familiarize students with essential laboratory equipment, safety protocols, and fundamental experimental purification techniques • To develop practical skills in basic organic synthesis through key reactions, including electrophilic substitution and other important transformations. • To introduce the methods of isolation and purification of naturally occurring organic compounds.	
Course Outcomes:	Students will be able to:	**Mapped to PSO**
	CO 1. Understand stoichiometric requirements during organic syntheses.	PSO1, PSO3, PSO4
	CO 2. Apply safe and good laboratory practices and develop skills in handling laboratory glassware, equipment and chemical reagents.	PSO1, PSO3, PSO4
	CO 3. Create the practical knowledge to perform experiments involving common	PSO1, PSO3, PSO4

	laboratory techniques like reflux, distillation, steam distillation, vacuum distillation, aqueous extraction, thin layer chromatography (TLC).			
	CO 4. Assess their expertise in isolation of some important natural products.		PSO1, PSO2, PSO3, PSO4	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**1.1 Introduction to laboratory equipment, apparatus and safety** a. Common Hazards in Chemical Laboratory, Risk assessment b. Accidents and Emergency procedures **1.2 Laboratory Techniques (Any Three)** a. Simple distillation: i. Simple distillation of thionyl chloride under anhydrous condition ii. Simple distillation under Nitrogen atmosphere of THF b. Fractional distillation: i. Chloroform-dichloromethane mixture using water condenser. ii. Toluene and cyclohexane using fractionating column. c. Vacuum distillation under inert atmosphere: Distillation of DMF, o-dichlorobenzene, $POCl_3$ d. Thin layer Chromatography: i. Purification and isolation of mixture of acids (o-nitrobenzoic acid and p-nitrobenzoic acid) by using Preparative TLC. ii. Purification and isolation of mixture of phenols (o and p-nitrophenols) by using Preparative TLC. iii. Purification and isolation of pharmaceutical drugs (ibuprofen tablet) using Preparative TLC.	**16**	CO1, CO2, CO3, CO4	K1, K2, K3, K4, K5
Module 2:	**Organic Synthesis (Any Four)** a. p-Iodonitrobenzene by Sandmeyer reaction b. Pinacol- Pinacolone rearrangement	**16**	CO1, CO2, CO3, CO4	K1, K2, K3, K4, K5

	c. Hydrogenation of Maleic acid (Hydrogen balloon) d. Preparation of nitrostyrene from aldehyde e. Preparation of dibromocinnamic acid f. Reduction of nitro compounds g. Synthesis of Urea from ammonium cyanate			
Module 3:	**3. Two-step Organic Synthesis (Any Two)** a. Benzamide-Benzoic acid-Ethyl Benzoate b. Phthalic anhydride-Phthalimide-Anthranilic acid. c. Methyl benzoate- m-nitrobenzoate- m-nitrobenzoic acid d. Chlorobenzene-2, 4 -dinitrochlorobenzene-2,4 dinitrophenol e. Acetanilide-p-Bromoacetanilide-p-Bromoaniline f. Acetophenone-Oxime-Acetanilide	**16**	CO1, CO2, CO3, CO4	K1, K2, K3, K4, K5
Module 4:	**4.1 Solvent Free Organic synthesis (Any One)** a. Reduction using ball milling technique b. Oxidation of 2° alcohol using $KMnO_4$/Alumina by grinding technique. c. Synthesis of 1,1'-Bi-2-naphthol (BINOL) d. Hunsdiecker reaction of cinnamic acid derivatives e. Beckmann rearrangement of oxime derivatives **4.2 Separation, Isolation and Identification of Organic compounds (Any One)** Separation, purification and identification of compounds of binary mixture (Solid-Solid, Solid-liquid and Liquid-liquid) using the TLC and column chromatography, chemical tests. IR spectra to be used for functional group identification.	**12**	CO1, CO2, CO3, CO4	K1, K2, K3, K4, K5, K6
Pedagogy:	Students should be given suitable pre- and post-lab assignments and explanation revising the theoretical aspects of laboratory experiments prior to the conduct of each experiment.			
Texts:	1. A. I. Vogel, A. R. Tatchell, B. S. Furniss, A. J. Hannaford, Vogel's Textbook of Practical Organic Chemistry, 5th ed. Prentice Hall, New Delhi, 2011 2. K. Tanaka, Solvent-Free Organic Synthesis, 2nd ed, Wiley-VCH, Weinheim, 2009			

	3. L. F. Fieser, K. L. Williamson, Organic Experiments, 7th ed. D. C. Heath, Lexington, 1992 4. K. L. Williamson, K. M. Masters, Macroscale and Microscale Organic Experiments, 6th ed. Cengage Learning, Boston, 2010 5. R. K. Bansal, Laboratory Manual in Organic Chemistry, 5th ed. New Age International, New Delhi 2016 6. O. R. Rodig, C. E. Bell Jr., A. K. Clark, Organic Chemistry Laboratory: Standard and Microscale Experiments, 3rd ed. Saunders College Publishing, Philadelphia, 2009
References/ Readings:	1. S. Delvin, Green Chemistry, 1st ed. Sarup & Sons, New Delhi, 2005. 2. J. Mohan, Organic Analytical Chemistry, 1st ed. Narosa Publishing House, New Delhi, 2014. 3. T. Laue, A. Plagens, Named Organic Reactions, 1st ed. John Wiley and Sons, Inc., Hoboken, 2005

Title of the Course	Physical Chemistry Practical-I
Course Code	CHP-5201
Number of Credits	02
Theory/Practical	Practical
Level	400
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	NIL	
Course Objectives:	• To develop experimental skills on basic lab techniques in physical chemistry • To understand fundamental laboratory concepts and acquire skills for data acquisition, analysis and interpretation • To understand and follow safety protocols for handling chemicals, equipment and instruments. • To apply the practical laboratory concepts for synthesis, problem solving and critical thinking • To develop research skills through the principles of laboratory chemical research.	
Course Outcomes:	Students will be able to:	**Mapped to PSO**
	CO 1. Explain and perform various fundamental lab techniques and experiments.	PSO1
	CO 2. Handle and operate basic laboratory equipment and use it for research work.	PSO1, PSO4
	CO 3. Apply the laboratory knowledge and skills for their dissertation and research work.	PSO4, PSO5, PSO6, PSO7

	CO 4. Design synthesis and/or experimental methods.		PSO5, PSO6, PSO7	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**1. Non- instrumental Experiments (Any 08)** 1. To study the kinetics of hydrolysis of ethyl acetate and to determine a) Energy of activation b) Entropy of activation and c) Free energy change. 2. To determine the order of reaction between potassium persulphate and potassium iodide by graphical, fractional change and differential methods. 3. To study the three-component system such as acetic acid, chloroform and water and obtain tie line. 4. To determine the molecular weight of polyvinyl alcohol by viscosity measurement. 5. To study the electro-kinetics of rapid reaction between SO_4^{2-} and I^- in an aqueous solution. 6. To determine the buffer capacity of acidic buffer solution. 7. To determine the partial molal volume of ethanol-water mixture at a given temperature. 8. To measure energy content of various types of plastics using bomb calorimetry 9. To determine number average molecular weight of a polymer sample with an indirect titration method. 10. To investigate basic hydrolysis of ethyl acetate at four different temperatures and find out energy of activation 11. To construct a phase diagram for a two-component system by plotting cooling curves for mixtures of different compositions. 12. To find the surface tension of methyl alcohol, ethyl alcohol and n-hexane at room temperature and then calculate the atomic parachors of carbon, hydrogen and oxygen.	**32**	CO1, CO3, CO4	K2, K3, K4, K5
Module 2:	**2. Instrumental Experiments (Any 07)** 1. To determine the degree of hydrolysis of salt of weak base and strong acid using conductometer.	**28**	CO2, CO3, CO4	K3, K4, K5

	2. To determine the dissociation constants of a tribasic acid (Phosphoric acid obtain derivative plot to get equivalence point. 3. To determine formal redox potential of Fe^{2+}/Fe^{3+} and Ce^{3+}/Ce^{4+} system obtain derivative plot to get equivalence point. 4. To study spectrophotometric titration of ferrous ammonium sulphate with potassium permanganate (or dichromate vs permanganate) 5. To determine Avogadro's number by improved electroplating. 6. To determine the zeta potential of colloidal system and investigate the effect of different surfactants on stability of the colloids. 7. To verify the Kohlrausch's law for weak electrolyte by conductometry. 8. To determine the transport numbers of Cu^{2+} and SO_4^{2-} ions in $CuSO_4$ solution by Hittorf's method.			
Pedagogy:	Students will be given pre-lab and post-lab assignments on theoretical aspects of laboratory experiments prior to the conduct of each experiment. Exams will be in the form of ISA, SEA which will involve performing given experiments and conduct of viva, systematic reporting of experiments, results and observations in laboratory report. Sessions can preferably be interactive in nature to enable peer group learning.			
Texts:	1. V. D. Athawale, P. Mathur, Experimental Physical Chemistry, New Age International Publishers, 1st ed., New Delhi, 2001. 2. J.N. Gurtu, A. Gurtu, Advanced Physical Chemistry Experiments, Pragati Publications, 1st ed., Meerut, 2008. 3. A. Findlay & J. A. Kitchener, Practical Physical Chemistry, Longmans, Green and Co., 1st ed., London 1954. 4. F. Daniels & J. H. Mathews, Experimental Physical Chemistry, McGraw-Hill, 1st ed., New York, 1941.			
References/ Readings:	1. A. M. James, Practical Physical Chemistry, Prentice Hall Press, 3rd ed., 1974. 2. D.P. Shoemaker & C. W. Garland, Experiments in Physical Chemistry, McGraw-Hill, 1st ed., New York, 1962. 3. T. Kandow & F. Mafune, Progress in experimental and theoretical studies of clusters, World Scientific publishers, 1st ed., New Jersey, 2002. 4. C. Arora & S. Bhattacharya, Advanced Physical Chemistry Practical Guide, Bentham Science Publishers, 1st ed., UAE, 2022. 5. A. K. Hagi, L. Pogliani, A. C. F. Ribeiro, Practical applications of Physical Chemistry in food science and technology, 1st ed., Apple Academic Press, USA, 2021.			

Title of the Course	Physical Chemistry Practical-II
Course Code	CHP-5202
Number of Credits	02
Theory/Practical	Practical
Level	400
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	NIL	
Course Objectives:	• To develop experimental skills on basic lab techniques in physical chemistry • To understand fundamental laboratory concepts and acquire skills for data acquisition, analysis and interpretation • To understand and follow safety protocols for handling chemicals, equipment and instruments. • To apply the practical laboratory concepts for synthesis, problem solving and critical thinking • To develop research skills through the principles of laboratory chemical research.	
Course Outcomes:	Students will be able to:	**Mapped to PSO**
	CO 1. Explain and perform various fundamental lab techniques and experiments.	PSO1
	CO 2. Handle and operate basic laboratory equipment and use it for research work.	PSO1, PSO4
	CO 3. Apply the laboratory knowledge and skills for their dissertation and research work.	PSO4, PSO5, PSO6, PSO7

	CO 4. Design synthesis and/or experimental methods.		PSO5, PSO6, PSO7	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**1. Non- instrumental Experiments (Any 09)** 1. To determine the radius of a molecule by viscosity measurements. 2. To determine ΔG, ΔH and ΔS of silver benzoate by solubility product method. 3. To investigate the adsorption of oxalic acid by activated charcoal and test the validity of Freundlich and Langmuir's isotherms. 4. To determine the molecular weight of a given polymer by turbidimetry. 5. To study the rate of reaction between ethyl bromoacetate and sodium thiosulphate kinetically. 6. To determine the percentage composition of a given mixture of two liquids by stalagmometer method. 7. To study the kinetics of hydrolysis of methyl acetate and to determine a) Energy of activation b) Entropy of activation and c) Free energy change. 8. To study the kinetics of the reaction between potassium persulphate ($K_2S_2O_8$), and potassium iodide (KI), and to determine a) Energy of activation b) Entropy of activation and c) Free energy change. 9. To determine the order of reaction for hydrolysis of ethyl acetate by graphical, fractional change and differential methods. 10. To determine the molecular weight of polystyrene by viscosity measurement.	**36**	CO1, CO3, CO4	K1, K2, K3, K4, K5
Module 2:	**2. Instrumental Experiments** 1. To determine the relative strength of chloroacetic acid and acetic acid by conductometry. 2. To determine the degree of hydrolysis of salt of weak base and strong acid using conductometry. 3. To determine the composition of a mixture of acetic acid, dichloroacetic acid and hydrochloric acid by conductometric titration. 4. To determine the dissociation constants of monobasic acid and dibasic acid and obtain derivative plot to get equivalence point.	**24**	CO2, CO3, CO4	K2, K3, K4, K5

	5. To determine the redox potential of Fe^{2+}/Fe^{3+} system by titrating it with standard $K_2Cr_2O_7$ solution. 6. To study the electrodeposition of metal.			
Pedagogy:	Students will be given pre-lab and post-lab assignments on theoretical aspects of laboratory experiments prior to the conduct of each experiment. Exams will be in the form of ISA, SEA which will involve performing given experiments and conduct of viva, systematic reporting of experiments, results and observations in laboratory report. Sessions can preferably be interactive in nature to enable peer group learning.			
Texts:	1. V. D. Athawale, P. Mathur, Experimental Physical Chemistry, New Age International Publishers, 1st ed., New Delhi, 2001. 2. J.N. Gurtu, A. Gurtu, Advanced Physical Chemistry Experiments, Pragati Publications, 1st ed., Meerut, 2008. 3. A. Findlay & J. A. Kitchener, Practical Physical Chemistry, Longmans, Green and Co., 1st ed., London 1954. 4. F. Daniels & J. H. Mathews, Experimental Physical Chemistry, McGraw-Hill, 1st ed., New York, 1941.			
References/ Readings:	1. A. M. James, Practical Physical Chemistry, Prentice Hall Press, USA 3rd ed., 1974. 2. D.P. Shoemaker & C. W. Garland, Experiments in Physical Chemistry, McGraw-Hill, 1st ed., New York, 1962. 3. T. Kandow & F. Mafune, Progress in experimental and theoretical studies of clusters, World Scientific publishers, 1st ed., New Jersey, 2002. 4. C. Arora & S. Bhattacharya, Advanced Physical Chemistry Practical Guide, Bentham Science Publishers, 1st ed., UAE, 2022. 5. A. K. Hagi, L. Pogliani, A. C. F. Ribeiro, Practical applications of Physical Chemistry in food science and technology, 1st ed., Apple Academic Press, USA, 2021.			

Title of the Course	Analytical Chemistry Practical - I
Course Code	CHA-5201
Number of Credits	2
Theory/Practical	Practical
Level	400
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	• To perform various experimental techniques for analysis. • To learn data analysis, handling and interpretation of spectra. • To determine concentration of solutions. • To use techniques for qualitative and quantitative estimation.	
Course Outcomes:	Students will be able to:	**Mapped to PSO**
	CO 1. Explain data analysis, handling and interpretation of spectra.	PSO1, PSO3, PSO4
	CO 2. Apply different techniques for qualitative and quantitative estimation.	PSO1, PSO2, PSO6
	CO 3. Determine concentration of solutions.	PSO1, PSO6
	CO 4. Perform various experimental techniques for analysis.	PSO1, PSO2, PSO6

Content:	This course consists of 8 units of experiments in various areas of Analytical chemistry. Minimum 15 experiments which include at least 01 experiment from each unit to be performed.	**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	Statistics: i. Calibration of selected Volumetric apparatus ii. Calibration of selected Laboratory instruments iii. Preparation of standard solutions and standardisation.	**4**	CO3	K5
Module 2:	Colorimetry/ UV-Visible Spectrophotometry: i. Estimation of Iron from Pharmaceutical sample (Tablet/capsule) by thiocyanate method ii. Estimation of phosphoric acid in cola drinks by molybdenum blue method. iii. Estimation of KNO_3 by UV spectroscopy and $K_2Cr_2O_7$ by Visible spectroscopy iv. Simultaneous determination and Verification of law of additivity of absorbances ($K_2Cr_2O_7$ and $KMnO_4$).	**8**	CO4, CO2	K6, K3
Module 3:	Flame Spectrophotometry and AES/AAS/ICP Spectroscopy i. Estimation of Na and K in food supplements or cosmetic products. ii. Estimation of Pb in water sample by AES/AAS/ICP. iii. Estimation of Fe and Al in Iron ore sample by AES/AAS/ICP.	**8**	CO1, CO2	K2, K3
Module 4:	Ion Exchange Chromatography and High Performance Liquid Chromatography (HPLC): i. Separation and Estimation of chloride and bromide using Ion exchange chromatography. ii. Separation of anthracene and naphthalene using reverse phase chromatography iii. Separation of benzaldehyde and benzyl alcohol using normal phase chromatography	**8**	CO4, CO2	K6, K3
Module 5:	Volumetric Titrations: i. Estimation of Ca in pharmaceutical tablet.	**8**	CO4, CO3	K6, K5

	ii. Estimation of Al and Mg in antacid tablet. iii. Estimation of CaO in cement.			
Module 6:	Solvent Extraction and spectrophotometry: i. Extraction of Cu as copper dithiocarbamate (DTC) using solvent extraction and estimation by spectrophotometry. ii. Determination of Ni as dimethylglyoxime complex byspectrophotometry. iii. Determination of silver as ion association complex with 1,10- phenanthroline and bromopyrogallol red.	**8**	CO4, CO3	K6, K5
Module 7:	Demonstration and Interpretation Exercises: i. Thermal studies: TG/DTA and Isothermal weight loss studies of various hydrated solids like $CuSO_4 \cdot 5H_2O$, $CaC_2O_4 \cdot H_2O$, $FeC_2O_4 \cdot 2H_2O$. ii. X-ray powder diffractometry: Calculation of lattice parameters from X-ray powder pattern of cubic system such as $NiMn_2O_4$, $CoFe_2O_4$. iii. IR spectra of urea, benzoic acid, copper sulphate pentahydrate etc.	**8**	CO1, CO2	K2, K3
Module 8:	Demonstration: i. Turbidimeter. ii. KF instrument. iii. Polarimeter. iv. LCMS. v. NMR.	**8**	CO1, CO2	K2, K3
Pedagogy:	Prelab exercises / assignments / presentations / lab hand-out or a combination of some of these. Sessions shall be interactive in nature to enable peer group learning.			
Texts:	1. J. Mendham, R. C. Denney, J. D. Barnes, M. Thomas, B. Sivasankar, Vogel's Text Book of Quantitative Chemical Analysis, 6th ed., Pearson, New Delhi, 2009. 2. R. A. Day & A.L. Underwood, Quantitative Analysis, 6th ed., Pearson Education India, 2015. 3. J. Kenkel, Analytical Chemistry for Technicians, 3rd ed., Lewis publishers, USA, 2002. 4. R. M. Silverstein, F. X. Webster, D. Kiemle, D. Bryce, S. Samant, V. S. Nadkarni, Spectrometric Identification of Organic compounds, An Indian Adaptation, Wiley, India, 8th ed., 2022 5. A. J. Elias, Collection of interesting chemistry experiments, University press, Hyderabad, 2002.			

References/ Readings:	1. G. D. Christian, Analytical chemistry, 5th ed., John Willey and Sons, USA, 1994 2. J. H. Kennedy, Analytical Chemistry: Principles, 2nd ed., Saunders College Publishing, Philadelphia, 1990. 3. A. Kar, Pharmaceutical Drug Analysis, New Age International, India, 2005 4. M. Asadi, Beet-Sugar Handbook, John Wiley & Sons, USA, 2006 5. R. E. Ardrey, Liquid Chromatography - Mass Spectrometry: An Introduction, John Wiley & Sons, England, 2003

Title of the Course	Analytical Chemistry Practical - II
Course Code	CHA-5202
Number of Credits	2
Theory/Practical	Practical
Level	400
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	• To perform various experimental techniques for analysis. • To learn data analysis, handling and interpretation of spectra. • To determine concentrations of solution. • To use techniques for qualitative and quantitative estimation.	
Course Outcomes:	Students will be able to:	**Mapped to PSO**
	CO 1. Explain data analysis, handling and interpretation of spectra.	PSO1, PSO3, PSO4
	CO 2. Apply different techniques for qualitative and quantitative estimation.	PSO1, PSO2, PSO6
	CO 3. Determine concentration of solutions.	PSO1, PSO6
	CO 4. Perform various experimental techniques for analysis.	PSO1, PSO2, PSO6

Content:	This course consists of 8 units of experiments in various areas of Analytical chemistry. Minimum 15 experiments which include at least 01 experiment from each unit to be performed.	**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	Statistics: i. Calibration of selected Volumetric apparatus ii. Calibration of selected Laboratory instruments iii. Preparation of standard solutions and standardisation.	**4**	CO3	K5
Module 2:	Titrimetric Analysis: i. Standardisation and estimation of Chloride using precipitation titration (Mohr's method) ii. Analysis of commercial caustic soda by neutralisation method. iii. Determination of sulphates by complexometric titration.	**8**	CO4, CO2	K6, K3
Module 3:	Flame Spectrophotometry and AES/AAS/ICP Spectroscopy i. Estimation of sodium and potassium in food supplements or cosmetic products using flame photometer. ii. Estimation of chromium in water sample by AES/AAS/ICP. iii. Estimation of nickel, molybdenum in Hastelloy C-22 using AES/AAS/ICP.	**8**	CO1, CO4	K2, K6
Module 4:	Natural product isolation and Ion Exchange Chromatography. i. Isolation of cinnamaldehyde from cinnamon. ii. Isolation of caffeine from tea powder. iii. Separation and estimation of cadmium and zinc.	**8**	CO4, CO2	K6, K3
Module 5:	UV-Visible Spectrophotometry and High Performance Liquid Chromatography (HPLC). i. Estimation of KNO_3 and $K_2Cr_2O_7$ using UV- Visible spectroscopy. ii. Separation of benzaldehyde and benzoic acid using reverse phase HPLC. iii. Quantification of naphthalene in a sample using reverse phase HPLC.	**8**	CO4, CO3	K6, K5
Module 6:	Solvent Extraction and spectrophotometry i. Spectrophotometric determination of aspirin/phenacetin/caffeine in APC tablet	**8**	CO4, CO3	K6, K5

	using solvent extraction. ii. Colorimetric determination of iron with salicylic acid. iii. Determination of copper in brass sample by colorimetry.			
Module 7:	Data Interpretation Exercises: i. NMR/Mass spectra ii. HPLC and GC chromatograph iii. XRD powder pattern of cubic systems iv. Thermogram of coordination compounds	**8**	CO1, CO2	K2, K3
Module 8:	Demonstration: i. Turbidimeter. ii. KF instrument. iii. Polarimeter. iv. LCMS. v. NMR.	**8**	CO1, CO2	K2, K3
Pedagogy:	Prelab exercises / assignments / presentations / lab hand-out or a combination of some of these. Sessions shall be interactive in nature to enable peer group learning.			
Texts:	1. J. Mendham, R. C. Denney, J. D. Barnes, M. Thomas, B. Sivasankar, Vogel's Text Book of Quantitative Chemical Analysis, 6th ed., Pearson, New Delhi, 2009. 2. R. A. Day & A.L. Underwood, Quantitative Analysis, 6th ed., Pearson Education India, New-Delhi, 2015. 3. J. Kenkel, Analytical Chemistry for Technicians, 3rd ed., Lewis publishers, USA, 2002. 4. R. M. Silverstein, F. X. Webster, D. Kiemle, D. Bryce, S. Samant, V. S. Nadkarni, Spectrometric Identification of Organic compounds, An Indian Adaptation, Wiley, India, 8th ed., 2022 5. A. J. Elias, Collection of interesting chemistry experiments, University press, Hyderabad, 2002. 6. A. Kar, Pharmaceutical Drug Analysis, New Age International, India, 2005			
References/ Readings:	1. G. D. Christian, Analytical chemistry, 5th ed., John Willey and Sons, USA, 1994 2. J. H. Kennedy, Analytical Chemistry: Principles, 2nd ed., Saunders College Publishing, Philadelphia, 1990. 3. M. Asadi, Beet-Sugar Handbook, John Wiley & Sons, USA, 2006 4. R. E. Ardrey, Liquid Chromatography - Mass Spectrometry: An Introduction, John Wiley & Sons, England, 2003			