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(Accredited by NAAC)

GU/Acad –PG/BoS -NEP/2023/78/4 Date:24.05.2023

Ref: GU/Acad –PG/BoS -NEP/2022/339/11 dated 19.08.22

CIRCULAR

In supersession to the above referred Circular, the updated approved Syllabus with revised Course Codes of the **Master of Science in Chemistry Programme** is enclosed.

The approved Syllabus of the **Master of Science in Chemistry** Programme (Organic, Inorganic, Analytical and Physical, Pharmaceutical Chemistry) is attached.

The Dean/ Vice-Deans of the School of Chemical Sciences/ Principals of Affiliated Colleges offering the **Master of Science in Chemistry** Programme 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: 2023.05.24 17:31:44 +05'30'

(Ashwin Lawande)
Assistant Registrar – Academic-PG

To,

1. The Dean, School of Chemical Sciences, Goa University.
2. The Vice-Deans, School of Chemical Sciences, Goa University.
3. The Principals of Affiliated Colleges offering the Master in Sciences in Chemistry Programme.

Copy to:

1. The Chairperson, Board of Studies in Chemistry PG.
2. The Programme Director, M. Sc. Chemistry, Goa University.
3. The Controller of Examinations, Goa University.
4. The Assistant Registrar, PG Examinations, Goa University.
5. Directorate of Internal Quality Assurance, Goa University for uploading the Syllabus on the University website.

ANNEXURE-I

M.Sc. Pharmaceutical Chemistry AY 2022-23

SEM I			
Sr. No.	**Subject code**	**Paper title**	**Credits**
1.	CHO-500	Fundamentals of Organic Chemistry	4
2.	CHH - 500	Fundamentals of Pharmaceutical Chemistry-I	4
3.	CHP-500	General Physical Chemistry	4
4.	CHA-500	Techniques in Analytical Chemistry-I	4
5.	CHO-521	Practical Course in Organic Chemistry-I	2
6.	CHO-522	Practical Course in Organic Chemistry-II	2
7.	CHH - 521	Practical Course in Pharmaceutical Chemistry-I	2
8.	CHH - 522	Practical Course in Pharmaceutical Chemistry-II	2
9.	CHP-521	Practical Course in Physical Chemistry-I	2
10.	CHP-522	Practical Course in Physical Chemistry-II	2
11.	CHA-521	Practical Course inAnalytical Chemistry-I	2
12.	CHA-522	Practical Course in Analytical Chemistry-II	2
SEM II (Pharmaceutical Chemistry)			
1.	CHH - 501	Fundamentals of Pharmaceutical Chemistry-II	4
2.	CHH - 502	Drug Product Formulation, Development and Manufacture	4
3.	CHH - 503	Drug Design, Discovery and Development	4
4.	CHH - 504	Biopharmaceutics and Pharmacokinetics	4

SEM III			
1.	**CHH-600**	Practical Course in Pharmaceutical Chemistry-III	4
2.	**CHH-601**	Practical Course in Pharmaceutical Chemistry-IV	4
3.	**CHH-604**	Retrosynthetic Approach and Heterocyclic Drug Synthesis	4
4.	**CHH-605**	Research Methodology in Pharmaceutical Chemistry and instrumental techniques	4
5.	**CHH-621**	Polymers in Pharmaceuticals and novel drug delivery systems	4
6.	**CHH-622**	Pharmacotherapeutics	4
7.	**CHH-623**	API Process, Manufacture and Green Chemistry	4
8.	**CHH-624**	Pharmaceutical and Spectral analysis	4
9.	**CHH-625**	Bioorganic and Medicinal Chemistry	4
SEM IV			
1.	**CHH-602**	Pilot Plant Scale-Up Techniques for Pharmaceuticals	4
2.	**CHH-603**	Pharmacological and Toxicological Screening Techniques	4
3.	**CHC-651**	Discipline Specific Dissertation	16

M.Sc. Part-I (Chemistry)

Title of the course: Fundamentals of Organic Chemistry

Course Code: CHO-500

Number of Credits: **04**

Effective from AY: **2022-23**

Prerequisites for the course:	Students should have studied chemistry courses at graduate level or must have cleared change of discipline entrance test conducted by Goa University.	
Course Objective:	1. To study the various concepts based on molecular orbital theory. 2. To understand the concepts of topicity, prostereoisomerism and chemo-, regio- and stereoselectivity in organic reactions. 3. To understand the mechanistic aspects of various type of reactions in organic synthesis.	
Content	**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, resonance, 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.	No of hours 08
	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)	08
	3.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 centres. b. Conformational analysis of open chain compounds (Butane, 2, 3-butane diol, 2,3-dibromobutane etc.). *Erythro* and *threo* nomenclature. c. Topicity and Prostereoisomerism: Topicity of ligands and faces-homotopic, enantiotopic and Cram's rule /diastereotopic ligands and faces.	14

	d. Introduction to chemoselective, regioselective and stereoselective reactions. e. Stereochemistry of *cis*- and *trans*-decalins, conformation and reactivity of cyclohexane and substituted cyclohexanes, cyclohexene / cyclohexanone. conformational isomerism and analysis in acyclic and simple cyclic systems –substituted ethanes, cyclopentane, cyclohexane cycloheptane, cyclooctane and decalins, 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.	
	4.Reaction Mechanism a. Brief revision of carbocations, carbanions, free radicals, carbenes, Arynes and nitrenes with reference to generation, structure, stability and reactivity; b. Types of mechanisms, types of reactions, thermodynamic and kinetic control. c. The Hammond postulate and principle of microscopic reversibility, d. Methods of determining reaction mechanisms like- 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 vi. Isotope effect (at least two reactions to exemplify each method be studied)	08
	5.Aliphatic Nucleophilic substitution a. Brief revision of nucleophilic substitutions with respect to Mechanism, 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)	08
	6.Elimination reactions a. The E2, E1 and E1cB mechanisms. Orientation of the double bond, Saytzeff and Hofmann rule. b. Effects of changes in the substrate, base, leaving group and	08

	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).	
	7. Selective reagents for Organic transformation a. Oxidation of organic compounds, PCC, PDC and MnO_2, ozonolysis, 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	06
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.	
References / Readings	1. W. Caruthers, I. Coldham, Modern Methods of Organic Synthesis, Cambridge University Press, 4th Ed., 2016. 2. M. B. Smith, Organic Synthesis, McGraw–HILL, New York, International Edition, 1994. 3. J. Clayden, N. Greeves, S. Warren, P. Wothers, Organic Chemistry, Oxford University Press, 2nd Ed., 2012. 4. R. Bruckner, Advanced Organic Chemistry – Reaction Mechanisms, San Diego, CA: Harcourt /Academic Press, San Diego, 2002. 5. J. Fuhrhop, G. Penxlin, Organic Synthesis – Concepts, Methods, Starting Materials, VCH Publishers Inc., New York, 1994. 6. H. O. House, Modern Synthetic Reactions, W. A. Benjamin, 2ndEd.,1965 7. M. Nogradi, Stereoselective Synthesis, VCH Publishers, Inc., Revised and Enlarged Edition, 1994. 8. F. A. Carey, R. J. Sundberg, Advanced Organic Chemistry, Springer India Private Limited, 5thEd, 2007. 9. T. Laue, A. Plagens, Named Organic Reactions, John Wiley and Sons, Inc., 2005.	
Course outcomes:	1. Students will be in a position to evaluate the effect of delocalization of electrons & presence or absence of aromaticity in organic compounds. 2. Students will be able to apply various concepts in stereochemistry to understand stereochemical outcome in a reaction. 3. Students shall be in a position to understand/propose plausible mechanism of organic reactions. 4. Students will be able to understand and apply various reagents for desired organic transformations.	

Title of the course: Fundamentals of Pharmaceutical Chemistry-I

Course Code: CHH-500

Number of Credits: 04

Effective from AY: 2022-23

Prerequisites for the course:	Students should have studied chemistry courses at graduate level or must have cleared change of discipline entrance test conducted by Goa University. Knowledge of Pharmaceutical Chemistry is added advantage but not mandatory. This is to understand the basics in pharmaceutical chemistry and importance of chemistry in pharmacy.	
Course Objective:	1. To get introduced to pharmaceutical chemistry and terms involved. 2. To understand the various classes of drugs with examples with special reference to Structure, IUPAC name, Mechanism of action, Structure Activity Relationships and Synthesis.	
Content	**1. Pharmaceutical chemistry, physicochemical properties of drugs, drug metabolism and assay of drugs:** 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, Ionisation 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.	No of hours 12
	Classification of Chemotherapeutic Drugs: Development of the following drugs including structure activity relationship (S.A.R.), mechanisms of action (MA), outline of synthesis ($), chemical nomenclature, generic names (GN) and side effects (SE) (outline of synthesis only of those marked$) **2. Anti-Infective agents-I:** **Antiseptics and Disinfectants**: Alcohols, substituted phenols, methenamine mandalate, Chloramine-T (MA), 8-hydroxy	12

	quinoline derivatives, Acridine derivatives, Mercurials like (Mercurochrome, Thiomersal) and Nitrofurantoin derivative,Triclosan $. **Antitubercular agents**- Aminosalicylic acid, PAS (MA), Pyrazinamide$, Ethambutol (SAR and $), Clofazemine, **Antimalarials**: Life cycle of parasite, drug acting on different stages- Quinine, Chloroquine$, Primaquine, Trimethoprim, Proguanil (MA), Cycloguanil, Drug combinations. **Antiamoebics**: General aspect of infection, Life cycle of parasite, Hydroxyl quinolines, Metronidazole (SAR and $), Lucanthone (MA), **Anthelmentics**: Diethylcarbamazine, Niclosamide, Mebendazole$, Oxamniquine.	
	3. Anti-Infective agents-II: **Antivirals** including drugs acting on HIV Idoxuridines, Amantadine Hydrochloride$,Acylclovir. **Antineoplastics**: 6-Mercaptopurine (MA), Thiotepa$, Chlorombucil, Taxol, **Antifungal**: **Antibiotics** like Nystatin, Tolnaflate$, Clotrimazole$. Sulfonamides and other antifolics: Sulfonamides (MA) 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
	4. Anti-lipidemics, Diuretics, and diagnostic agents: **Anti-lipidemics**: Clofibrate$, nicotinic acid, boxidine**Diuretics**: Acid forming osmotic diuretics, Mercurials-Meralurides,Sulfonamides-Acetazolamide$. Chlorthiazide$, Hydrochlorthiazide, Ethacrynic acid. **Synthetic sweeteners.** Diagnostic agents Inorganic compounds- Iodoxyl, Iodophendylate. **Dyes**- Rose Bengal, Fluorescein, Aminohippuric acid$.	12
	5. Hypotensive agents, General and Local Anaesthetics: **Hypotensive agents** acting on vascular smooth muscles: Nitrites, Amylnitrites, Glyceryl nitrite$, Pentaerythritol	12

	tetranitrate, Isosorbide dinitrate (MA). **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.	
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.	
References / Readings	1. D. A. Williams & T. L. Lemke, Foye's principles of medicinal chemistry, 5th edition, Lippincott Williams and Wilkins, 2006. 2. J. M. Beale & J. M. Block, Wilson &Gisvold's Text book of Organic Medicinal & Pharmaceutical Chemistry, Lippincott Williams and Wilkins, 2004. 3. D. J. Abraham & D.P. Rotella, Burger's Medicinal Chemistry Drug Discovery and Development (John Wiley & Sons N.Y), 7th edition, 2010. 4. D. Shriram, P. Yogeshwari, Medicinal Chemistry, Pearson Education, 2007. 5. G. L. Patrick: Introduction to Medicinal Chemistry, Oxford University Press, UK. 6th edition, 2017. 6. D. Lednicer& L.A. Mitscher, The Organic Chemistry of Drug Synthesis. (6 volume set) III. John Wiley & Sons, 2005. 7. H. Singh & V. K. Kapoor: Medicinal and Pharmaceutical Chemistry, Vallabh Prakashan, Pitampura, New Delhi, 2010. 8.G. R Chatwal, Medicinal Chemistry (Organic Pharmaceutical Chemistry), Himalaya Publishing house, 2002.	
Course Outcome:	1. Students will be able to identify the examples in different classes of drugs. 2. Students will be able to write IUPAC names and Structure of drugs. 3. Students will be in a position to understand the mechanism of action of selected classes of drugs. 4. The students will have a clear understanding of concepts on SAR analysis. 5. The students will be able to apply synthetic organic chemistry knowledge in devising a synthesis for a drug.	

Title of the course: General Physical Chemistry

Course Code: CHP-500

Number of Credits: 04

Effective from AY: 2022-23

Prerequisites for the course:	Students should have studied chemistry courses at graduate level or must have cleared change of discipline entrance test conducted by Goa University.	
Course Objective:	1. Introduction of various concepts on thermodynamics. 2. Introduction of electro chemistry and kinetics. 3. Learning quantum chemistry.	
Content	**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).	No of hours 12
	2. Quantum Chemistry a. Operators, Functions, Eigen value equations, Postulates. b. Schrodinger 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, Schrodinger 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
	3. Thermodynamics a. Thermodynamic properties: Gas laws, Real gasses, Boyle temperature, Critical temperature, State and path properties. Intensive and extensive properties. Exact and inexact differentials. Internal energy, enthalpy, entropy, free energy and their relations and significances. Maxwell relations. Thermodynamic equations of state b. Joule-Thomson effect. Joule-Thomson coefficient for van	12

	der Waals' gas. Joule-Thomson effect and production of low temperature, adiabatic demagnetization, Joule-Thompson 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.	
	4. Electrochemistry a. EMF series, The cell potential: The 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.	8
	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'tHoffs equation and analysis of Gibbs free energy of equilibrium reactions. c. Collision Theory and Maxwell Boltzmann distribution of energies of colliding molecules (derivation not required). The concept of collisional cross section and reactive cross section and its significance. d. Comparative study of transition state and collision state theory (derivation not required). 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	8

	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.	
References / Readings	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	
Course outcomes:	1. Students should be in a position to understand and explain various concepts in physical chemistry. 2. Students should be in a position to apply these concepts during the lab course in physical chemistry. 3. Students will be able to understand concepts of electrochemistry. 4. Students will be able to apply fundamentals of chemical kinetics for understanding reaction mechanisms.	

Title of the course: Techniques in Analytical Chemistry - I

Course Code: CHA-500

Number of Credits: 04

Effective from AY: 2022-23

Prerequisites for the course:	Students should have studied chemistry courses at graduate level or must have cleared change of discipline entrance test conducted by Goa University.	
Course Objective:	1. Learning various methods of data handling in analysis. 2. Understanding the significance of sampling and calibration techniques. 3. Understanding principles and applications of various types of techniques 4. Training the students to deduce structures based on IR, NMR, MS combined data.	
Content:	**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.	No. of Hours 5
	2. Sampling and Calibration Techniques Sampling and sample preparation, general steps in chemical analysis, calibration of glass wares. Finding the best straight line-least square regression, correlation coefficient; Calibration curves, standard addition technique and internal standards. Chemical concentrations.	5
	3. Classical methods of Analysis Gravimetry and Titrimetric methods, Principle, methodology, Advantages & Disadvantages over instrumental methods. Conditions for identifying a givenreaction as method of Analysis, Classification of reactions in titrimetricanalysis (Acid-Base, redox, complexometric and precipitation), Standardsolutions and their preparation. Selection of Visual Indicators in titrimetric Analysis	6
	4. Introduction to Electroanalytical techniques Introduction to electrochemical cell, electrode potential, Classification of electroanalytical techniques, working principles, and their applications	4
	5. Introduction to Thermoanalyticaltechniques Principle, Instrumentation and applications of Thermo Gravimetric Analysis, Differential Thermal Analysis, and Differential Scanning Calorimetry. Numericals based on TGA.	5
	6. Introduction to Chromatographic Techniques a. Principles of chromatography, classification of	15

	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). b. Principles and applications of Paper chromatography, thin layer chromatography, HPTLC, Size exclusion and Ion exchange chromatography. Counter-current chromatography for isolation of natural products. c. Gas and Liquid Chromatography: Introduction; Instrumental Modules; The Separation System; Choice of Conditions of Analysis; Sample Inlet Systems; Detectors; Practical Considerations in Qualitative and Quantitative Analysis; Coupled Systems-introduction to GCMS, LCMS; Applicability-interpretation and numericals.	
	7. Introduction to Spectroscopic Techniques a. Interaction of Electromagnetic Radiation with Matter: Electromagnetic spectra, regions of spectrum, numericals. b. 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. Calculating λmax for Conjugated Dienes, Trienes, polyenes, α,β-unsaturated carbonyl compounds, Numericals. 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. c. Infrared Spectroscopy: Infrared absorption and molecular structures, molecular vibrations, types of vibrations, IR spectra, overtones and bands-basis of NIR absorption. Spectra interpretation, Frequencies of functional group, Spectral Databases, Identification of unknown compounds. d. Spectrometric Instrumentation of UV-Vis and IR: Sources, monochromators, sample cells, detectors, instrumental wavelength and absorption calibration. e. Proton and Carbon NMR Spectroscopy: Theory of NMR, Instrumentation, Chemical shift, factors influencing chemical shift, solvents used in NMR, spin-spin splitting, coupling constant calculation, factors influencing coupling constant. f. Mass Spectrometry: Principle, Instrumentation and various	20

	fragmentation patterns. g. Conjoint spectrometry problems: Structural elucidation of organic molecules using IR, UV, NMR and MS. h. Raman Spectroscopy: Theory, Basic instrumentation and Structural analysis using Raman Spectra. (Note: Assignment based on all above spectrometric methods should be given to student. More weightage of lectures shall be given for solving IR and NMR data problems for structure elucidation)	
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.	
References / Readings:	1. G. D. Christian, Analytical Chemistry, 6th Ed.; Wiley, 2004. 2. J. H. Kennedy, Analytical Chemistry: Principles, 2nd Ed.; Saunders College Publishing, 1990. 3. G. W. Ewing, Instrumental Methods of Chemical Analysis, 5th Ed.; McGraw- Hill Int., 1985. 4. W. Kemp, Organic Spectroscopy, 3rd Ed.; Palgrave, 1991. 5. D. A. Skoog, D. M. West, F. J. Hollar, S. R. Crouch, Fundamentals of Analytical Chemistry, 9th Ed.; Cengage learning, 2014. 6. F. J. Holler, D. A. Skoog, S. R. Crouch, Principles of Instrumental Analysis, 6th Ed.; Thomson Books, 2007. 7. H. Willard, L. L. Merritt, J. A. Dean, F. A. Settle, Instrumental methods of Analysis, 7th Ed.; HCBS Publishing, 2004. 8. C. N. Banwell, E. M. McCash, Fundamentals of Molecular Spectroscopy, 4th Ed.; Tata McGraw- Hill, 2006. 9. R. M. Silverstein, F. X. Webster, Spectrometric identification of Organic Compounds, 6th Ed.; Wiley, 1998. 10. H. Gunzler, A. Williams, Handbook of Analytical Techniques, 1st Ed.; Wiley, 2001. 11. P. S. Kalsi, Spectroscopy of Organic Compounds, 2nd Ed.; New Age International, 2000. 12. E. Pretsch, P. Buhlmann, C. Affolter, Structural Determination of Organic Compounds, 2nd Ed.; Springer, 2005. 13. L. D. Field, S. Sternhell, J. R. Kalman; Organic Structures from Spectra, 4th Ed.; Wiley, 2007. 14. R. A. Day, A. L. Underwood, Quantitative Analysis, 6th Ed.; Prentice Hall, 2001. 15. B. K Sharma, Instrumental methods of chemical analysis, Goel Publishing House, Meerut, 2004. 16. K. Nakamoto, Infrared and Raman Spectra of Inorganic and Coordination Compounds, 6th Ed.; Wiley, 2009. 17. P. J. Larkin, Infrared and Raman Spectroscopy: principles and	

	spectral interpretation, 2th Ed.; Elsevier, 2018. 18. J. Mendham, R. C. Denney, J. D. Barnes, M. Thomas, B. Sivasankar, Vogel's Text Book of Quantitative Chemical Analysis, 6th Ed.; Pearson, 2009.
Course outcomes:	1.Students will be able to analyse the role of statistical tools for determination of error and organised data management for systematic interpretation. 2. Student will be able to apply the sampling and calibration methods for obtaining reliable results. 3. Students will be able to understand basic principles and scope of different methods of Analysis 4. Students will be able to solve problems based on IR, NMR, MS combined spectral data.

Title of the course: Practical Course in Organic Chemistry-I

Course Code: CHO-521

Number of Credits: **02**

Effective from AY: 2022-23

Prerequisites for the course	Students should have studied chemistry practical courses at graduate level or must have cleared change of discipline entrance test conducted by Goa University.	
Course Objective:	To translate certain theoretical concepts learnt earlier into experimental knowledge by providing hands on experience of basic laboratory techniques required for organic syntheses.	
Content	*Minimum 13 experiments from the list shall be conducted.* **1. Introduction to laboratory equipments, apparatus and safety** a. Use of common laboratory equipments like fume hoods, vacuum pumps, weighing balance etc. to be explained to the students. b. Introduction to various types of quick fit joints and apparatus to the students. c. Discussion of Safety Techniques: i Disposal of chemicals ii Usage of protective equipment's iii First aid iv Fire extinguishers, types of fire v Hazards of chemicals and risk assessment	No of hours 04
	2. **Laboratory Techniques** a. Simple distillation (any one): i. Toluene-dichloromethane mixture using water condenser. ii. Nitrobenzene and aniline using air condenser. b. Steam distillation (anyone): 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. iv. Decolorisation and crystallization of brown sugar (sucrose) with animal charcoal using gravity filtration. d. Sublimation: Simple or vacuum sublimation of camphor,	24

	naphthalene, anthracene or succinic acid (any one). e. Vacuum distillation (any one): o-dichlorobenzene, diphenyl ether. Also use of nomograph should be explained. f. Thin layer Chromatography (any one): i. Separation of *o* and *p*-nitroanilines. ii. Separation of analgesic drugs iii. Separation of *o* and *p*-nitrophenols,	
	3. Organic synthesis (Any Seven experiments) a. Aliphatic electrophilic substitution: Preparation of iodoform from ethanol &acetone. b. Aromatic electrophilic substitution (anyone): 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: Dibenzal acetone from benzaldehyde h. Acetoacetic ester condensation: Preparation of ethyl *n*-butylacetoacetate or ethyl acetoacetate. i. Cannizzaro reaction using 4-chlorobenzaldehyde as substrate. j. Friedel Craft's reaction (any one): i. using toluene and succinic anhydride ii. Resorcinol to resacetophenone, benzene and maleic anhydride to *β*-benzoylacrylic acid k. Solvent free preparation of coumarin by the Knoevenagel condensation under MW irradiation. l. Preparation of oxidizing agent (any one): Pyridinium chlorochromate-silica, pyridinium chlorochromate-alumina, MnO_2. m. Preparation of cuprous chloride.	24
	4. **Isolation from natural sources (Any two)** i. Caffeine from tea powder. ii. Piperine from pepper. iii. Cinnamaldehyde from cinnamon	8

	iv. Lemongrass oil from lemongrass	
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. Each of the experiments should be done individually by the students.	
References / Readings	1. A.I. Vogel, A., R. Tatchell , B. S. Furniss, A.J. Hannaford, Vogel's Textbook of Practical Organic Chemistry, 5thEd., Prentice Hall; 2011. 2. D. Pasto, C. Johnson and M. Miller, Experiments and Techniques in Organic Chemistry, 1stEd., Prentice Hall, 1991. 3. L.F. Fieser, K.L. Williamson,Organic Experiments, 7thedition D. C. Heath, 1992. 4. K.L. Williamson, K.M. Masters, Macroscale and Microscale Organic Experiments, 6thEdition, Cengage Learning, 2010 5. R.K. Bansal, Laboratory Manual in Organic Chemistry, New Age International, 5thEdition, 2016. 6. S. Delvin, Green Chemistry, Sarup& Sons, 2005. 7. O.R. Rodig, C.E. Bell Jr. and A.K. Clark, Organic Chemistry Laboratory Standard and Microscale Experiments, Saunders College Publishing, 3rdedition, 2009. 8. J. Mohan, Organic Analytical Chemistry, Narosa Publishing House, 2014.	
Course outcomes	1. Students will be in a position to understand stoichiometric requirements during organic syntheses. 2. Students will be in a position to understand Safe and good laboratory practices, handling laboratory glassware, equipment and chemical reagents. 3. Students will be in a position to apply the practical knowledge to perform experiments involving common laboratory techniques like reflux, distillation, steam distillation, vacuum distillation, aqueous extraction, thin layer chromatography (TLC) etc. 4. Students will be able to acquire hands-on experience on isolation of some important natural products.	

Title of the course: Practical Course in Organic Chemistry-II

Course Code: CHO-522

Number of Credits: 02

Effective from AY: 2022-23

Prerequisites for the course	Students should have studied chemistry practical courses at graduate level or must have cleared change of discipline entrance test conducted by Goa University.	
Course Objective:	To translate certain theoretical concepts learnt earlier into experimental knowledge by providing hands on experience of basic laboratory techniques required for organic syntheses.	
Content	*Minimum 13 experiments from the list shall be conducted.* **1. Introduction to laboratory equipments, apparatus and safety** a. Common Hazards in Chemical Laboratory, Risk assessment b. Accidents and Emergency procedures	No of hours 04
	2. Laboratory Techniques (Any Two) a. Simple distillation i. Simple distillation of thionyl chloride under anhydrous condition ii. Simple distillation under Nitrogen atmosphere b. Fractional distillation i. Chloroform-dichloromethane mixture using water condenser. ii. Toluene and cyclohexane by fractionating column. c. Vacuum distillation under inert atmosphere Dry Distillation of DMF, *o*-dichlorobenzene, $POCl_3$ d. Thin layer Chromatography i. Purification and isolation of mixture of acids by using Preparative TLC. ii. Purification and isolation of mixture of phenols by using Preparative TLC. iii. Purification and isolation of pharmaceutical drugs using Preparative TLC.	08
	3. Organic Synthesis (Any Four) a. *p*-Iodonitrobenzene by Sandmeyer reaction b. Pinacol- Pinacolone rearrangement c. Hydrogenation of Maleic acid (Hydrogen balloon) d. Preparation of nitrostyrene from aldehyde e. Preparation of α,β-dibromocinnamic acid f. Reduction of nitro compounds	16

	g. Synthesis of Urea from ammonium cyanate	
	4. Solvent Free Organic synthesis (Any Two) a. Reduction using ball milling technique b. Oxidation of 2° alcohol using $KMnO_4$/Alumina by grinding technique. c. Synthesis of (±)-Binol from β-naphthol d. Hunsdiecker reaction of cinnamic acid derivatives e. Beckmann rearrangement of oxime derivatives	08
	5. 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*–Bromo acetanilide – *p*–Bromoaniline f. Acetophenone – Oxime – Acetanilide	16
	6. Separation, Isolation and Identification of Organic compounds (Any One) a. 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.	08
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.	
References / Readings	1. A. I. Vogel, A. R. Tatchell, B. S. Furniss, A. J. Hannaford, Vogel's Textbook of Practical Organic Chemistry, 5th Ed., Prentice Hall; 2011. 2. K. Tanaka, Solvent-free Organic Synthesis, Wiley-VCH, 2nd Ed., 2009 3. L. F. Fieser, K. L. Williamson "Organic Experiments" 7th edition D. C. Heath, 1992. 4. K. L. Williamson, K. M. Masters, Macroscale and Microscale Organic Experiments, 6th Edition, Cengage Learning, 2010 5. R. K. Bansal, Laboratory Manual in Organic Chemistry, New Age International, 5th Edition, 2016. 6. S. Delvin, Green Chemistry, Sarup& Sons, 2005. 7. O. R. Rodig, C. E. Bell Jr., A. K. Clark, Organic Chemistry Laboratory Standard and Microscale Experiments, Saunders College Publishing, 3rdedition, 2009. 8. J. Mohan, Organic Analytical Chemistry, Narosa Publishing House, 2014.	
Course outcomes	1. Students will be in a position to adopt Safe and good laboratory practices, handling laboratory glassware, equipment and chemical reagents. 2. Students will be in a position to understand and calculate stoichiometric	

	requirements during organic syntheses. 3. Students will be in a position to perform common laboratory techniques including reflux, distillation, vacuum distillation, aqueous extraction, thin layer chromatography (TLC). 4. Students will be able to acquire hands-on experience on isolation of some important natural products.

Title of the course: Practical Course in Pharmaceutical Chemistry-I

Course Code: CHH-521

Number of Credits: 02

Effective from AY: 2022-23

Prerequisites for the course	Students should have studied chemistry practical courses at graduate level or must have cleared change of discipline entrance test conducted by Goa University.	
Course Objective:	1. To acquire hands on training in laboratory techniques. 2. To understand organic synthesis with reference to medicinal compound preparations.	
Content	**1) Qualitative and Quantitative tests of (Any 1)** (1) Purified Water as per IP Monograph (2) Ibuprofen as per IP Monograph	No of hours 10
	2) Titrimetric Assay of the following bulk drugs: **(4 x 2 = 8) (Any 2)** a) Pheniramine Maleate b) Salbutamol c) Ofloxacin	08
	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
	4) Synthesis of following bioactive or drug molecules (2x3=6 hours) Any 2 a) 3-Acetylcoumarin b) 2-Phenylbenzimidazole c) 2,3-Diphenyl Quinoxaline	06
	5) Multistep synthesis (Any one) a) Flavone from 2-hydroxyacetophenone b) Paracetamol from Acetanilide	08
	6)Dissolution experiment: To study the dissolution rate of sustained release Theophylline tablets IP.	06
	7) High Performance liquid Chromatographic experiment: To develop and validate the analytical method of any one drug using high performance liquid chromatography.	06
Pedagogy	Pre-lab and Post-lab exercises. Demonstrations of experiments. Explanation	

	of procedures.
References/ Readings	1. A. I. Vogel, A. R. Tatchell, B. S. Furniss, A. J. Hannaford, Vogel's Textbook of Practical Organic Chemistry, 5th Edition, Prentice Hall; 2011. 2. K. A. Connors, Text book of Pharmaceutical analysis, 3rdEdition, Wiley Interscience Publication, 1990. 3. J. Bassett, J. Mendhan, R. C. Denny, Vogel's Text book of quantitative chemical analysis revised by G.H. Jeffery , 6th Edition, Pearson Education Publication, 2007. 4. Indian Pharmacopoeia., United States Pharmacopoeia, British Pharmacopoeia. European Pharmacopoeia. 5. J. E. F. Reynolds, Martindale-The Extra Pharmacopoeia, 30th Edition, Pharmaceutical Press, London, 1993. 6. J. Moini, Pharmaceutical Laboratory Procedures, 1st Edition, Cengage Learning India Pvt. Ltd., New Delhi, 2010.
Course Outcome	1. Students will be able to understand the theoretical concepts and practical applications. 2. Students will be able to handle analytical instruments like UV-VIS spectrophotometer and carry out drug analysis. 3. Students will be able to perform multistep synthesis. 4. Students will be able to perform HPLC analysis

Title of the course: Practical Course in Pharmaceutical Chemistry-II

Course Code: CHH-522

Number of Credits: 02

Effective from AY: 2022-23

Prerequisites for the course	Students should have studied chemistry practical courses at graduate level or must have cleared change of discipline entrance test conducted by Goa University.	
Course Objective:	1. To acquire hands on training in laboratory techniques. 2. To understand organic synthesis with reference to medicinal compound preparations.	
Content	**1) Qualitative and Quantitative tests of (**Any 1) (1) Paracetamol as per IP Monograph (2) Aspirin as per IP Monograph	No of hours 10
	2) Titrimetric Assay of the following bulk drugs: (2 x 4 = 8) Any 2 a) Chloramphenicol capsules IP b) Furosemide injection IP c) Ketoprofen d) Phenytoin	08
	3) UV Spectrophotometric Assay of the following drugs (in different dosage forms): (4 x 2= 8) Any 2 Mefenamic acid, Furosemide, Chloramphenicol	08
	4) Synthesis of following bioactive or drug molecules: (2 x 4 = 8 hours) Any 2 a) Warfarin b) 2-(*p*-Chlorophenyl)benzoxazole c) Monastrol d) Nitazoxanide	08
	5)Dissolution experiment: Dissolution rate study of sustained release Diclofenac tablets IP.	06
	6) Thin Layer Chromatographic experiments on Pharmaceuticals (Any 1) a) To identify the given drug amongst the paracetamol, aspirin and caffeine citrate with the help of thin layer chromatography and calculate its *Rf* value. b) To identify the given sulpha drug among the sulphadiazine, sulphamethoxazole and trimethoprim with the help of thin layer chromatography and calculate its *Rf*	04

	value.	
	7) High Performance liquid Chromatographic experiment: To demonstrate high Performance liquid chromatography and analyse Diazepam Tablets by High Pressure Liquid Chromatography.	06
	8)Separation of mixture of o-nitroaniline and p-nitroaniline using column chromatography.	06
	9)Infrared Spectroscopic analysis **Demonstration of Instrumentation and Interpretation of Representative Spectra (Any 1)** a) To differentiate between analgesic-NSAIDs:Aspirin, Ibuprofen, Paracetamol. b) To differentiate between Acetophenone, *p*-Nitroacetophenone, Benzamide	04
Pedagogy	Pre-lab and Post-lab exercises. Demonstrations of experiments. Explanation of procedures.	
References/ Readings	1. A. I. Vogel, A. R. Tatchell, B. S. Furniss, A. J. Hannaford, Vogel's Textbook of Practical Organic Chemistry, 5th Edition, Prentice Hall; 2011. 2. K. A. Connors, Text book of Pharmaceutical analysis, 3rdEdition, Wiley Interscience Publication, 1990. 3. J. Bassett, J. Mendhan, R. C. Denny, Vogel's Text book of quantitative chemical analysis revised by G.H. Jeffery , 6th Edition, Pearson Education Publication, 2007. 4. Indian Pharmacopoeia., United States Pharmacopoeia, British Pharmacopoeia. European Pharmacopoeia. 5. J. E. F. Reynolds, Martindale-The Extra Pharmacopoeia, 30th Edition, Pharmaceutical Press, London, 1993. 6. J. Moini, Pharmaceutical Laboratory Procedures, 1st Edition, Cengage Learning India Pvt. Ltd., New Delhi, 2010	
Course Outcome	1. Students will be able to understand the theoretical concepts and practical applications. 2. Students will be able to handle analytical instruments like UV-VIS spectrophotometer and carry our drug analysis. 3. Students will be able to perform synthesis.. 4. Students will be able to perform HPLC analysis	

Title of the course: Practical course in Physical Chemistry-I

Course Code: CHP-521

Number of Credits: 02

Effective from AY: 2022-23

Prerequisites for the course:	Students should have studied chemistry courses at graduate level or must have cleared change of discipline entrance test conducted by Goa University.	
Course Objective:	1. To develop experimental skills on basic lab techniques in physical chemistry 2. To acquire skills for data analysis and interpretation 3. To help the students to develop research skills	
Content	Minimum 13 Experiments to be performed per Semester Non-instrumental Experiments (any 7) 1. To study the kinetics of hydrolysis of ethyl acetate and to determine a)Energy of activation b) Entropy of activation and c) Free energychange. 2. To determine the order of reaction between potassium persulphateand 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 tieline. 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	No of hours 30
	Instrumental Experiments (any 6)	30

	11. To determine the degree of hydrolysis of salt of weak base and strong acid usingconductometer. 12. To determine the dissociation constants of a tribasic acid (Phosphoricacid obtain derivative plot to get equivalencepoint. 13. To determine formal redox potential of Fe^{2+}/Fe^{3+} and Ce^{3+}/Ce^{4+} system obtain derivative plot to get equivalencepoint. 14. To study spectrophotometric titration of ferrous ammonium sulphate with potassium permanganate (or dichromate vs permanganate) 15. To determine Avogadro's number by improved electroplating. 16. To determine the zeta potential of colloidal system and investigate the effect of different surfactants on stability of the colloids 17. To verify the Kohlrausch's law for weak electrolyte by conductometry 18. To determine the transport numbers of Cu^{2+} and SO_4^{2-} ions in $CuSO_4$ solution by Hittorf's method.	
Pedagogy	Mainly pre-laboratory exercises Seminars / term papers /assignments / presentations / lab hand-out /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.	
References / Readings	1. A. Finlay & J.A. Kitchener, Practical Physical Chemistry,Longman, 2. F. Daniels & J.H. Mathews, Experimental Physical Chemistry,Longman 3. A.M.James, Practical PhysicalChemistry, Longman 4. D.P. Shoemaker & C.W. Garland, Experimental Physical Chemistry, McGraw-Hill	
Course outcomes:	1. Students will able to explain various fundamental lab techniques. 2. Students should be in a position to apply the knowledge for their dissertation and research work. 3. Students will be able to use spectrophotometric titrations for appropriate analysis. 4. Students will be able to determine molecular weight of some polymers.	

Title of the course: Practical course in Physical Chemistry-II

Course Code: CHP-522

Number of Credits: 02

Effective from AY: 2022-23

Prerequisites for the course:	Students should have studied chemistry courses at graduate level or must have cleared change of discipline entrance test.	
Course Objective:	1. To develop experimental skills on basic lab techniques in physical chemistry 2. To acquire skills for data analysis and interpretation 3. To help the students to develop research skills	
Content	Minimum 13 experiments to be conducted per Semester **Non-instrumental Experiments (any 8)** 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 per sulphate ($K_2S_2O_8$), 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	No of hours 35

	viscosity measurement.	
	Instrumental Experiments (any 5) 11. To determine the relative strength of chloroacetic acid and acetic acid by conductometry. 12. To determine the degree of hydrolysis of salt of weak base and strong acid using conductometry. 13. To determine the composition of a mixture of acetic acid, dichloroacetic acid and hydrochloric acid by conductometric titration. 14. To determine the dissociation constants of monobasic acid and dibasic acid and obtain derivative plot to get equivalence point. 15. To determine the redox potential of Fe^{2+}/Fe^{3+} system by titrating it with standard $K_2Cr_2O_7$ solution. 16. To study the electrodeposition of metal.	25
Pedagogy	Mainly pre-laboratory exercises Seminars / term papers /assignments / presentations / lab hand-out /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.	
References / Readings	1. A. Finlay & J.A. Kitchener, Practical Physical Chemistry,Longman, 2. F. Daniels & J.H. Mathews, Experimental Physical Chemistry,Longman, 3. A. M. James, F. E. Prichard, Practical PhysicalChemistry, Longman, 4. D.P. Shoemaker & C.W. Garland, Experimental Physical Chemistry, McGraw-Hill,	
Course outcomes:	1. Students will gain knowledge of various fundamental lab techniques. 2. Students should be in a position to apply the knowledge for their dissertation and research work. 3. Students will be able to use spectrophotometric titrations for appropriate analysis. 4. Students will be able to determine molecular weight of some polymers.	

Title of the course: Practical Course in Analytical Chemistry - I

Course Code: CHA-521

Number of Credits: 02

Effective from AY: 2022-23

Prerequisites for the course:	Students should have studied chemistry practical courses at graduate level or must have cleared change of discipline entrance test conducted by Goa University.	
Course Objectives:	1. Introduction of various experimental techniques for analysis. 2. Learning data analysis, handling and interpretation of spectra.	
Content:	*This course consists of 7 units of experiments in various areas of Analytical chemistry. Minimum 13 experiments which include at least 02 experiments from unit 1-6 and 01 experiment from unit 7 shall be conducted.*	No of hours
	Unit 1: Statistics i. Calibration of selected Volumetric apparatus ii. Calibration of selected Laboratory instruments Preparation of standard solutions and standardisation.	9
	Unit 2: Colorimetry/ UV-Visible Spectrophotometry i. Estimation of Iron from Pharmaceutical sample (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
	Unit 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.	9
	Unit 4: Ion Exchange Chromatography and High Pressure Liquid Chromatography i. Separation and Estimation of chloride and bromide. ii. Separation of Anthracene and Naphthalene using reverse phase chromatography iii. Separation of Benzaldehyde and Benzyl alcohol using normal phase chromatography	10
	Unit 5: Volumetric Titrations	10

	i. Estimation of Ca in pharmaceutical tablet. ii. Estimation of Al and Mg in antacid tablet. iii. Estimation of CaO in cement.	
	Unit 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 by spectrophotometry. iii. Determination of Silver as ion association complex with 1,10-Phenanthroline and Bromopyrogallol red.	10
	Unit 7: Interpretation Exercises i. Thermal studies: TG/DTA and Isothermal weight loss studies of various hydrated solids like $CuSO_4 \cdot 5H_2O$, $Ca_2C_2O_4 \cdot H_2O$, $Fe_2C_2O_4 \cdot 2H_2O$. ii. X-ray powder diffractometry: Calculation of lattice parameters from X-ray powder pattern of cubic system such as $NiMn_2O_4$, $CoFe_2O_4$ etc. iii. IR spectra of Urea, benzoic acid, Copper sulphate pentahydrate etc.	4
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.	
References / Readings:	1. J. H. Kennedy, Analytical Chemistry Principles, Saunders College Publishing, 2nd Ed., 1990. 2. G. D. Christian, Analytical chemistry, 5th Ed., John Willey and Sons, 1994 3. J. Mendham, R.C. Denney, J.D. Barnes, M. Thomas, B. Sivasankar, Vogel's Textbook of Quantitative Chemical Analysis, 6th Ed., Pearson Education Asia 2009. 4. A. J. Elias, Collection of interesting chemistry experiments, University press, 2002. 5. R.A. Day & A.L. Underwood, Quantitative Analysis, 6th Ed., Prentice Hall, 2001. 6. J. Kenkel, Analytical Chemistry for Technicians, 3rd Ed., Lewis publishers, 2002.	
Course outcomes:	1. Students will be able to explain how to determine an unknown concentration of solution. 2. Students will use statistical methods to analyse data in laboratory. 3. Students will be able to use different techniques for qualitative and quantitative estimation. 4. Students will be able to interpret TG/X-Ray/IR spectra.	

Title of the course: Practical Course in Analytical Chemistry - II

Course Code: CHA-522

Number of Credits: 02

Effective from AY: 2022-23

Prerequisitesfor the course:	Students should have studied chemistry practical courses at graduate level or must have cleared change of discipline entrance test conducted by Goa University.	
Course Objectives:	1. Introduction of various experimental techniques for analysis. 2. Learning data analysis, handling and interpretation of spectra.	
Content:	*This course consists of 7 units of experiments in various areas of Analytical chemistry. Minimum 13 experiments which include at least 02 experiments from unit 1-6 and 01 experiment from unit 7 shall be conducted.*	No of hours
	Unit 1: Statistics i. Calibration of selected Volumetric apparatus ii. Calibration of selected Laboratory instruments iii. Preparation of standard solutions and standardisation.	9
	Unit 2: Titrimetric Analysis i. Standardisation and estimation of Chloride using precipitation titration (Mohr's method) ii. Analysis of commercial caustic soda by neutralisation titrimetric method iii. Determination of sulphates by complexometric titrations using EDTA.	8
	Unit 3: Flame Spectrophotometry and AES/AAS/ICP Spectroscopy i. Estimation of Na and K 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.	10
	Unit 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	9
	Unit 5: UV-Visible Spectrophotometry and High-Pressure Liquid Chromatography i. Estimation of KNO_3 and $K_2Cr_2O_7$ using UV- Visible spectroscopy	10

	ii. Separation of Benzaldehyde and benzoic acid using reverse phase HPLC. iii. Quantification of naphthalene in a sample using reverse phase HPLC.	
	Unit 6: Solvent Extraction and spectrophotometry i. Spectrophotometric determination of aspirin/phenacetin/ caffeine in APC tablet using solvent extraction ii. Colorimetric determination of iron with salicylic acid. iii. Determination of copper in brass sample by colorimetry.	10
	Unit 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	4
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.	
References / Readings:	1. J. H. Kennedy, Analytical Chemistry Principles, Saunders College Publishing, 2nd Ed., 1990. 2. G. D. Christian, Analytical chemistry, 5th Ed., John Willey and Sons, 1994 3. J. Mendham, R.C. Denney, J.D. Barnes, M. Thomas, B. Sivasankar, Vogel's Textbook of Quantitative Chemical Analysis, 6th Ed., Pearson Education Asia 2009. 4. J. Elias, Collection of interesting chemistry experiments, University press, 2002. 5. R.A. Day & A.L. Underwood, Quantitative Analysis, 6th Ed., Prentice Hall, 2001. 6. J. Kenkel, Analytical Chemistry for Technicians, 3rd Ed., Lewis publishers, 2002.	
Course outcomes:	1. Students will be able to standardize a material to determine an unknown concentration. 2. Students will use statistical methods to analyse data in laboratory. 3. Students will be able to use different techniques for qualitative and quantitative estimation. 4. Students will be able to interpret TG/X-Ray/IR spectra.	

Title of the course: Fundamentals of Pharmaceutical Chemistry-II

Course Code: CHH-501

Number of Credits: 04

Effective from AY: 2022-23

Prerequisites for the course:	Should have studied Pharmaceutical Chemistry at Semester I.	
Course Objective:	1. To learn major classes of drugs w.r.t. IUPAC nomenclature, structure and functional groups. 2. To understand the SAR of selected drugs and their Mechanism of action. 3. To get acquainted with the synthesis of selected drug molecules	
Content	**Classification of Chemotherapeutic Drugs: Development of the following drugs including structure activity relationship (S.A.R.), mechanisms of action (MA), outline of synthesis ($), chemical nomenclature, generic names (GN) and side effects (SE) (outline of synthesis only of those marked$)**	
	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 (MA,$), Guanethidine, Ephedrine, Amphetamine, Tranylcypromine, Pragyline, Norepinephrine, Epinephrine, Pronethalol, Propranalol$, Atenolol$, Metoprolol.(SAR)	No of hours 12
	2. **Drugs acting on the central nervous system**: Hypnotics and sedatives: Chloral hydrate, Phenobarbital$, Secobarbital, Thiopental$, Nitrazepam, (SAR) Drugs acting as anticonvulsants: Phenytoin$, phenacemide, Clonazepam, Phensuximide, Phenobarbital, (Classification of Barbiturates), Primidone, Carbamazepine$. Psychotherapeutic agents: Phenothiazines such as Chloropromazine, Chlorodiazepoxide$, Oxazepam, Diazepam$, Imipramine, Nialamide, Tranylcypromine, Pargyline. CNS stimulants: Phenmetrazine, Nikethamide$, Iproniazid, Picrotoxines, Tetrazole, Amphetamine.	12

	3.**Antihistaminics, antiemetic, antiulcer drugs, Drugs used in parkinsonism and Alzhemeier's:** Diphenhydramine, Triprolidine, Cyclizine, Promethazine$(SAR), Cimetidine, Omeprazole (MA), Ranitidine, Sumatriptan, Ondansetron. Drugs used in Parkinsonism: Benzotronine mesylate, Levodopa, Carbidopa, Amantadine hydrochloride. Drugs for Alzheimer's diseases: Serine, Velnacrine (MA), Aniracetam.	10
	4. **Cardiovascular drugs, antihypertensive agents**, **and antibiotics:** Digitoxin, Quinidine, Procainamide, Verapamil. Antihypertensive agents which elicit their action through autonomous nervous system previously described under 1 and 2, Clonidine, Hydralazine, ACE inhibitors- Enalapril and related drugs vasodilators such as Nitroglycerine, Isoxsuprine, Nylidrin, Antibiotics: Penicillin and semisynthetic penicillin's and Cephalosporins, Amoxicillin, Cloxacillin, Streptomycin, Chloramphenicol, Tetracycline and derivatives, Erythromycin.	10
	5. Analgesics, Antipyretics and Inflammatory agents: Analgesics, antipyretics and anti-inflammatory agents: Sodium salicylate, Acetaminophen$, Phenacetin, Phenylbutazone, Oxyphenabutazone$, Naproxen$, Probenecid, Allopurinol, Profen, Diclofenac $. Narcotic analgesic agents: Morphine, Codeine, Meperidine, Methadone, Dextropropoxyphene. Non-narcotic analgesic agents: Dextropropoxyphene Levallorphan.	10
	6. **Neglected Tropical diseases**. Background, overview of Neglected tropical diseases, (Poverty diseases) Human Schistosomiasis, African trypanosomiasis (Chagas), leishmaniasis, sleeping sickness. Nitroheterocycles, Benznidazole, Nifurtimox ($, MA and side-effects)	06
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.	
References / Readings:	1. D. A. Williams & T. L. Lemke, Foye's principles of medicinal chemistry, 5th edition, Lippincott Williams and Wilkins, 2006. 2. J. M. Beale & J. M. Block, Wilson &Gisvold's Text book of Organic Medicinal & Pharmaceutical Chemistry, Lippincott Williams and Wilkins,	

	2004. 3. D. J. Abraham & D. P. Rotella, Burger's Medicinal Chemistry Drug Discovery and Development, 7th edition, John Wiley & Sons N.Y, 2010. 4. D. Shriram, P. Yogeshwari, Medicinal Chemistry, Pearson Education, 2007. 5. G. L. Patrick: Introduction to Medicinal Chemistry, Oxford University Press, UK. 6th edition, 2017. 6. D. Lednicer& L. A. Mitscher, The Organic Chemistry of Drug Synthesis. (6 volume set) III. John Wiley & Sons, 2005. 7. H. Singh & V. K. Kapoor, Medicinal and Pharmaceutical Chemistry, Vallabh Prakashan, 2010. 8.G. R Chatwal, Medicinal Chemistry (Organic Pharmaceutical Chemistry), Himalaya Publishing house, 2002.
Course Outcome:	1. Students will be able to identify the examples in different classes of drugs. 2. Students will be able to write IUPAC names and Structure of drugs. 3. Students will be in a position to understand the mechanism of action of selected classes of drugs. 4. The students will have a clear understanding of concepts on SAR analysis. 5. The students will be able to apply synthetic organic chemistry knowledge in devising a synthesis for a drug.

Title of the course: Drug Product Formulation, Development and Manufacture

Course Code: CHH-502

Number of Credits: 04

Effective from AY: 2022-23

Prerequisites for the course:	Should have studied Pharmaceutical Chemistry at Semester I.	
Course Objective:	1. To understand the concept of drug dosage forms, types of formulations and pilot plant processes. 2. To study the drug formulation development with specific examples.	
Content	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 analysing polymorphs using ultraviolet, infra-red, solid state NMR, DSA-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.	No of hours 15
	2. **Pilot plant** Scale up techniques, Benefits of pilot plant- Broad guidelines of process development. General Consideration. Industrial manufacturing method and flow charts of sulphamethoxazole, Rifampicin, Chloramphenicol maleate, Actinobolin, BTZO43, Piperaquine, Propranolol hydrochloride.	15
	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

	4. Dosage forms-formulation components, manufacturing and QC Types of dosage forms: Liquids-monophase &biophase including ENT preparation, sprays. Semisolid eg. Ointment, creams, gels, liniment, paste, lotion etc. Solid dosage forms eg. Tablets-Types of tablets, capsules, granules, powders, pastilles, lozenges, Sterile dosage forms eg. Injectables and ophthalmic preparations. Suppositories etc. Routes of drug administration, their advantages and disadvantages. Details pertaining to manufacturing processes for variety of dosage forms as listed above. Quality control evaluation of the dosage forms for assurance.	15
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.	
References / Readings:	1. L. V. Allen Jr., N. G. Popovich, H. C. Ansel, *Ansel‟s pharmaceutical dosage forms and drug delivery systems,* Lippincott Williams & Wilkins, 2005. 2. R. K. Khar, *Lachman/Lieberman's The Theory and Practice of Industrial Pharmacy*, 4th Edition, CBS Publishers & Distributors, 2020. 3. G. Banker, *Modern Pharmaceutics*, Marcel Dekker, Inc, 2002. 4. S. J. Carter, *Dispensing for Pharmaceuticals students*, CBS Publishers & Distributors, Delhi, 2007. 5. J. P. Remington, *Remington's Pharmaceuticals Sciences*, Mack Publishers,1990. 6. M. E. Aulton, *Pharmaceutics Science of Dosage forms and design,* Kevin Taylor Elsevier, Health Sciences Division, 2001.	
Course Outcome:	1. Students should will be able to formulate APIs. 2. Students will be able to apply this knowledge for formulation experiments in laboratory. 3. Students will be able to evaluate formulations qualitatively. 4. Students will be able to understand Pharmaceutical manufacturing operations	

Title of the course: Drug Design, Discovery and Development

Course Code: CHH-503

Number of Credits: 04

Effective from AY: 2022-23

Prerequisites for the course:	Should have studied Pharmaceutical Chemistry at Semester I.	
Course Objective:	1. To make the students well versed with theories of drug action. 2. To make the students understand the Structure Activity Relationship studies citing various examples. 3. To acquaint the students with the concepts ofdrug designing by molecular modelling. 4. To introduce various terms involved in patenting and IPR.	
Content	1. **Introduction to Drug design, Lead compounds and Pro-drug Concept.** 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.	No of hours 12
	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
	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.	12

	Introduction to molecular modelling using computers and docking, uses of molecular modelling manual use, further computer programming.	
	4.**Designing of Enzyme Inhibitors as drugs** Structure-based drug design: Process of structure based drug design, deactivation of certain drugs necessary for T cell functioning, determination of the active site with special reference to chymotryspin, design of inhibitors**.** Design of Enzyme Inhibitors, 9-alkylpurines, 9-mercaptopurines and allopurines, active site directed irreversible enzyme inhibition, suicide enzyme inactivators.	12
	5. Development of New drugs High throughput screening. Drug Design software's and its applications. Intellectual property rights, patents, industrial designs, geographical indications, trademarks, trade secrets. Patentable inventions. Patentable drugs. Role of patents in Pharmaceutical industry. Trade related aspects (TRIPS), international & regional agreements. Patent writing for drug designed. Examples of new drugs developed.(5 examples with one designing strategy)	12
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.	
References / Readings:	1. S. S. Pandeya and J. R. Dimmock, An Introduction to Drug Design New Age International (P) Ltd. Publishers, 2007. 2.M. E. Wolff., Burger's Medicinal Chemistry and Drug Discovery, Vol I (Ch 9 and 14), John Wiley and Sons, New York, 1997. 3. Alen-Gringauz, Introduction to Medicinal Chemistry, 1st edition, Wiley-VCH,1996. 4. D. Lednicer and L. A. Mitscher, The Organic Chemistry of Drug Synthesis, Vol. I to V, John Wiley, 2005. 5. Alen-Gringauz, Introduction to Medicinal Chemistry, Wiley-VCH, 1997. 6. R.B. Silverman, Organic Chemistry of Drug design and Drug action, 3rd edition, Academic Press, 2014. 7. A. Leach, Molecular Modelling: Principles and applications, 2nd edition, Pearson India, 2001. 8. Norman Bailey, Statistical methods in Biology, 3rd edition, Cambridge University Press, 1995. 9. P. Krogsgaard-Larsen, U. Madsen, T. Liljefors A Textbook of Drug Design	

	and Development, 2nd edition, CRC Press, 1996. 10. G. Jolles and R. H. Wooldridge, Drug Design–Fact or Fantasy, Academic Press, 1984. 11. E. B. Roche, Design of Biopharmaceutical properties through prodrug and analogs, Am. Pharm. Assoc. Academy of Pharm. Sci., 1977. 12. G. L. Patrick, An Introduction to Medicinal Chemistry, 2nd edition, (Indian edition), Oxford University Press, 2001 13. N.R. Subbaran, What everyone should know about Patent, Pharma Book Syndicate, 2005. 14. Current Patent Acts of various countries. 15. P. W. Grubb, Patents for Chemicals, Pharmaceuticals & Biotechnology, 4th edition, Oxford University Press, 2005.
Course Outcome:	1. Students will be able to explain the theories of drug action. 2. Students will have a clear understanding of concepts on SAR analysis and will be able to apply Quantitative Structure Activity Relationship knowledge in drug designing. 3. Students will be able to analyze the effect of different functional groups on the biological activity of drugs. 4. The students will be able to illustrate an example of drug designing by molecular modelling. 5. The students will be able to explain the terms in patents.

Title of the course: Biopharmaceutics and Pharmacokinetics

Course Code: CHH-504

Number of Credits: 04

Effective from AY: 2022-23

Prerequisites for the course:	Should have studied Pharmaceutical Chemistry at Semester I.	
Course Objective:	1. To learn ADMET. Drug absorption drug distribution Drug Action Drug metabolism and excretion. 2. To learn how bioavailability is important in understanding the efficacy of a drug product.	
Content	1. **Introduction:** Definitions, ADME, concentration time profile, plotting the data, different fluid compartments and blood flow rate compartment models, biological half life, elimination rate constant. Biopharmaceutics and pharmacokinetics in drug research.	No of hours 08
	2. **Drug Absorption, Dissolution and Distribution** GIT Absorption of drugs: Mechanism, physico-chemical, biological and pharmaceutical factors affecting drug absorption through GIT. Techniques for the GIT absorption assessment. mechanisms of drug absorption, factors affecting drug absorption: Biological, physiological, physico-chemical and pharmaceutical. Noyes-Whitney's dissolution rate law, study of various approaches to improve dissolution of poorly soluble drugs, In-vitro dissolution testing models, In-vitro-in-Vivo correlation. Factors affecting drug distribution, volume of distribution, protein binding – factors affecting, significance and kinetics of protein binding.	12
	3.**Drug Metabolism and Excretion** Metabolism of drugs, Xenobiotics, Drug metabolizing organs and enzymes (microsomal &nonmicrosomal), Chemical pathways - Phase I reactions (Oxidative, reductive and hydrolytic reactions) and Phase II reactions (Conjugation), Significance of cytochrome P_{450} 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	12

	of drugs (Any two types).	
	4. **Bioavailability and Bioequivalency studies** 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.	12
	5. Pharmacokinetics: Protein and tissue binding: Factors affecting protein binding, kinetics of protein binding, determination of rate constant and different plots (direct, scatchard and reciprocal), Implication of protein binding on pharmacokinetic parameters. 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. Physiologic pharmacokinetics models: Mean Residence Time; Statistical Moment Theory; Application and limitations of physiologic pharmacokinetic models. Miscellaneous Topics: Chronopharmacokinetics, Drug toxicity and forensic pharmacokinetics, kinetics of maternal-fetal drug transfer, pharmacokinetics v/s pharmacological/ clinical response, metabolic kinetics.	16
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.	
References / Readings:	1. M. Gibaldi, *Biopharmaceutics and Clinical Pharmacokinetics*, 4th edition, Philadelphia, Lea &Febiger, 1991. 2. D.M. Brahmankar& Sunil B. Jaiswal, *Biopharmaceutics and Pharmacokinetics: A Treatise,* Vallabh Prakasan, Pitambura, Delhi, 1998. 3. L Sharjel. & A. B. C. Yu, *Applied Biopharmaceutics and Pharmacokinetics,* 2nd edition, Connecticut, Appleton Century Crofts,	

	1985. 4. J. Swarbrick., Lea &Febiger, *Current Concepts in Pharmaceutical Sciences: Biopharmaceutics,* Philadelphia, 1970. 5. H. M. Abdou, *Dissolution, Bioavailability and Bioequivalence*, Mack Publishing Company, Pennsylvania, 1989. 6. R. E. Notari, *Biopharmaceutics and Clinical Pharmacokinetics-An Introduction*, 4th edition, Marcel Dekker Inc, New York and Basel, 1987. 7. J. G. Wagner and M. Pernarowski, *Biopharmaceutics and RelevantPharmacokinetics*, 1st edition, Drug intelligence Publications, Hamilton, Illionois, 1971. 8. J. Swarbrick, J. C. Boylan, *Encyclopedia of Pharmaceutical Technology*, Vol. I, 2nd edition, Marcel Dekker Inc, New York, 2002. 9. S. K. Niazi, *Textbook of Biopharmaceutics and Clinical Pharmacokinetics*, BSP Books Private Limited, 2010. 10. Niazi, S. K., *Handbook of Bioequivalence Testing*, 1st edition, CRS Press, 2007.
Course Outcome:	1. Students will be able to relate drug absorption to bioavailability. 2. Students will be able to get an in depth knowledge of drug metabolism concept. 3. Students will be able to understand Bioavailability 4. Students will be able to understand Pharmacokinetics

Title of the course: Practical Course in Pharmaceutical Chemistry-III

Course Code: CHH-600

Number of Credits:4

Effective from AY: 2023-24

Prerequisites for the course	Should have studied the courses at M.Sc. Part-I.	
Course Objective:	1.To translate certain theoretical concepts learnt earlier into experimental knowledge. 2.To provide hands-on experience of laboratory techniques required for drugsyntheses, analysis and purification.	
Content	**1. Syntheses of drugs and drug like entities (Minimum 8 experiments of 6h each)** a) Phenothiazine from diphenylamine b) Propranolol from α-Naphthol c) Eosin from Fluorescein d) Gramine from Indole e) 3-Methyl-1-phenyl pyrazolone from phenyl hydrazine f) Schiff base of Antipyrine with p-bromobenzaldehyde g) Methyl Salicylate from Salicylic acid h) Sulphanilamide from p-acetamido benzene sulphanilamide i) Chlorbutanol from acetone j) 1,2,3,4-Tetrahydrocarbazole from cyclohexanone k) 1,5-Benzodiazepine from acetophenone l) Ethyl Nalidixate from 2-amino-6-methylpyridine m) 2-Phenyl Benzothiazole from 2-Amino thiophenol n) 2-Methylbenzimidazole from o-phenylene diammine o) Monastrol from thiourea, ethylacetoacetate and 3-hydroxybenzaldehyde p) Substituted chalcone from 4-chlorobenzaldehyde (Claisen Schmidt condensation)	No of hours 48
	2. Selected experimentsin organic synthesis (Minimum 3 experiments of 4h each) a) p-Iodotoluene from p-toluidine. (Diazotisation) b) Cinnamic acid from benzaldehyde (Perkin reaction) c) Benzanilide from benzophenone (Beckmann Rearrangement) d) Vanillin to Vanillyl alcohol (using $NaBH_4$)	12

	e) Methyl orange from sulphanilic acid (coupling diazotization process) f) Benzhydrol from Benzaldehyde (Grignard reaction)	
	3.Titrimetric assay of the following bulk drug/tablets. (Any 2) Paracetamol, Isoniazid, Dapsone, Metronidazole, Calcium Gluconate	6
	4. Spectrophotometric assay of the following tablets. (Any 2) Allopurinol, Propranolol, p-Aminosalicylic acid	6
	5.Dissolution Experiments (Any 2) Carbamazepine tablets, Diclofenac, Ibuprofen, Isoniazid	8
	6. Quality Control Evaluation of Tablets (1 experiment) Hardness tests, friability testing and disintegration testing to be performed.	4
	7. Chromatographic techniques **a. Thin Layer Chromatography (Any 1)** i. To identify the given drug amongst the Ibuprofen, Aspirin and caffeinecitrate with the help of thin layer chromatography and calculate its Rf value. ii. To identify the given sulpha drug amongst the sulphacetamide, sulphanilamide and trimethoprim with the help of thin layer chromatography and calculate its Rf value. **b. Column Chromatography (Any 1)** i. Salicylic acid and Acetylsalicylic acid ii. p-Aminobenzoic acid and Benzocaine iii. Benzil and Dilantin iv. Salicylaldehyde and 3-Acetyl coumarin c. **HPLC analysis of the following drugs and combination of drugs: (Any 2)** i. Paracetamol ii. Ibuprofen iii. Celecoxib iv. Sulphanilamide v. Diclofenac sodium and Paracetamol in combined	20

	dosage form.	
	8. Identification of following drugs by IR spectroscopy (Any 2) Celecoxib, Antipyrine, Chloramphenicol, Sulphanilamide	4
	9. Drug Design Experiments Use of software packages in chemistry for the following: Towrite a computer program to obtain a slope and intercept forlinear data using least square fit. a. Use of ChemDraw, ISISDraw for drawing structures, chemicalreactions, equations. b. Molecular docking softwares such as Hex software orautodocking. c. Energy minimization of molecules and finding intermolecularinteractions of small molecule with macromolecule such as Coxinhibitor, thymidilate synthase, glycogen synthase, E.Coli protein. **(Any 2)** d. Viewing Tools and Graphics Tools: Rasmol (http://www.umass.edu/microbio/rasmol/) VMD (http://www.ks.uiuc.edu/Research/vmd/) Molscript (http://www.avatar.se/molscript/) e. Determination of log P, MR, hydrogen bond donors and acceptors of selected drugs using softwares. f. 2D based experiments.	12
Pedagogy	Students should be given suitable pre- and post-lab assignments and explanations revising the theoretical aspects of laboratory experiments prior to the conduct of each experiment.	
References /Readings	1. K.A. Connors, Text book of Pharmaceutical analysis, 3rd Ed., Wiley Interscience Publication 1990, 2. J. Bassett, J. Mendhan, R.C. Denny, Vogel's Text Book of Quantitative Chemical Analysis, revised by G.H. Jeffery, 6th Ed., Pearson Education Publication, 2007. 3. Indian Pharmacopoeia., United States Pharmacopoeia, British Pharmacopoeia. European Pharmacopoeia. 4. JEF Reynolds, Martindale, The Extra Pharmacopoeia, The Pharmaceutical Press, London, 1989. 5. M. Jahangir, Pharmaceutical Laboratory Procedures, 1st Ed., New Delhi	

	Cengage Learning India Pvt. Ltd. 2010. 6. A. Kar, Advanced Practical Medicinal Chemistry, New Age International Limited Publishers 2004. 7. A. I. Vogel, A. R. Tatchell, B. S. Furniss, A. J. Hannaford, Vogel's Textbook of Practical Organic Chemistry, 5th Ed., Prentice Hall 2011. 8. N.K. Vishnoi, Advanced Practical Organic Chemistry, South Asia Books, 2010. 9. L. F. Fieser, K. L. Williamson, Organic Experiments, 7th Ed., D. C. Heath, 1992. 10. R. K. Bansal, Laboratory Manual in Organic Chemistry, 5th Ed. New Age International, 2016. 11. S. Delvin, Green Chemistry, Sarup& Sons, 2005. 12. J. Mohan, Organic Analytical Chemistry, Narosa Publishing House, 2014. 13. F. D. King, Medicinal Chemistry: Principles and Practice, Royal Society of Chemistry: Cambridge, 1994. 14. K. V. Raman, Computers in Chemistry, Tata Mc.Graw-Hill, 1993. 15. S. K Pundir, A. Bansal, Computers for Chemists, Pragati Prakashan, 2010. 16. A. Leach, Molecular Modelling, Principles and applications, Longman, 1998.
Course Outcome:	1. Students will be in a position to perform synthesis of drugs. 2. Students will be in a position to understand stoichiometric requirements in drug syntheses. 3.Students will be able to analyse drug spectrophotometrically and chromatographically 4.Students will be able to carry out purification of drug by column separation. 5. Students will be able to apply this knowledge for their dissertation work.

Title of the course: Practical Course in Pharmaceutical Chemistry-IV

Course Code: CHH-601

Number of Credits:4

Effective from AY: 2023-24

Prerequisites for the course	Should have studied the courses at M.Sc. Part-I.	
Course Objective:	1. To translate certain theoretical concepts learnt earlier into experimental knowledge. 2. To provide hands-on experience of laboratory techniques required for drug syntheses, analysis and purification.	
Content	**1. Syntheses of drugs and drug like entities (Minimum 8 experiments of 6h each)** a. 2-Phenylbenzimidazole from o-phenylene diammine and benzoic acid b. 6-Bromo-2-chloro-3-formylquinoline from acetanilide c. Schiff base of Antipyrine with p-Chlorobenzaldehyde d. Sodium benzoate from Salicylic acid e. Sorbic acid from crotonaldehyde f. Barbiturate from diethyl-n-butylmalonate g. Tolbutamide from p-toluene sulphonamide h. 1,4-dihyropyridine from ethylacetoacetate i. 2-MethylBenzothiazole from 2-Amino thiophenol j. Substituted of 2'-hydroxychalcone (Claisen Schmidt condensation) k. Synthesis of azo-stilbene compounds	No of hours 48
	2. Selected experimentsin organic synthesis (Minimum 3 experiments of 4h each) a)Benzhydrol from benzophenone (Reduction) b) p-Iodobenzoic acid from p-aminobenzoic acid (Diazotization) c) 3-Acetylindole from Indole (Friedal Crafts reaction) d)Acetophenone oxime to Acetanilide (Beckmann Rearrangement) e) Enzymatic reduction of ethylacetoacetate using Baker's yeast f) Terephthalic acid from p-xylene (Oxidation process).	12
	3.Titrimetric assay of the following bulk drug/tablets. (Any 2)	6

	Ferrous sulphate, Chlorpheniramine Maleate , Benzyl Penicillin, Phenobarbitone	
	4. Spectrophotometric assay of the following tablets. (Any 2) Chloroquine phosphate (CHP) Zolmitriptan. Promethazine HCl, Indomethacin,	6
	5.Dissolution Experiments (Any 2) Saccharin, Celecoxib, Chlorpheniramine maleate, Chloramphenicol	8
	6. Quality Control Evaluation of Capsules (1 experiment) Hardness tests, friability testing and disintegration testing to be performed.	4
	7. Chromatographic techniques **a) Thin Layer Chromatography (Any 1)** i. i) To identify the given drug amongst the paracetamol, acetanilide, and caffeine citrate with the help of thin layer chromatography and calculate its Rf value. ii. To identify the given sulpha drugs amongst the Dapsone, sulphaacetamide and trimethoprim with the help of thin layer chromatography and calculate its Rf value. **b) Column Chromatography (Any 1)** i. Benzil and Benzilic acid ii. Glycine and Hippuric acid iii. o-phenylene diamine and 2,3-diphenylquinoxaline iv. Salicylaldehyde and coumarin **c) HPLC analysis of the following drugs: (Any 1)** i. Methyl Dopa ii. Sulphaacetamide iii. Paclitaxel	20
	8. Identification of following drugs by IR spectroscopy (Any 2) Benzocaine, Caffeine, Phenytoin, Suphaacetamide	4
	9. Drug Design Experiments Use of software packages in chemistry for the following: Towrite a	12

	computer program to obtain a slope and intercept forlinear data using least square fit. a. Use of ChemDraw, ISISDraw for drawing structures, chemicalreactions, equations. b. Molecular docking softwares such as Hex software orautodocking. c. Energy minimization of molecules and finding intermolecularinteractions of small molecule with macromolecule such as Coxinhibitor, thymidilate synthase, glycogen synthase, E.Coli protein. **(Any 2)** d. Viewing Tools and Graphics Tools: Rasmol (http://www.umass.edu/microbio/rasmol/) VMD (http://www.ks.uiuc.edu/Research/vmd/) Molscript (http://www.avatar.se/molscript/) e. Determination of log P, MR, hydrogen bond donors and acceptors of selected drugs using softwares. 2D based experiments.	
Pedagogy	Students should be given suitable pre- and post-lab assignments and explanations revising the theoretical aspects of laboratory experiments prior to the conduct of each experiment.	
References /Readings	1. 1. K.A. Connors, Text book of Pharmaceutical analysis, 3rd Ed., Wiley Interscience Publication 1990. 2. 2. J. Bassett, J. Mendhan, R.C. Denny, Vogel's Text Book of Quantitative Chemical Analysis, revised by G.H. Jeffery, 6th Ed., Pearson Education Publication, 2007. 3. 3.Indian Pharmacopoeia., United States Pharmacopoeia, British Pharmacopoeia. European Pharmacopoeia. 4. 4. J.E.F. Reynolds, Martindale, The Extra Pharmacopoeia, The Pharmaceutical Press, London, 1989. 5. 5. M. Jahangir, Pharmaceutical Laboratory Procedures, 1st Ed., New Delhi Cengage Learning India Pvt. Ltd. 2010. 6. 6.A. Kar, Advanced Practical Medicinal Chemistry, New Age International Limited Publishers 2004. 7. 7. A. I. Vogel, A. R. Tatchell, B. S. Furniss, A. J. Hannaford, Vogel's Textbook of Practical Organic Chemistry, 5th Ed., Prentice Hall 2011. 8. 8. N.K. Vishnoi, Advanced Practical Organic Chemistry, South Asia Books,	

	2010. 9. 9. L. F. Fieser, K. L. Williamson, Organic Experiments, 7th Ed., D. C. Heath, 1992. 10. R. K. Bansal, Laboratory Manual in Organic Chemistry, 5th Ed. New Age International, 2016. 11. S. Delvin, Green Chemistry, Swarup & Sons, 2005. 12. J. Mohan, Organic Analytical Chemistry, Narosa Publishing House, 2014. 13. F. D. King, Medicinal Chemistry: Principles and Practice, Royal Society of Chemistry: Cambridge, 1994. 14. K. V. Raman, Computers in Chemistry, Tata Mc.Graw-Hill, 1993. 15. S. K Pundir, A. Bansal, Computers for Chemists, Pragati Prakashan, 2010. 16. A. Leach, Molecular Modelling, Principles and applications, Longman, 1998.
Course Outcome:	1. Students will be in a position to perform synthesis of drugs. 2. Students will be in a position to understand stoichiometric requirements in drug syntheses. 3. Students will be able to analyse drug spectrophotometrically and chromatographically 4. Students will be able to carry out purification of drug by column separation. 5. Students will be able to apply this knowledge for their dissertation work.

Title of the course: Retrosynthetic Approach and Heterocyclic Drug Synthesis

Course Code: CHH-604

Number of Credits:4

Effective from AY: 2023-24

Prerequisites for the course	Students should have studied Pharmaceutical Chemistry courses at M.Sc. Part-I.	
Course Objective:	1. To apply the knowledge gained in organic synthesis for making new molecules. 2. To understand various strategies involved in retrosynthesis of organic molecules 3. To understand the concepts of heterocyclic chemistry in drug designing 4. To be able to propose routes for synthesis of heterocycles	
Content	**1. Synthon approach and retrosynthetic applications** a. Basic principles, terminologies and advantages of retrosynthesis; guidelines for dissection of molecules. Functional group interconvertion and addition (FGI and FGA) b. C-X disconnections; C-C disconnections – alcohols and carbonyl compounds; 1,2-, 1,3-,1,4-, 1,5-, 1,6-difunctionalized compounds c. Strategies for synthesis of three, four, five and six-membered ring. (*General review problems to be discussed for above approaches*)	No of hours 12
	2. Disconnection strategies a. Disconnection of heteroatom and heterocyclic compounds such as ethers, amines, heterocycles, amino acids b. Convergent and divergent synthesis c. Strategic devices for carbon-heteroatom bonds, polycyclic compounds: the common atom approach d. Considering all possible disconnections e. Alternative FGI's before disconnection- the cost of synthesis f. Features which dominate strategy, functional group addition and molecules with unrelated functional groups	12
	3. Protecting groups a. Role of protection in organic synthesis	12

	b. Protection for the hydroxyl group, including 1,2-and1,3-diols: as ethers, esters, carbonates, cyclic acetals & ketals c. Protection for the carbonyl group: as acetals and ketals d. Protection for the carboxyl group: as amides and hydrazides, esters e. Protection for the amino group: as carbamates and amides.	
	Heterocyclic Chemistry: Introduction, classification and nomenclature of mono- and bicyclic heteroaromatic molecules. Organic Name reactions with their respective mechanism and application involved in synthesis of drugs containing five, six membered and fused heterocyclics such as Debus-Radziszewski imidazole synthesis, Knorr Pyrazole Synthesis Pinner Pyrimidine Synthesis, Combes Quinoline Synthesis, Bernthsen Acridine Synthesis, Smiles rearrangement and Traube purine synthesis.	12
	5. Synthesis of representative drugs with retrosynthetic approach Retrosynthetic approach and synthesis of few representative drugs containing these heterocyclic nucleus such as Metronidazole, Miconazole, Celecoxib, Alprazolam, Triamterene, Sulfamerazine, Trimethoprim, Hydroxychloroquine, Quinacrine, Prochlorpherazine, Chlorpromazine, Theophylline, Mercaptopurine and Thioguanine.	12
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.	
References / Readings	1. S. Warren, *Designing Organic Synthesis*, John Wiley & Sons, 2009. 2. G. S. Zweifel, M. H. Nantz, P. Somfai, Modern *Organic Synthesis: An Introduction*, 3rd Ed. W. H. Freeman and Company, New York, 2022. 3. J. Clayden, N. Greeves & S. Warren, *Organic Chemistry*, Oxford, 2016. 4. J. A. Joule, K. Mills & G. F. Smith, *Heterocyclic Chemistry*, 3rd Ed., Wiley-Blackwell, 1995. 5. J. A. Joule & K. Mills, *Heterocyclic Chemistry*, 5th Ed., Wiley-Blackwell, 2010. 6. T. L. Gilchrist, *Heterocyclic Chemistry*, Pitman Publishing, 2005. 7. R. M. Acheson, *An Introduction to Chemistry of Heterocyclic Compounds*, 3rdEd., John Wiley and Sons, 1977. 8. D. W. Young, *Heterocyclic Chemistry*, Longman Group Ltd., London, 1975.	

	9. A. Weissberger & E. Taylor, *Chemistry of Heterocyclic Compounds*,Vol.47,Wiley Publishers, 1987. 10. A. R. Katritzky, *Advances in Heterocyclic Chemistry*, 1st Ed., Academic Press Inc., Vol.47,1990. 11. R. O. C. Norman and J. M. Coxon. *Principles of Organic Synthesis*, 3rd Ed., CRC Press,2009. 12. Stephen R Wilson & Anthony W Czarnik, *Combinational Chemistry – Synthesis and applications*, Wiley – Blackwell, 1997. 13.V.K Ahluwalia and R. Agarwal, *Organic Synthesis - Special Techniques,* Narosa Publishers, 2001. 14. D. Shriram, P. Yogeshwari, Medicinal Chemistry, Pearson Education, 2007. 15. D. Lednicer& L.A. Mitcher*Organic Chemistry of Drug Synthesis* Vol. I to III. John Wiley & Sons, 2005. 16. Drug Preparation Database.http://www.drugfuture.com/synth/synth_query.asp
Course Outcome:	1.Students will be in a position to understand how a carbon-carbon bond can be constructed and/or cleaved 2.Students will be in a position to understand how retrosynthesis can be used in finding out easily available chemical precursors for making molecules 3.Students will be in a position to apply retrosynthetic strategies and propose routes for synthesis of containing heterocycles 4.Students will be able to understand and apply the concepts of the reactivity of heterocycles towards electrophilic, nucleophilic, reducing and oxidizing reagents. 5.Students will be able to apply this knowledge for their dissertation work.

Title of the course: Research Methodology in Pharmaceutical Chemistry and instrumental techniques

Course Code: CHH-605

Number of Credits:4

Effective from AY: 2023-24

Prerequisites	Students should have studied chemistry courses at MSc-I.	
Course Objective:	1.To introduce various aspects of research methodology. 2.To provide understanding ethics & scientific conduct 3. To introduce academic writing 4. To introduce databases used in chemistry 5.To provide understanding and importance of lab safety. 6.To understand the usefulness of various instrumental techniques in characterization of chemical compounds. 7.To provide knowledge about tissue culture for pharmacological screening methods.	
Content	**Unit 01: Introduction to Research Methodology** a. Research- meaning, objectives, motivation, types and methodology. Process- formulating the research problem; literature survey; developing the hypothesis and the research design; sample design and collection of the data; execution of the project; analysis of data; testing of hypothesis; generalizations and interpretation, and preparation of the report or presentation of the results & conclusions.	No of hours **5**
	Unit 02: Scientific conduct and ethics a. Ethics: definition, nature of moral judgements and reactions, Ethics with respect to science and research b. Intellectual honesty and research integrity c. Scientific misconducts: Falsification, Fabrication, and Plagiarism (FFP) d. Redundant publications: duplicate and overlappingpublications e. Selective reporting and misrepresentation of data	**5**
	Unit 03. Academic writing a. Publication ethics: definition, introduction and importance b. Conflicts of interest	**5**

	c. Publication misconduct: definition, concept, problems that lead to unethical behaviour and vice versa d. Violation of publication ethics, authorship and contributorship e. Identification of publication misconduct, complaints and appeals f. Predatory publishers and journals	
	Unit 04. Data bases and research metrics Databases: 1. Indexing databases 2. Citation databases: Web of Science, Scopus, UGC-Care List etc. Research Metrics: 1. Impact Factor of journal as per Journal Citation Report, SNIP, SJR, IPP, Cite Score 2. Metrics: h-index, g index, i10 index etc	**3**
	Unit 06. Safety in Chemistry a. Good laboratory practices. b. Handling of various chemicals, solvents & glassware. c. Fires and fighting with fires. d. Hazardous substances, classification and handling e. Safety Data Sheet	**5**
	Unit 06. Softwares in Chemistry a. Data plotting b. Structure Drawing c. Molecular docking softwares	**7**
	5. Instrumental methods of analysis: Demonstration and/ or data analysis in following techniques. a. Elemental analysis: CHNS analysis and AES b. Infrared (IR), Raman, Ultraviolet-Visible (UV-Vis) c. Nuclear magnetic resonance (^{1}H, ^{13}C) d. Chromatographic techniques: HPLC, GC, e. Hyphenated Techniques: LC-MS & GC-MS, f. Diffraction methods: XRD g. Thermal analysis: DSC	**20**
	6. Animal Tissue Culture for pharmacological screening a. Basic concepts b. Laboratory safety and Biohazards c. Role of media components d. Handling and storage of cell lines e. Cell culture technique	**10**

	f. Types of cell culture system	
Pedagogy	Mainly lectures/recorded video lectures/ tutorials, discussions, seminars, internal exams/ assignments, / demonstration/ self-study or a combination of some of these. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning.	
References / Readings	1. C.R. Kothari. Research Methodology: Methods & Techniques New Age International Pvt. Ltd., 2004. 2. Bird, A. Philosophy of Science. London:Routledge. 2006. 3. Anne M. Coghill &Lorrin R. Garson, The ACS Style Guide: Effective Communication of Scientific Information, OXFORD University press 2006. 4. Y K Singh Fundamentals of Research Methodology & Statistics, New Age International Pvt. Ltd., 2006. 5. Prudent practices in the laboratory: handling and management of chemical hazards, The National Academies Press, USA, 2011. 6. B.S. Furniss, A.J. Hannaford, V. Rogers, P.W.G. Smith & A. R. Tatchell. Vogel's Textbook of Practical Organic Chemistry, 5th Ed., ELBS London, 2007. 7. E.A. V. Ebsworth, D. W. H. Rankin & S. Craddock, Structural Methods in Inorganic Chemistry, ELBS, 1987. 8. R.S. Drago. Physical Methods in Chemistry,W. B. Saunders Company, 2016. 9. R. M. Silverstein, G. C. Bassler& T.C. Morrill, Spectrometric Identification of organic Compounds, 5th Ed., John Wiley 1991 10. J. Mendham, R.C. Denny, J. D. Barnes & M. Thomas, Vogel's Textbook of Quantitative Chemical Analysis 6th Ed., Pearson Education Asia, Delhi, 2002. 11. H. V. Keer, Principles of the Solid State new Age International, 1994 12. G.D. Christian, Analytical Chemistry, 6th Ed., Wiley, 2004. 13. D. A. Skoog, D. M. West, F. J. Holler & S. R. Crouch. Fundamentals of Analytical Chemistry Cengage learning 9th Ed., 2013. 14. D. A. Skoog, F. J. Holler & S. R. Crouch. Principles of Instrumental Analysis,7th Ed., Cengage learning 2017 15. D. Pavia, G. Lampman, G. Kriz& J. Vyvyan, Introduction to Organic Spectroscopy 5th Ed, Cengage Learning, 2015. 16. V. Rajaraman, Computer Programming in Fortran 90 And 95, PHI Learning Pvt. Ltd., 2013. 17. A. Szabo & N. S. Ostlund, Modern Quantum Chemistry Introduction to Advanced Electronic Structure Theory, Dover Publications, Inc. Mineola,	

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Course Outcome:	1. Students will be able to apply the concepts of research methodology during their research work. 2. Students will be able to apply computer technology to solve their research problems in chemistry. 3. Students will know in advance the safety precautions to be taken in the chemical lab. 4. Students will gain fundamental knowledge on characterization techniques. 5. Students will acquire adequate knowledge on animal tissue culture.

Title of the course: Polymers in Pharmaceuticals and novel drug delivery systems

Course Code: CHH-621

Number of Credits:4

Effective from AY: 2023-24

Prerequisites for the course	Students should have studied the courses in M.Sc. Part I.	
Course Objective:	1. To learn classification synthesis and properties of polymers. 2.To learn the role of polymers in drug delivery systems. 3.To learn new innovations in drug delivery systems	
Content	**1. Brief history of natural and synthetic polymers** Classification & nomenclature of polymers, functionality concept-linear, -branched and -cross linked polymers. Introduction to biodegradable polymers:General methods of synthesis, properties, mechanism of biodegradation in the body.Analytical methods for monitoring biodegradation processes of environmentally degradable polymers. Characterization and evaluation of biodegradable polymers.	No of hours 8
	2. Introduction to Novel drug delivery systems Foundations of drug delivery in a conceptual and mathematical context. Drug deliverycarriers, routes of administration.Recent developments in responsive polymers, polymer therapeutics, and advanced systems designed for molecular recognition or engineered for intracellular delivery of novel therapeutics.Polymeric devices for drug delivery systems: Diffusion-controlled (monolithic devices), solvent-activated (swelling- or osmotically-controlled devices), chemically controlled (biodegradable), or externally-triggered systems (e.g., pH, temperature).	10
	3. Types of polymers for novel drug delivery systems Poly lactic-co-glycolic acid (PLGA), PGA(poly glycolic acid), Polyglutamic acid (PGA) , Polylactic acid, PNIPAAm [Poly(N-isopropylacrylamide)], pHEMA[Poly 2-hydroxyethyl methacrylate], PPy [Polypyrrole], PAMAM [Poly (amidoamine)], DEXTRAN.	8
	4. Types of drug delivery systems Theory of controlledrelease drug delivery systems. Microencapsulation – Methods ofencapsulation. Transdermal	8

	drug delivery systems – Theory,formulation, production and evaluation. Targeted drug deliverysystems – concept of drug targeting, importance in therapeutics.	
	5.**Advanced biopolymeric systems for drug delivery** Critical Points in Biopolymeric-Controlled Release Matrix Systems, Biopolymeric Gels in Drug Delivery, In Situ Polymeric Gels for Topical Drug Delivery, Smart Polysaccharide Hydrogels in Drug Delivery and Release, Polysaccharide-Based Nanoparticles: Nanocarriers for Sustained Delivery of Drugs, Polysaccharide-Based Nanocarriers for Oral Delivery of Insulin in DiabetesLiposomes and Dendrimers for Advanced Drug Delivery, Marine Polysaccharides Systems for Drug Delivery applications.	14
	6.**Recent Innovations in polymeric drug delivery systems and its applications** Recent innovations in conventional dosage form like tablets, capsules, sterile dosage forms, pellets, Mucoadhesive system, GRDDS, peptide drug delivery, supercritical fluid technique, PEGylation, Nanoparticulate drug delivery. Sustained In Vitro and In Vivo Delivery of Metformin from Plant Pollen-Derived Composite MicrocapsulesPolymeric Hydrogels for Controlled Drug Delivery to Treat ArthritisAdvancements in Rectal Drug Delivery Systems: Clinical Trials, and Patents Perspective. Future opportunities and challenges.	12
Pedagogy	Lectures/ tutorials/ project work/ industry visits/viva/seminars/ term papers/assignments/ presentations/ self-study/Case Studies etc. or a combination of some of these. Sessionshall be interactive in nature to enable peer group learning.	
References / Readings	1. V. R. Gowarikar, N.V. Vishwanathan, J. Sreedhar, Polymer Science, New Age International, 2015. 2. J. R. Fried, Polymer Science and Technology, PHI Pvt. Ltd.,2000. 3. R. Sinha, Outlines of Polymer Technology: Manufacture of Polymers, PHI Pvt Ltd., 2000. 4. K. Y. Saunders, Organic Polymer Chemistry, Chapman and Hall, UK, 1976. 5. H. R. Kircheldorf, Handbook of Polymer Synthesis, PART A and B, Marcel Dekkar Inc., 1992. 6. R. P. Brown, Handbook of Plastic Test Methods, 2nd Ed.,George Godwin Ltd., 1981.	

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	Synthesis, Characterization and Applications, 1st Ed., Wiley Publishers, 2011. 29. V. V. Ranade & J. B. Cannon, Drug Delivery Systems, 3rd Ed., CRC Press, 2011. 30. A.K. Nayak & Md. S. Hasnain, Advanced Biopolymeric Systems for Drug Delivery, 1st Ed., Springers, 2020. 31. V.A. Guerrera, Innovative Polymers for controlled drug delivery, Pharmaceutics, 1st Ed., Vol.14, Multidisciplinary Digital Publishing Institute, 2022.
Course Outcome:	1. Students will be able to identify the type of polymers that can be used for drug delivery systems. 2. Students will be able to get the knowledge of innovative drug delivery systems and apply it for their lab project. 3. Students will be able to understand the Advanced biopolymeric systems for drug delivery 4. Students will be able to understand the new innovations in drug delivery systems

Title of the course: Pharmacotherapeutics

Course Code: CHH-622

Number of Credits:4

Effective from AY: 2023-24

Prerequisites for the course	Students should have studied the courses in M.Sc. Part I.	
Course Objective:	1. To enable the students to understand the different approaches to treat and manage various disease conditions. 2. To impart knowledge and skills in optimizing drug therapy of a patient by personalizing the treatment. 3. To summarize the therapeutic approach for management of various diseases. 4. To explain the rationale for drug therapy andplan through evidence-based medicines.	
Content	**1. Diseases of central nervous system**: Epilepsy, Parkinson's disease, Stroke, Headache, Alzheimer's disease, Neuralgias and Pain pathways and Pain management. Psychiatric disorders: Schizophrenia, Depression, Anxiety disorders, Sleep disorders, drug induced psychiatric disorders.	No of hours 10
	2. Infectious diseases: General guidelines for the rational use of antibiotics and surgical prophylaxis, urinary tract infections, respiratory tract infections, Gastroenteritis, tuberculosis, malaria, bacterial endocarditis, septicemia. meningitis, HIV and opportunistic infections, rheumatic fever, dengue fever, H1N1, helmenthiasis, fungal infections. Neglected tropical diseases: leishmaniasis, schistosomiasis, chagas, sleeping sickness.	10
	3. Diseases of cardiovascular and respiratory system: Hypertension, Congestive cardiac failure, Acute coronary syndrome, Arrhythmias, Hyperlipidemias, Asthma, Chronic obstructive airways disease, Drug induced pulmonary diseases.	10
	4. Diseases of gastrointestinal system: Peptic ulcer diseases, Reflux esophagitis, Inflammatory bowel diseases, Jaundice & hepatitis, Cirrhosis, Diarrhoea and Constipation, Drug-induced liver disease.	10
	5.Oncologicaldisorders: General principles of cancer chemotherapy, pharmacotherapy of breast cancer, lung cancer,	8

	head & neck cancer, hematological malignancies, management of nausea and vomiting, Palliative care.	
	6. Other Diseases Bone and joint disorders: Rheumatoid arthritis, osteoarthritis, gout, osteoporosis. Dermatological Diseases: Psoriasis, eczema and scabies, impetigo, drug induced skin disorders. Ophthalmology: Conjunctivitis, glaucoma. Diseases of renal system: Acute renal failure, chronic renal failure, renal dialysis, drug induced renal disease. Gynaecological disorders: Dysmenorrhea, hormone replacement therapy. Endocrine system: Diabetes Mellitus, thyroid diseases. Hematological diseases: Anaemia, deep vein thrombosis, drug induced hematological disorders.	12
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.	
References / Readings	1. R. Walker. Clinical Pharmacy and Therapeutics, 5th Ed., Churchill Livingstone publication, 2012. 2. J. DiPiro, Pharmacotherapy: A Pathophysiologic Approach, 7th Ed., McGraw Hill Publishers 2008. 3. S.L.Robins, Pathologic basis of disease., 9th Ed., W.B. Saunders publication 2014. 4. E. T. Herfindal. Clinical Pharmacy and Therapeutics, 3rd Ed., Lippincott Williams and Wilkins Publication, 1984. 5. L.Young and M.A. Koda-Kimble, Applied Therapeutics: The clinical Use of Drugs, 9th Ed., Lippincott Williams and Wilkins, 2008. 6. C.B. Wells, S. Malone and J. P. Dipiro. Pharmacotherapy Principles and practice, 4th Ed., McGraw Hill Publication. 2016. 7. C. M. Porth. Principles of Pathophysiology, 3rd Ed., Lippincott Williams and Wilkins Publications, 2010. 8. Harrison's Principles of Internal Medicine. (Vol1 and 2), 20th Ed., McGraw Hill Publications, 2018. 9. R. Mannhold& H. Buschmann, Neglected Tropical Diseases Drug Discovery and Development, Vol 37, John Wiley and Sons, 2019. 10. P. Hotez, Neglected Tropical Diseases, Vol 1-5(book series), Springers, 2022.	

Course Outcome:	1. Students will be able to discuss the clinical controversies in drug therapy. 2. Students will be able to identify the patient specific parameters relevant in initiating drug. 3. Students will be able to prepare individualized therapeutic plans based on diagnosis, medicine therapy, and monitoring therapy. 4. Students will be able understand various infectious and non-infectious diseases.

Title of the course: API Process, Manufacture and Green Chemistry

Course Code: CHH-623

Number of Credits:4

Effective from AY: 2023-24

Prerequisites for the course:	Should have studied courses at M.Sc. Part-I.	
Course Objective:	1. To learn about the selected drugs. 2. To learn about the role of process chemistry. 3. To understand the process research and development of PenicillinG CAS and Rabeprazole CAS 4. To understand the drug optimization and drug discovery. 5. To understand various concepts involved in green synthesis. 6. To understand green technologies used in chemistry. 7. To learn application of green chemistry approaches to pharmaceutical industry.	
Content	**1.Process chemistry in pharmaceutical industry –** Background of process chemistry – role of process chemistry. Strategy of process research & development in pharma industry. Case studies: A practical synthesis of Ifetrobansodium. Synthesis of 5-lipoxygenase inhibitors Chemistry of Vitamin D: A challenging field for process researchDilevalol Hydrochloride: Development of a commercial processThe process research and development of DuPont Merck's cyclic urea diols, anew class of HIV protease inhibitors. Process research and development of PenicillinG CAS Reg. No.[61-33-6] (antibacterial); Fosinopril CAS Reg. No.[98048-97-6](antihypertensive) ; Combinatorial chemistry: Introduction – Drug Optimization – Drug discovery – Solid Phase Technique – parallel synthesis – Mixed Combinatorial Synthesis.	No of hours 12
	2.Biocatalysis, phase transfer catalysis, asymmetric synthesis and polymorphism: Biocatalysis and Engineering: An interdisciplinary approach to the manufacture of the Benzodiazepine drug candidate LY 300164. Application of phase transfer catalysis technology in pharmaceutical industry for drug synthesis. Asymmetric Synthesis and Enantioselectivity: Enantioselective synthesis of chiral 2-hydroxycarboxylic acids and esters – asymmetric catalysis –eg.asymmetric	12

	hydrogenation – L-Dopa process ;Sharpless asymmetric epoxidations eg.synthesis of Fluoxetine enantiomers. Chiral (Salen)Mn(III) Complexes in asymmetric epoxidations: Practical Synthesis of cis-Aminoindanol and its application to enantiopure drug synthesis. Practical Enantio- and Diastereo-selective Processes for Azetidinones. Polymorphism – solid state – crystallization – recrystallization of drug molecules eg.isolation techniques and characterization of polymorphs of Venlafaxine hydrochloride[99300-78-4] Clopidogrelbisulphate [135046-48-9] and Lorazepam[846- 49-1] (any two).	
	3. Chemical Process safety norms: Concept of Green Chemistry, its 12 principles and Green Chemistry Metrics. Introduction, industrial disasters of the world, definition of green chemistry, twelve green principles, Need for green chemistry in pharmaceuticals, green chemistry for better sustainability. Green Chemistry metrics for measuring greenness (E-factor, atom economy, mass intensity, process mass intensity, process mass efficiency, chemical yield). Waste prevention, management andhierarchy. Atom Economy: Calculation and predicting greenness of a reaction. Comparison of Diels Alder reaction and Wittig Reaction. Addition v/s Elimination v/s Substitution. Less hazardous chemical synthesis: Avoiding use of hazardous substances for any synthesis (Thiamine hydrochloride to be preferred over KCN for benzoin condensation). Role of chirality in the need for designing safer chemicals with illustration of Thalidomide.	8
	4. Safer solvents in chemistry. Knoevenagel condensation by grinding method. Advantages and disadvantages of solvent-free reaction. Water as green solvent in organic synthesis (Diels Alder Reaction). In water and on water mechanisms. Ionic liquids as designer solvents with one application. Supercritical solvents and their application in extractions. Deep Eutectic solvent (DES) with example and one application. Fluorous solvents and biphasic extraction.	8
	5. Emerging greener technologies for energy efficiency and catalysis	10

	Organic synthesis at ambient temperature and pressure, photochemical reactions as green process (advantages). Microwave assisted organic synthesis: Principle and applications. Sonochemistry as a sustainable alternative for organic synthesis, giving examples. Electrifying organic synthesis in designing new target molecules. Continuous flow synthesis as a sustainable technology for pharmaceutical industry. Impact of continuous flow chemistry in the synthesis of naturalproducts and active pharmaceutical ingredients. Recent examples of green chemistry articles of interest to the pharmaceutical industry: C-H activation, green fluorination, continuous processing and process intensification.	
	6. Green Synthesis of representative drugs Multicomponent synthesis: Ugi, Biginelli, Passerni, Mannich, Strecker. One-Pot Synthesis of (S)-Baclofen.Synthesis of Ibuprofen, Boots (conventional) and green synthesis. Comparison and atom economy. Green synthesis of Paracetamol, Aspirin, Celecoxib, Sildenafil citrate, Sertraline, Artemisinin, Paroxetine, Pregabalin, Imatinib, Simvastatin, Quinapril HCl.	10
Pedagogy	Mainly lectures and tutorials. Seminars / term papers /assignments / presentations / industry visits/field trips/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.	
References / Readings	1. M. Lancaster, Green Chemistry, The Royal Society of Chemistry, Cambridge,UK, 2002. 2. V. K. Ahluwalia, Green Chemistry: Environmentally Benign Reactions, Ane Books India, New Delhi, 2006. 3. A. S. Matlack, Introduction to Green Chemistry, Marcel Dekker, Inc., New York, 2001. 4. P. T. Anastas and T. C. Williamson, Green Chemistry: Frontiers in benign chemical synthesis and processes, Oxford University Press, Oxford, Eds. 1998. 5. R. Sanghi and M. M. Srivastava, Green Chemistry: Environment Friendly Alternatives, Narosa Publishing House, Eds. New Delhi, 2007. 6. Samuel Delvin, Green Chemistry, IVY Publishing House, Delhi, 2006. 7. V. K. Ahluwalia and M. Kidwai, New Trends in Green Chemistry, 1st Ed., Anamaya Publishers, New Delhi, 2004.	

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	hydroxychloroquine, J. Org. Chem. 2018, 14, 583– 592. 24. R. Porta, M. Benaglia, & A. Puglisi. Flow Chemistry: Recent Developments in the Synthesis of Pharmaceutical Products. Org. Process Res. Dev. 2016, 20, 2−25. 25. K. G. Gadamasetti, Process chemistry in the pharmaceutical industry, 1st Ed., Taylor and Francis, 1999. 26. K. G. Gadamasetti, Process chemistry in the pharmaceutical industry: Challenges in an everchanging climate, 2nd Ed., Taylor and Francis, 2019.
Course Outcome:	1. Students will be able toacquire knowledge about the Top drugs. 2. Students will be to learn about the role of process chemistry and understand the Process research and development of PenicillinG CAS and Rabeprazole CAS 3. Students will be able to understand the drug optimization and drug discovery. 4. Students will be in a position to understand how chemistry can be done using greener alternatives. 5. Students will be able to apply green technologies as a sustainable solution for making drug molecules. 6. Students will be able to understand and apply the concepts of green chemistry to develop scalable processes in industry.

Title of the course: Pharmaceutical and Spectral Analysis

Course Code: CHH-624

Number of Credits:4

Effective from AY: 2023-24

Prerequisites for the course	Students should have studied the courses in M.Sc. Part I.	
Course Objective:	1. To study the advanced pharmaceutical analytical techniques. 2. To acquire the knowledge of theory and practical skills of instruments. 3. To understand and interpret the spectral data.	
Content	**1. Introduction to pharmaceutical analysis and techniques**: Scope and range of modern pharmaceutical analysis. Listing of various pharmaceutical analytical techniques, with broad discussion on their instrumentation, working and pharmaceutical applications: HPLC, GC, HPTLC, DSC-DTA, XRD. Material and product specifications: Definition of specifications, study of ICH Q6 guidelines and understanding of specifications through study of pharmacopoeial monographs on drug substances and products. Reference standards used: Types (primary, secondary, working and test standards), preparation, containers, labelling, storage and use. Documentation of analytical data-STPs, certificate of analysis, laboratory books: Typical documents used in a GLP laboratory including standard test protocols, COA and laboratory notebooks. Electronic records & signatures (21CFR Part-11 requirement)	No of hours 10
	2. Calibration and Validation: Method validation: Definition and methodology, discussion on each parameter with examples, special considerations in bioanalytical method validation. Calibration and qualification of equipment: Difference of definitions, calibration standards, calibration frequency, examples of calibration of pH meter, potentiometer, Flame photometer, FTIR, UV spectrophotometer and HPLC. Definition of qualification process involving URS [user requirement specification], DQ, IQ, OQ, CQ and PQ.	10
	3. Quality and risk management in analytical laboratory: Definition of quality risk management in ICH Q9 guideline. Its	8

	importance and application to analytical laboratory with examples. Quality of analysis by design. Impurity profiling: Types of impurities in drug substances and products. Method development for impurity analysis, techniques, identification and quantization. Management of analytical laboratory: Organization of laboratories based on their types, staffing, skill development and training, budgeting and financing, purchase of costly equipment, qualities of laboratory manager and management styles. Laboratory inspections and audit: Internal inspection, external audit, concepts, preparing for inspections and audits.	
	4. Spectral Analysis-I **i) Ultra Violet (UV)-visible spectroscopy and its pharmaceutical applications**: a) Electronic excitations, Beer Lamberts Law, predicting UV absorption using Woodward-Fieser, Fieser-Kuhn and Nelson rules; Calculation of λmax for β-Carotene, Lycopene, Piperine, Curcumin, Factors affecting UV spectra Non-conjugative effect, solvent effect, S-Cis band. Types of UV spectroscopic analytical techniques with illustrative examples: Simultaneous equation method: Paracetamol and Diclofenac sodium, Norfloxacin and Tinidazole,Quercetin, curcumin, and piperine. Difference spectrophotometric method:Leflunomide, Pioglitazone and metformin. Derivative spectrophotometric method: Quantitative assay of Diazepam. Variants of derivative spectroscopy: Ratio derivative: Successive ratio derivative spectra method, absorption ratio method with application. **ii) Infrared (IR)spectroscopy**: Principle of Infra Red spectroscopy, Hooke's Law, types of vibrations, Correlation of structure with IR spectra: Influence of substituents, ring size, hydrogen bonding, vibrational coupling and field effect on frequency. Applications: Identification of functional groups in the following drugs:Acyclovir, Chloroquine, Mebendazole, Ethambutol, Metronidazole,Dapsone, Cis-Platin, Ibuprofen, Chloramphenicol, Lidocaine, Aminohippuric acid, Theophylline, Determination of stereochemistry-Ethambutol and Methyl Dopa. Spectral interpretation with examples. Problem solving of UV and IR for structure elucidation.	12
	5.Spectral Analysis-II **Nuclear Magnetic Resonance (NMR) spectroscopy**: Principle of	14

	proton NMR spectroscopy,chemical shift-shielding and deshielding effect, magnetic anisotropic effect, TMS as reference standard, spin-spin splitting-coupling constant, NMR solvents and their residual peaks. Interpretation of NMR spectra of some compounds and drugs (Ibuprofen, Metronidazole, Morphine, Chloramphenicol, Isoniazid, Mebendazole, Lidocaine, 2-methylbenzothiazole, benzoxazole, pyrimidine,2-phenylbenzminidazole).^{13}C-NMR, correlation of structure with spectra: Chemical environment, shielding and carbon-13 chemical shift, calculation, proton-coupled Carbon Spectra, Protondecoupled Cspectra, Nuclear Overhauser Enhancement (NOE), Distortion less Enhancement by Polarization Transfer (DEPT), Heteronuclear coupling for carbon to deuterium, carbon to ^{19}F, carbon to ^{31}P.Fluorine chemical shift Anisotropy and exchange for Screening (FAXS). Three Fluorine Atoms for Biochemical Screening (3-FABS). NMR for Lead optimization and SAR studies. Explanation of spectra of some compounds and drugs. (Fluconazole, Thiotepa, Chlorphenaramine, Dapsone, Nitrogen mustard) NMR problem solving for structure elucidation.	
	6.Mass spectrometry (MS): Molecular ion and metastable peak, fragmentation patterns, nitrogen and ring rules, McLafferty rearrangement, electron and chemical ionization modes, applications. Mass spectra of any 2 drugs. (Combined UV, IR, NMR, Mass Problems for structure elucidation)	6
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.	
References / Readings	1. F. Rouessac& A. Rouessac, Chemical Analysis: Modern Instrumentation Methods and Techniques, 2nd Ed., Wiley Publishers, 2013. 2. M. Valcarcer, Principles of Analytical Chemistry, 2000th Ed., Springers, 2012. 3. M. E. Swartz& I. S. Krull, Analytical Method Development and Validation, 1st ed., 1997, CRC Press. 4. J. P. Seiler, Good Laboratory Practices, Springer, 2001. 5. D. A. Skoog, F. J. Holler & T. A. Nineman, Principles of Instrumental	

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Course Outcome:	1. Students will be able understand various pharmaceutical analytical techniques. 2. Students will be able to apply this knowledge to various pharmaceutical industries. 3. Students will be able to explain all characterization techniques for pharmaceutical products. 4. Students will be able to analyse spectral data.

Title of the course: Bioorganic and Medicinal Chemistry

Course Code: CHH-625

Number of Credits:4

Effective from AY: 2023-24

Prerequisites for the course	Students should have studied the courses in M.Sc. Part I.	
Course Objective:	1. To understand the concepts of bioorganic chemistry and medicinal chemistry. 2. To study in brief about carbohydrates, nucleic acids and enzyme chemistry. 3. To introduce the topic of biomimetics. 4. To acquire knowledge on biosynthesis of natural products. 5. To understand the concept of drugs as enzyme inhibitors. 6. To synthesize selected drugs and understand its mechanism.	
Content	**1. Introduction to Bioorganic chemistry**: Basic concepts, definition, Proximity effects in organic chemistry and overlapping subject biochemistry and organic chemistry, Molecular adaptation, Molecular recognition.	No of hours 4
	2. Carbohydrates, Nucleic acids and Protein Chemistry. Chemical structure and properties of nucleosides, nucleotides, nucleic acids. The biological and biochemical mechanisms of DNA replication and transcription.The structure of amino acids and the primary, secondary and tertiary structure of peptides and proteins. Determination of configuration of Glucose (Fischer's proof). Cyclic structure of glucose. Mutarotation Haworth projections. Lobry de Bruyn-van Ekenstein rearrangement; stepping–up (Kiliani- Fischer method) and stepping–down (Ruff's &Wohl's methods) of aldoses; end-group interchange of aldoses. Linkage between monosachharides, structure of disacharrides (sucrose, maltose, lactose.)	6
	3. Enzyme Chemistry: Introduction, Nomenclature, classification and extraction of enzymes, Introduction to catalysis and enzymes; Multifunctional catalysis, Intramolecular catalysis, mechanism of enzyme action, factors responsible for enzyme specificity, enzyme activity and kinetics (Michaelis Menten and Lineweaver–Burk plots), enzyme inhibitions (Reversible and irreversible), structure, mechanism of action and applications of α-Chymotrypsin, Ribonuclease, lysozyme and Carbopeptidase-A. Enzymes in synthetic organic chemistry. [Reactions to be covered-Additions, eliminations, substitutions,	8

	condensations, oxidations, reductions and rearrangement]	
	4. Biomimetics and Biosynthesis of Natural products- **Biomimetics**: Definition**,** biological mechanisms, natural mechanisms, biomimetic structures, biomimicry at the cell-material interface, tissue structure and biomimetic applications. Biomimetic chemistry for NADH model. **Biosyntheses of natural products:** Biosyntheses of Alkaloids: Types of Metabolites of plants (Primary and secondary), Types of metabolic pathways: Shikimic and Mevalonic. Biosyntheses of Morphine from tyrosine and Nicotine from Ornithine. Biosyntheses of Steroids: Testosterone and Cholesterol.Biosyntheses of 6-methylsalicylic acid, tetracyclins. Modular polyketide synthase, Erythromycin biosynthesis, engineering novel polyketide antibiotics.	10
	5. Co-Enzyme Chemistry-Chemical structures of co-enzymes and cofactors, Oxidoreduction (NAD+, NADP+), Pyridoxal phosphate (PLP) in transamination, Thiamine pyrophosphate (TPP), Biotin (CO_2 carrier), Haemoglobin (O_2- carrier), Flavin (FMN, FAD, $FADH_2$), Oxene Reactions, Lipoic acid, Mechanisms of reactions catalyzed by co-factors. Oxidation by cytochrome-450. Hansester as NADH model (give an example)	10
	6. Medicinal Chemistry and Pharmacology Role of medicinal chemistry, properties of drug and receptor, Pharmacophore, toxicophore and metabiophore. Pharmacodynamics and Pharmacokinetics. Drug Design based on Target based and phenotype approach. Enzyme inhibitors as drugs. Antagonist behaviour of Caffeine, Role of Enoyl acp reductase, cyclooxygenase inhibitors, Kinase, α-Glucosidase, Dihydrofolate reductase, ACE-2 in the biological processes. Designing the drug and Mechanism of action of Isoniazid, Ibuprofen, Erlotinib, acarbose, captopril. Concept of molecular docking in computer aided drug designing. Structure –activity relationships of drug molecules, binding role of –OH group,-NH_2 group, double bond and aromatic ring to receptor. SAR of following drugs (Chloramphenicol, Procaine, Isoniazid, Chloroquine, Methyl Dopa).	12
	5. Synthesis of drugs with mechanism: **Anti inflammatory Drugs**: Naproxen, Celecoxib. **Anti-hypertensive**	10

	Drugs: Captopril, Atenolol. **Drugs acting on CNS**: (a) CNS Stimulant : Dextro-amphetamine (b) Respiratory Stimulant : Doxapram (c) CNS anti-depressant : (i) Chlorpromazine (Antipsychotic) (ii) Diazepam(Anxiolytic) (iii) Phenobarbital (Antiepileptic) (d) Anaesthetic Drugs: (a) General : Ketamine (b) Local : (i) Lidocaine. **Antibiotics**: Amoxycillin**.** **Antimycobactrial**: Ethambutol. **Antiviral**: Acyclovir. **Antimicrobial**: Sulfamethoxazole. **Antidiabetics**: Tolbutamide (k). **Antineopastic Drugs**: (a) Antagonist: Fluorouracil (b) Alkylating agents: i) Chlorambucil (ii) Cis-Platin. **Antimalarial**: Hydroxychloroquine	
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.	
References / Readings	1. D. A. Williams & T. L. Lemke, *Foye's principles of medicinal chemistry*, 5th edition, Lippincott Williams and Wilkins, 2006. 2. J. M. Beale & J. M. Block, *Wilson &Gisvold's Text book of Organic Medicinal & Pharmaceutical Chemistry*, Lippincott Williams and Wilkins; 2004. 3. D. J. Abraham & D. P. Rotella, *Burger's Medicinal Chemistry Drug Discovery and Development*, 7th edition, John Wiley & Sons N.Y, 2010. 4. D. Shriram, P. Yogeshwari, *Medicinal Chemistry*, Pearson Education, 2007. 5. G. L. Patrick: *Introduction to Medicinal Chemistry*, Oxford University Press, UK. 6th edition, 2017. 6. D. Lednicer& L. A. Mitscher, *The Organic Chemistry of Drug Synthesis*. (6 volume set) III. John Wiley & Sons, 2005. 7. H. Singh & V. K. Kapoor, *Medicinal and Pharmaceutical Chemistry*, Vallabh Prakashan, 2010. 8. G. R Chatwal, *Medicinal Chemistry (Organic Pharmaceutical Chemistry)*, Himalaya Publishing house, 2002. 9. N. K. Tripathi & R. C. Verma, *Bioorganic and Medicinal Chemistry, Theory and Practical*s, Thakur Publications Pvt Limited, 2021. 10.T. M. Kutchan,*Alkaloid biosynthesis – the basis for metabolic engineering of medicinal plants*. Plant Cell, 1995. 7, 1059-1070. 11. Y. Bar-Cohen,*Biomimetics: Nature-Based Innovation*, CRC Press, 2012. 12. I. L. Finar, *Organic Chemistry: Stereochemistry and the Chemistry of Natural Products*, Pearson Education India, 2002. 13. K. Nakanishi, *Natural Product Chemistry*, Academic Press, 2013.	

	14. D. R. Dalton, *The Alkaloids*. New York: M. Dekker, 1979. 15. D. Barton & W. D.Olis, *Comprehensive Organic Chemistry*, Pergamon, 1979. 16. D. Paul, *Medicinal Natural Products:A Biosynthetic Approach*, John Wiley and Sons, 2002. 17. M. Paolo, *Biosynthesis of Natural Products*, Wiley Publishers, 2010. 18. J. ApSimon, *The Total Synthesis of Natural Products*, John Wiley and Sons, 1992. 19. J. M. Beale Jr. & J. Block, *Wilson and Gisvold's Textbook of organic and medicinal chemistry*, 12thEd.,Wolters Kluwer India Pvt. Ltd, 2010.
Course Outcome:	1.Students will be able to apply the knowledge of carbohydrates, proteins, nucleic acids, enzymes, co-enzymes for designing enzyme inhibitors. 2.Students will be able to put into practice the knowledge of biomimetics. 3.Students will be able to biosynthesize natural products. 4.Students will be able to synthesize drugs, present structure activity relationship studies and also write its mechanism.

Title of the course: Pilot Plant Scale-Up Techniques for Pharmaceuticals

Course Code: CHH-602

Number of Credits:4

Effective from AY: 2023-24

Prerequisites for the course	Students should have studied the courses in M.Sc. Part I.	
Course Objective:	1. To understand the various Pilot Plant scale-up techniques as adopted for industrial processes. 2. To examine Pilot Plant formula to determine its ability to with stand Batch-scale and process modification 3. To learn unit processes involving various chemical reactions. 4. To learn industrial synthesis of selected list of drugs. 5. To learn the need for pilot plant in industry and also the flowchart on various manufacturing methods of drugs.	
Content	**1. Introduction to Pilot Plant**: Definition, objectives and significance of Pilot Plant. Need to conduct Pilot Plant studies. Uses of Pilot Plant Scale-Up. Several considerations in Pilot Plant scale up activities in R and D development Scale up process. The layout of the relationship between different activities during technology transfers from the pilot plant to the production facility. Future developments. The layout of the relationship between different activities during technology transfers from the pilot plant to the production facility. Limitations of pilot plant.	No of hours 10
	2. Unit processes for various chemical reaction types for pilot plant: Concept of unit processes in systematization of chemicalreactions, explanation of one example each for unit processes:Alkylation, amination, (by ammonolysis, reduction), carbonylation,carboxylation, condensation, dehydration, diazotization, disproportionation, esterification, halogenation, hydration,hydroformylation, hydrogenation, hydrolysis, hydroxylation,nitration, oxidation and reduction.	10
	3. Industrial Synthesis:	

	Introduction to pharmaceutical manufacturing – raw materials, detailed manufacturing procedure, therapeutic function, commonname, chemical name, structural formulae of the following drugs:Acyclovir, alprazolam, propanolol, naproxen, ibuprofen, aspirin,levodopa and cimetidine, lidocaine, ethambutol hydrochloride, 5-fluorouracil, amoxycillin sodium.	12
	4.General Considerationsfor Pilot Plant scale up process: Reporting Responsibility: Space requirements, Personnel requirements, Training, Review of the Formula, Raw Materials, Relevant processing equipment, process rate and evaluation, Preparation of Master Manufacturing Procedure, GMP Consideration-advantages and disadvantages, Transfer of Analytical Methods to Quality Assurance, Pilot plant scale up considerations for solids.	10
	5. Pilot Plant Scale Up considerations for solids, oral liquids and semi-solids. Layout of pilot plant, Stages of Production of Tablets, Material handling, Dry blending, Granulation, Drying, Reduction of particle size, Blending, Direct compression, Slugging (dry granulation techniques). Process evaluation. Master Manufacturing Procedures, Product, stability, and uniformity. Good Manufacturing practices. Flow chart on Pilot plant process scale-up.Steps of liquid manufacturing process, Critical aspects of liquid manufacturing, solution, suspension, emulsions. Pilot plant scale up considerations for semi-solids.Contract manufacturing: Scope and limitations	12
	6. SUPAC (Scale Up and Post-approval changes guidelines) and Platform Technology: The SUPAC Guidelines define, the components or composition changes, The site changes of manufacture, Changes in Batch Size (Scale-Up/Scale-Down), Manufacturing Changes. Introduction to platform technology:Pharmaceutical Platform technologies, Importance platform technology, Types of platform technology.	6
Pedagogy	Mainly lectures and tutorials. Seminars / term papers /assignments / presentations /industry visits/ 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.	
References / Readings	7. Levin M. *Pharmaceutical Process Scale-Up*. New York: Marcel Dekker, Inc..2001.	

4. Groggins, *Unit processes in Chemical Engineering*, 1st Ed., McGraw-Hill, 1958.
5. Drydens, *Unit processes in chemical engineering*, McGraw-Hill Higher Education, 2004.
6. William Andrew, *Pharmaceutical Manufacturing Encyclopedia Vol.I& II*., 3rd Ed William Andrew, 2007,
7. W.W.M. Wenland, *Thermal Analysis*, 2nd Ed., John Willey & Sons, New York, 1974,
8. S.B. Chandalia, *Hand Book of Process Development*, Multitech Publishing Company, Mumbai, 1998.
9. K. G. Gadamasetti, *Process Chemistry in PharmaceuticalIndustries*, 1st Ed., Taylor & Francis Group, 1999.
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11. M.V. Krishnan, *Safety Management in Industries*, Jaico Publishers, Mumbai, 2002.
12. R. K. Khar, S.P. Vyas, F. J. Ahmad, G.K. Jain, *Industrial Pharmacy*. 4th Ed., New Delhi: CBS Publishers & Distributors Pvt Ltd, 2013. pp. 947-1002.
13. V. P. Shah, J.P. Skelly, W.H. Barr, H. Malinowski, G.L. Amidon. *Scale-up of Controlled Release Products - Preliminary Considerations*. Pharm Technol 1992; 16(5):35-40.
14. N.V.N. Mounica, R.V. Sharmila, S. Anusha, L. Evangeline, M. V. Nagabhushanam, D. Nagarjunareddy. *Scale up and Postapproval changes (SUPAC) Guidance for Industry: A Regulatory note*. Int J Drug Regul. Aff., 2017; 5(1): 13-19.
15. L. Lachman, H. A. Lieberman, J. L.Kanig: *The Theory and Practice of Industrial Pharmacy: Section IV: Chapter 23:Pilot Plant Scale-Up Techniques:* 3rd edition,Varghese Publishing house, 2009; 681-710.
16. J. Swarbrick, J. C. Boylan: *Encyclopedia of Pharmaceutical Technology: Pilot Plant Design, Volume 12* New York, 2001; 171-186.
17. Leon Lachman, Herbert A. Lieberman, Joseph B. Schwartz: *Pharmaceutical dosage forms: Tablets. Volume 3*, 2nd edition. 2001, 303-365.
18. J. P. Sitompul, H.W. Lee, Y. C. Kim &W. Mathew, A. Chang: *Scaling-up Synthesis from Laboratory Scale toPilot Scale and to near Commercial Scale for Paste-Glue Production,* J. of Eng. and Tech. Sci. 2013; 45(1): 9-24.

	19. J. W. Zawistowski, A.I.A. and J.D. Rago, *Pilot Plant Scale-Up Facilities: Establishing the Basis for a Design*, J. of Pharm. eng.july/august. 1994, 24-32.
Course Outcome:	1.Students will be able to explain unit processes for various organic chemical reactions. 2.Students will be able to apply industrial synthesis knowledge for the synthesis of drug like molecules in laboratory. 3.Students will be able to apply the knowledge of waste effluent treatment methods. 4.Students will be able to apply the knowledge of pilot plant scale-up techniques in industry.

Title of the course: Pharmacological and Toxicological Screening Techniques

Course Code: CHH-603

Number of Credits:4

Effective from AY: 2023-24

Prerequisites for the course:	Students should have studied Pharmaceutical Chemistry courses at M.Sc. Part-I.	
Course Objective:	1. To learn screening methods of biological assay. 2. To learn terms involved in toxicology. 3. To learn methods of analysis for toxicology	
Content	**1. Laboratory Animals, Principles of Biological Standardisation, Screening methods** a. Introduction to pharmacological research. Animal ethics, regulations for conducting animal experimentation. Common laboratory animals: Description, handling and applications of different species and strains of animals. Transgenic animals: Production, maintenance and applications Anaesthesia and euthanasia of experimental animals. Maintenance and breeding of laboratory animals. CPCSEA guidelines to conduct experiments on animals Good laboratory practice. b. Statistical treatment of model problems in evaluation of drugs-methods of biological assay, principles of biological assays-methods used in bioassay of vitamins, hormones, vaccines,cardiac drugs and other pharmacopeial preparations. c. Zebrafish model to screen pharmaceutical molecules Organisation of Screening for the pharmacological activity ofnew substances. Anti-inflammatory agents-carrageenan inducedpaw oedema, cotton pellet method. Anticonvulsants: Convulsions induced by chemicals, induced by electroshock, combined procedures. Sympathomimetic agents: Mydriasis, theuterus and ascending colon of the rat.	No of hours 20
	2. Introduction to Toxicology: Definition and types of toxicology, Basic principles of toxicology,	12

	Carcinogenicity, mutagenicity, teratogenicity, acute, sub acute and chronic toxicity. Detailed toxicity (mild/moderate/severe toxicology wherever applicable) and treatment of drugs such as salicylates/ paracetamol, opium, quinine, ethyl alcohol, etc. Toxic chemicals in the environment, impact of toxic chemicals on enzymes. Biochemical effects of arsenic, lead mercury, cadmium, carbon monoxide, pesticides and carcinogens	
	3. Essentials of Analytical Toxicology Physicochemical, biochemical & genetic basis of toxicity; Principles of toxicokinetics, mutagenesis and carcinogenesis – Behavioural, inhalation toxicity, hypersensitivity and immune response, range finding tests – Acute, subacute and chronic toxicity studies. Classification of Toxins: Acute toxicity tests, Determination of LD50 value, Subacute tests - Histopathological and biochemical estimations on toxicity induced in animal models – Modern methods of analysis for Toxins-Barbiturate poisoning, Amphetamine poisoning.	12
	4. Safety aspects in pharmacological studies Preclinical toxicological requirements for biological and biotechnological products: Safety analysis; problems specific to recombinant products secondary pharmacology. Safety Pharmacology - ICH S7 and S7B guidelines. Safety pharmacological studies for pharmaceuticals. Safety pharmacological studies for biological products.	8
	5. Applications of Toxicology Clinical Toxicology, Environmental Toxicology/ Ecotoxicology Forensic Toxicology/ Post-mortem, Toxicology Industrial/Occupational Toxicology. Food Toxicology Behavioural toxicology Preventive toxicology Descriptive Toxicology Mechanistic Toxicology Regulatory Toxicology Genetic Toxicology Systemic Toxicology.	8
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.	
References /	1. S.K. Gupta, Uma Singh and T. Velpandian, Analytical Toxicology	

Readings	for Poisoning Management and Toxicovigilance, Varosa Publishing House, 2002. 2. E.G.C.Clarke, Isolation and Identification of Drugs, Body Fluids and Post-mortem Material. The Pharmaceutical Press, 1986. 3. A. K. De, Environment Chemistry, Wiley Eastern Ltd., New Delhi, 2003. 4. R.K. Trivedi & P.K. Goel, Chemical and Biological Methods for Water, Pollution Studies, Environment Publications, Karad (India), 1984. 5. B. K. Sharma, Industrial Chemistry, 1st Ed., Narosa Publishing House,1998. 6. W. Andrew, Pharmaceutical Manufacturing Encyclopaedia Vol I and II, 3rd Ed., William Andrew Publishing, 2007. 7. R. A. Turner, P. Hebborn, Screening Methods in Pharmacology, Vol.-1 &2, Elsevier Science & Technology Books, 1971. 8. H. G. Vogel & W. H. Vogel, Drug Discovery and Evaluation, Springer, 2006. 9. S. K. Kulkarni, Handbook of Experimental Pharmacology, Vallabh Prakashan, Delhi, 1993. 10. R.S. Satoskar& S.D. Bhandarkar, Pharmacology and Pharmacotherapeutics, Popular Prakashan Ltd, 2006. 11. Louis S. Goodman & Alfred Gillman, The Pharmacology Basis of Therapeutics, McGraw-Hill Professional Publishing, 2010. 12. H.P. Rang & M.A. Dale, Pharmacology, Elsevier – Health Sciences Division, 2011. 13. CPCSEA guidelines (http://cpcsea.nic.in)
Course Outcome:	1.Students will be able to apply the role of various screening methods in bioassay. 2.Students will be able to create various in vivo and in vitro assay methods for various targets. 3. Students will be able to evaluate various effects of toxins. 4. Students will be able to analyse the safety aspects in pharmaceuticals 5. Students will be able to apply this knowledge for their dissertation work.

Title of the course: Discipline Specific Dissertation

Course Code: CHC-651

Number of Credits: 16

Effective from AY: 2023-24

Prerequisites for the course:	Students should have studied chemistry courses at MSc-I level.	
Course Objective:	To develop the skills of preparing and conducting independent research.	
Content	As per OA-35	No of Hours 480
Pedagogy:	Dissertation carried out individually by each student throughout the academic year.	
References / Readings:	As required for the development of review and methodology.	
Course Outcome:	Students will be able to understand and apply the tools and techniques of chemistry in conducting independent research.	