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

Goa University
Taleigao Plateau, Goa - 403 206
Tel : +91-8669609048
Email : registrar@unigoa.ac.in
Website: www.unigoa.ac.in

(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. Chemistry (SEM I & II) Syllabus (80 Credit course) as per NEP 2020 for AY 2022-23

SEM I			
Sr. No.	**Subject code**	**Paper title**	**Credits**
1.	CHO-500	Fundamentals of Organic Chemistry	4
2.	CHI-500	Fundamentals of Inorganic Chemistry	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.	CHI-521	Practical Course in Inorganic Chemistry-I	2
8.	CHI-522	Practical Course in Inorganic 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 in Analytical Chemistry-I	2
12.	CHA-522	Practical Course in Analytical Chemistry-II	2
SEM II (Inorganic Chemistry)			
1.	CHI-501	Chemistry of Coordination & Organometallic Compounds	4
2.	CHI-502	Chemistry of Materials	4
3.	CHI-503	Concepts in Molecular Symmetry and Spectroscopy	4
4.	CHI-504	Concepts in Inorganic Chemistry	4

SEM II (Analytical Chemistry)			
1.	**CHA-501**	Chemical Methods of Analysis	4
2.	**CHA-502**	Techniques in Analytical Chemistry-II	4
3.	**CHA-503**	Separation Techniques	4
4.	**CHA-504**	Instrumental Methods of Analysis	4
SEM II (Organic Chemistry)			
1.	**CHO-501**	Organic Spectroscopy	4
2.	**CHO-502**	Pericyclic and Organic Photochemical Reactions	4
3.	**CHO-503**	Synthetic Methodologies in Organic Chemistry	4
4.	**CHO-504**	Stereochemistry and Organic Transformations	4
SEM II (Physical Chemistry)			
1.	**CHP-501**	Quantum Chemistry and Statistical Thermodynamics	4
2.	**CHP-502**	Group Theory and Molecular Spectroscopy	4
3.	**CHP-503**	Chemical Kinetics and Thermodynamics	4
4.	**CHP-504**	Electrochemistry and Surface Studies	4

Name of the Programme: M.Sc. Part-I (Chemistry)

Course Code: CHA-500 **Title of the course:** Techniques in Analytical Chemistry - I

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 given reaction as method of Analysis, Classification of reactions in titrimetric analysis (Acid-Base, redox, complexometric and precipitation), Standard solutions 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 Thermoanalytical techniques 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.

Name of the Programme: M.Sc. Part-I (Chemistry)

Course Code: CHA-521 **Title of the course:** Practical Course in Analytical Chemistry - I

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.* **Unit 1: Statistics** i. Calibration of selected Volumetric apparatus ii. Calibration of selected Laboratory instruments Preparation of standard solutions and standardisation.	No of hours 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 i. Estimation of Ca in pharmaceutical tablet. ii. Estimation of Al and Mg in antacid tablet. iii. Estimation of CaO in cement.	10
	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.	

Name of the Programme: M.Sc. Part-I (Chemistry)

Course Code: CHA-522 **Title of the course:** Practical Course in Analytical Chemistry - II

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 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	10

	spectroscopy 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.	

Name of the Programme: M.Sc. Part-I (Chemistry)

Course Code: CHI-500**Title of the course:** Fundamentals of Inorganic Chemistry

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 introduce atomic structure, molecular structure, bonding, and symmetry. 2. To provide fundamental knowledge of solid state chemistry, coordination chemistry, organometallic chemistry, and bioinorganic chemistry. 3. To provide fundamental aspects of transition & inner transition elements & their compounds. 4. To introduce air and water pollution, and its treatments, to follow directive of the Supreme Court in 1993 to introduce environmental education at all levels.	
Content	**1. Atomic structure, molecular structure and bonding** a. Atomic Structure: Structures of hydrogenic atoms: some principles of quantum mechanics, atomic orbitals. Many electron atoms: penetration & shielding, building up principle, classification of elements. Spectroscopic terms. Atomic properties: atomic radii, ionic radii, ionization energy, electron affinity, electronegativity, polarizability. b. Molecular Structure & bonding: Lewis structures: octet rule, resonance. VSEPR model: basic shapes, modification of the basic shapes. Valence bond theory: hydrogen molecule, homonuclear diatomic molecules, polyatomic molecules, promotion, hypervalence, hybridization. Molecular orbital theory: approximation, boding & antibonding orbitals. Homonuclear diatomic molecules & Heteronuclear diatomic molecules	No of hours 10
	2. Molecular Symmetry a. Symmetry elements and symmetry operations. b. Equivalent symmetry elements and equivalent atoms, symmetry point groups with examples, point groups of higher symmetry. c. Systematic procedure for symmetry classification of molecules and illustrative examples, dipole moment, optical activity and point groups	4
	3. Solid state chemistry a. Structures of solids: crystal structures, lattices and unit cells,	10

	fractional atomic coordinates and projections, close packing of spheres, holes in closed-packed structures. b. Structures of metals & alloys: polytypism, nonclosed-packed structures, polymorphism of metals, atomic radii of metals, alloys, substitutional and interstitial solid solutions, intermetallic compounds. c. Ionic solids: characteristic structures of ionic solids, binary phases, ternary phases, rationalization of structures, ionic radii, radius ratio, structure maps, energetics of ionic bonding, lattice energy and the Born–Haber cycle, The calculation of lattice enthalpies. (numerical expected)	
	4. Chemistry of transition & inner transition elements a. Transition elements**:** IUPAC definition of transition elements, occurrence, physical and chemical properties, noble character, metal halides, oxides & oxido complexes, examples of metal-metal bonded clusters, difference between 1^{st} row and other two rows. b. Inner transition elements: Lanthanides, occurrence, properties, oxidation states, electronic structure, colour and spectra, magnetic properties, lanthanide contraction, compounds of lanthanides. Actinoid chemistry: general trends and properties, electronic spectra, thorium and uranium.	10
	5. Coordination and Organometallic Chemistry a. Coordination chemistry: Introduction, representative ligands, nomenclature. Constitution and geometry: low coordination numbers, intermediate coordination numbers, higher coordination numbers, polymetallic compounds. Isomerism & chirality in square planar and octahedral complexes, ligand chirality. Thermodynamics of complex formation: formation constants, chelate and macrocyclic effects, steric effects and electron delocalization. Electronic properties of metal complexes: CFT applied to octahedral and tetrahedral complexes, magnetic moments, CFSE. Electronic spectroscopy: basic concepts, interpretation of spectra of d^1 & d^9 ions (Orgel diagram for octahedral and tetrahedral complexes). b. Organometallic Chemistry: Introduction to organometallic chemistry, nomenclature, stability and inert gas rules (neutral atom and donor pair electron count methods). Ligands: CO & phosphines, homoleptic carbonyls its synthesis and properties, oxidation-reduction of carbonyls, metal carbonyl basicity, reactions of CO ligand, spectroscopic properties of metal carbonyls. Oxidative addition and reductive elimination.	12
	6. Basic Bioinorganic Chemistry a. Macronutrients/micronutrients. Role of elements in biology.	4

	Metal ion transport role. b. Definition of metallobiomolecules, metalloporphyrins, structure of porphine and heme group, examples of metalloenzymes of Cu and Zn.	
	7. Environmental Chemistry a. Air Pollution: Classification of air pollutants and photochemical reactions in the atmosphere. Common air pollutants (e.g. CO, NOx, SO_2, hydrocarbons and particulates) (a) sources (b) physiological and environmental effect (c) monitoring, (d) various remedial & technological measures to curb pollution. Air quality standards. b. Water pollution: Importance of buffer & buffer index in waste water treatments. Chemical, physical & biological characteristics of water pollution, specific & non-specific characterization of water. DO, BOD, COD, and chlorine demand, typical water treatment & waste water treatment (Municipal). Impact of plastic pollution and its effect.	10
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, T. Overton, J. Rourke, M. Weller, F. Armstrong, Shriver & Atkins Inorganic Chemistry, 5th Ed.; Oxford Publications, 2009. 2. J. E. Huheey, E. A. Kieter, R. L. Kieter, O. K. Medhi, Inorganic Chemistry: Principles of Structure & Reactivity, 4th Ed.; Pearson, 2011. 3. F. A. Cotton, G. Wilkinson, P. L. Gauss, Basic Inorganic Chemistry, 3rd Ed.; Wiley, 2008 (reprint). 4. J. D. Lee, Concise Inorganic Chemistry, 5th Ed.; Wiley, 2008. 5. F. A. Cotton, Chemical applications of group theory, 3rd Ed.; Wiley Eastern, 2012 (reprint). 6. L. Pauling, The Nature of The Chemical Bond, 3rd Ed.; Cornell University Press, 1960. 7. M. C. Day, J. Selbin, Theoretical Inorganic Chemistry, 2ed Ed.; Van Nostrand-Reinhold, 1969. 8. H. V. Keer, Principles of Solid state Chemistry, 1st Ed.; New Age Intl. Ltd, 1993, (reprint 2008). 9. A. R. West, Solid State Chemistry and Its Applications, 1st Ed.; John Wiley & Sons, Singapore, 1984 (reprint 2007). 10. D. K. Chakrabarty, Solid State Chemistry, 2ed Ed.; New Age Intl. Publishers, 2010. 11. F. A. Cotton, G. Wilkinson, Advanced Inorganic Chemistry, 3rd Ed.; Wiley Eastern, 2001. 12. A. V. Salker, Environmental Chemistry: Pollution and Remedial Perspective, 1st Ed.; Narosa Publication, 2017.	

	13. A.K. De, Environmental Chemistry, 3rd Ed.; New Age Intl. Publishers, 2005. 14. A. C. Stern, R. W. Boubel, D. Bruce turner, D. L. Fox, Fundamentals of Air Pollution, 1st Ed.; Academic Press, 1984. 15. R. A. Horne, Chemistry of Our Environment, 1st Ed.; John Wiley, 1978. 16. R. S. Drago, Physical Methods in Inorganic Chemistry, Affiliated East West Press Pvt. Ltd., 2017 17. G. C. Miessler, D. A. Tarr, Inorganic Chemistry, 3rd Ed.; Pearson, 2004
Course outcomes:	1. Students will be able to predict geometry and shape of different molecules, and the point group symbols. 2. Students will be able to explain the fundamentals of atomic and molecular structure, solid state chemistry, coordination chemistry, organometallic chemistry, and bioinorganic chemistry. 3. Students should be able to describe and explain the properties and usefulness of transition & inner transition metals. 4. Students will able to explain different air and water pollutants and will be in a position to apply knowledge to treat these pollutants.

Name of the Programme: M.Sc. Part-I (Chemistry)

Course Code: CHI-521 **Title of the course:** Practical course in Inorganic Chemistry-I

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. Students shall acquire skills in synthetic inorganic chemistry. 2. Students will learn to prepare coordination compounds. 3. Students will learn to prepare useful potash alum from scrap aluminum. 4. Students will learn how to grow single crystals. 5. Students will acquire skills in determination of chromium, oxalate, and aluminum by redox titrations. 6. Students will be trained to fix the formula of compounds and find lattice water molecules by complexometric, redox & iodometric titrations. 7. Students shall acquire skills in determination of metal content at very low concentrations (ppm) using colorimetry / spectrophotometry.	
Content	*Minimum 13 experiments from the list shall be conducted.* **1. Preparations / Synthesis of Inorganic Compounds: (Any Five)** i. Preparation of hexaamminenickel(II) chloride. ii. Preparation of Trisethylenediaminecobalt(III) chloride. iii. Preparation of potassium trioxalatoaluminate trihydrate. iv. Preparation of potassium hexathiocyanato-*κN*-chromate tetrahydrate. v. Preparation of potassium trioxalatochromate trihydrate. vi. Preparation of potash alum from scrap aluminum.	No of hours 25
	2. Estimations / Determinations: (Any Eight) i. Estimation of nickel in $[Ni(NH_3)_6]Cl_2$ by complexometry or Gravimetry. ii. Estimation of cobalt in $[Co(en)_3]Cl_3$ by complexometry. iii. Estimation of oxalate in $K_3[Al(C_2O_4)_3]\cdot xH_2O$ or $K_3[Cr(C_2O_4)_3]\cdot xH_2O$ iv. Estimation of nitrite by redox titration. v. Estimation of calcium from calcite ore. vi. Iodometric determination of Copper in gun metal alloy/Devarda's alloy. vii. Determination of chromium in chrome alum and $K_3[Cr(C_2O_4)_3]\cdot xH_2O$ and to determine degree of hydration. viii. Colorimetric/Spectrophotometric determination of nickel or	35

	chromium. ix. Estimation of manganese by colorimetric / spectrophotometry method.	
Pedagogy	Students will be given pre-lab and post-lab assignments on theoretical aspects of laboratory experiments prior to the conduct of each experiment. Exams will be in the form of ISA, SEA which will involve performing given experiments and conduct of viva, systematic reporting of experiments, results and observations in laboratory report. Sessions should be interactive in nature to enable peer group learning.	
References / Readings	1. G. Brauer, Handbook of Preparative Inorganic Chemistry, Vol. 1 & 2, 1963. 2. G. Pass & H. Sutcliffe, Practical Inorganic Chemistry, Preparations, Reactions and Instrumental Methods, 2nd Ed.; Chapman & Hall, 1974. 3. S. De Meo, J. Chem. Ed., Vol 80, Pg.No.796-798, 2003. 4. W. L. Jolly, The Synthesis & Characterization of Inorganic Compounds, Prentice-Hall, INC, 1970. 5. A. J. Elias, General Chemistry Experiments, Revised Ed.; University Press, 2008. 6. J. Mendham, R.C. Denney, J.D. Barnes, M.J. K. Thomas, Vogel's Text Book of Quantitative Chemical Analysis,6th Ed.; Pearson, 2002. 7. G. Svehla, Vogel's Text Book of Qualitative Inorganic Analysis, 7th Ed, Pearson, 2011. 8. G. Marr, B. W. Rockett, Practical Inorganic Chemistry, Van Nostrnad Reinhold London, 1972.	
Course outcomes:	1. Students will be in a position to synthesis coordination compounds with different metals and ligands. 2. Students will be able to grow single crystal. 3. Students will be able to prepare potash alum compound from waste scrap Al source. 4. Students will be able to determine metal content in the synthesised inorganic compounds. 5. Students will be able to fix the formula of compounds. 6. Students will be able to use and explain the diverse methods available for estimation of the metals including colorimeters and spectrometers.	

Name of the Programme: M.Sc. Part-I (Chemistry)

Course Code: CHI-522**Title of the course:** Practical course in Inorganic Chemistry-II

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. Students shall acquire skills in synthetic inorganic chemistry. 2. Students will learn to prepare coordination compounds. 3. Students will learn how to grow single crystals. 4. Students will acquire skills in determination of metal present by gravimetric and titrimetric method. 5. Students shall acquire skills in determining the metal content at very low concentrations (ppm) using colorimetry / spectrophotometry.	
Content	*Minimum 13 experiments from the list shall be conducted.* **1. Preparations / Estimation of Inorganic Compounds: (Any Nine)** i. Preparation of hexaamminecobalt(III) nitrate. ii. Estimation of cobalt in hexaamminecobalt(III) nitrate by volumetric titration. iii. Preparation of Potassium Trioxalatoferrate(III) Trihydrate iv. Estimation of iron and oxalate by redox titration v. Synthesis of metal nanoparticles (Cu, Ag, Au, Ni) and determining the absorption maxima by UV-visible spectrophotometer. vi. Estimation of amount of calcium in given sample by gravimetric method. vii. Estimation of amount of nickel in given sample by gravimetric method. viii. Estimation amount of zinc present in given sample by gravimetric method. ix. Estimation of iron by colorimetric / spectrophotometry method. x. Estimation of barium by complexometric titration method. xi. Estimation of manganese in presence of iron by complexometric titration method.	No of hours 40
	2. Semi-micro qualitative analysis of cation and anion in a given inorganic mixture: (Any four mixture) Mixture containing total six cations and/or anions. **Cations :** Pb^{2+}, Cu^{2+}, Cd^{2+}, Sn^{2+}, Fe^{2+}, Fe^{3+}, Al^{3+}, Cr^{3+}, Zn^{2+},	20

	Mn^{2+}, Ni^{2+}, Co^{2+}, Ba^{2+}, Sr^{2+}, Ca^{2+}, Mg^{2+}, $(NH_4)^+$, K^+ **Anions:** Cl^-, Br^-, I^-, NO_2^-, NO_3^-, SO_3^{2-}, CO_3^{2-}, SO_4^{2-}, PO_4^{3-}, S^{2-}	
Pedagogy	Students will be given pre-lab and post-lab assignments on theoretical aspects of laboratory experiments prior to the conduct of each experiment. Exams will be in the form of ISA, SEA which will involve performing given experiments and conduct of viva, systematic reporting of experiments, results and observations in laboratory report. Sessions should be interactive in nature to enable peer group learning.	
References / Readings	1. G. Brauer, Handbook of Preparative Inorganic Chemistry, Vol. 1 & 2, 1963. 2. G. Pass & H. Sutcliffe, Practical Inorganic Chemistry, Preparations, Reactions and Instrumental Methods, 2nd Ed.; Chapman & Hall, 1974. 3. S. De Meo, J. Chem. Ed., Vol 80, Pg.No.796-798, 2003. 4. W. L. Jolly, The Synthesis & Characterization of Inorganic Compounds, Prentice-Hall, INC, 1970. 5. A. J. Elias, General Chemistry Experiments, Revised Ed.; University Press, 2008. 6. J. Mendham, R.C. Denney, J.D. Barnes, M.J. K. Thomas, Vogel's Text Book of Quantitative Chemical Analysis,6th Ed.; Pearson, 2002. 7. G. Svehla, Vogel's Text Book of Qualitative Inorganic Analysis, 7th Ed, Pearson, 2011. 8. G. Marr & B. W. Rockett, Practical Inorganic Chemistry, Van Nostrand Reinhold Company, London, 1972.	
Course outcomes:	1. Students will be in a position to synthesize coordination compounds with different metals and ligands. 2. Students will be able to grow single crystal. 3. Students will be able to determine metal content in the given sample. 4. Students will be in position to apply diverse methods available for estimation of the metals and can use colorimeters and spectrometers. 5. Students will able to detect cations and anions in the given salt.	

Name of the Programme: M.Sc. Part-I (Chemistry)

Course Code: CHO-500 **Title of the course:** Fundamentals of Organic Chemistry

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. d. Introduction to chemoselective, regioselective and	14

	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, trappingandaddition 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 medium on	08

	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, 2nd Ed.,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, 5th Ed, 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 understand and apply various reagents for desired organic transformations.	

Name of the Programme: M.Sc. Part-I (Chemistry)

Course Code: CHO-521 **Title of the course:** Practical Course in Organic Chemistry-I

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, naphthalene, anthracene or succinic acid (any one). e. Vacuum distillation (any one): o-dichlorobenzene, diphenyl	24

	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 iv. Lemongrass oil from lemongrass	8
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 get hands-on experience on isolation of some important natural products.	

Name of the Programme: M.Sc. Part-I (Chemistry)

Course Code: CHO-522 **Title of the course:** Practical Course in Organic Chemistry-II

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 g. Synthesis of Urea from ammonium cyanate	16

	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 get hands-on experience on isolation of some important natural products.

Name of the Programme: M.Sc. Part-I (Chemistry)

Course Code: CHP-500 **Title of the course:** General Physical Chemistry

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 der	12

	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't Hoffs 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 Br_2, Homogeneous reactions and acid-base catalysis.	8

	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 understand concepts of electrochemistry. 4. Students will be able to apply fundamentals of chemical kinetics for understanding reaction mechanisms.	

Name of the Programme: M.Sc. Part-I (Chemistry)

Course Code: CHP-521 **Title of the course:** Practical course in Physical Chemistry-I

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 energy change. 2. To determine the order of reaction between potassium persulphate and potassium iodide by graphical, fractional change and differential methods. 3. To study the three-component system such as acetic acid, chloroform; and water and obtain tie line. 4. To determine the molecular weight of polyvinyl alcohol by viscosity measurement. 5. To study the electro-kinetics of rapid reaction between SO_4^{2-} and I^- in an aqueous solution. 6. To determine the buffer capacity of acidic buffer solution. 7. To determine the partial molal volume of ethanol-water mixture at a given temperature. 8. To measure energy content of various types of plastics using bomb calorimetry 9. To determine number average molecular weight of a polymer sample with an indirect titration method. 10. To investigate basic hydrolysis of ethyl acetate at four different temperatures and find out energy of activation	No of hours 30
	Instrumental Experiments (any 6)	

	11. To determine the degree of hydrolysis of salt of weak base and strong acid using conductometer. 12. To determine the dissociation constants of a tribasic acid (Phosphoric acid obtain derivative plot to get equivalence point. 13. To determine formal redox potential of Fe^{2+}/Fe^{3+} and Ce^{3+}/Ce^{4+} system obtain derivative plot to get equivalence point. 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.	30
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 Physical Chemistry, 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.	

Name of the Programme: M.Sc. Part-I (Chemistry)

Course Code: CHP-522 **Title of the course:** Practical course in Physical Chemistry-II

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 Physical Chemistry, 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.	

Name of the Programme: M. Sc -I (Organic Chemistry)

Course Code: CHO-501 **Title of the course:** Organic Spectroscopy

Number of Credits: 04

Effective from AY: 2022-23

Prerequisites for the course:	Students should have studied Organic chemistry courses at M.Sc. Chemistry in semester I	
Course Objective:	1. To study various theoretical concepts related to organic spectroscopic techniques. 2. To understand the introductory aspects of commonly used 2D NMR techniques. 3. To learn interpretational aspects of spectral data pertaining to UV, IR, PMR, CMR and MS.	
Content	**1. UV-Visible Spectroscopy** a. Introduction. Electronic transition and energy levels, the absorption laws. b. Measurement of the spectrum, chromophores, Effect of solvent, Conjugation on UV-spectra. c. Study of Tautomerism, Steric effect and geometrical isomerism in UV spectra. d. Woodward-Fieser rule for conjugated dienes and carbonyl compounds.	No of hours 04
	2. **Infrared Spectroscopy** a. IR spectroscopy in structural elucidation of organic compounds (various functional classes to be considered). b. Methods in IR-Spectroscopy, effect of hydrogen bonding and solvent effect on vibrational frequencies, overtones, combination and Fermi resonance bands. c. Factors influencing vibrational frequencies. d. Characteristic frequencies of organic molecules. e. Interpretation of spectra.	08
	3. **NMR Spectroscopy** a. Principles of NMR. b. Instrumentation. c. Chemical shift- (revision of the basic concepts) d. Interpretation of PMR spectra. i.Coupling constants and AB, A_2B_2/A_2X_2, AMX and ABX spin systems. ii. Double resonance and decoupling iii. Nuclear Overhauser Effect and its applications. iv. NMR Shift reagents v. Determination of Absolute and Relative configuration	14

	4. ^{13}C –NMR spectroscopy a. Introductionto ^{13}C –NMR spectroscopy. b. ^{13}C- chemical shifts effects (α-, ß-, γ-, δ-substituent effects, π-conjugation, heavy atom effect and ring size effects) c. Proton coupled and proton decoupled 13Cspectra. d. Off- resonance decoupling, APT & DEPT techniques.	8
	5. ^{19}F- NMR and ^{31}P- NMR spectroscopy Principles and applications; heteronuclear coupling of carbon to ^{19}F and ^{31}P.	6
	6. Two-dimensional NMR spectroscopy Introduction to 2D NMR techniques and interpretation ofspectra of simple organic compounds using following 2d-NMR techniques-COSY, NOESY, HSQC, HMQC, HMBC, TOCSY and INADEQUATE	8
	7. Mass spectrometry a. Ionization Methods, Mass Analysis, Even and odd electron ions and fragmentation modes. b. Molecular Formulae Index (D.B.E), Molecular ion peak, base peak, metastable ions, Nitrogen rule, effect of isotopes. c.Prediction of molecular formulae based on relative abundance. Rules for fragmentation, McLafferty rearrangement, retro-Diels-Alder fragmentation, fragmentation associated with functional groups; rearrangement and mass spectra of some chemical classes. **Note: Problems involving combined use of different type of spectra, in line with course objective/ Course outcomes are to be emphasized.**	12
Pedagogy	Mainly lectures and tutorials. Seminars/term papers/assignments/presentations/self-study or a combination of some of these can be used. ICT mode should be preferred. Sessions should be interactive to enable peer group learning.	
References / Readings	1. P.S. Kalsi, Spectroscopy of Organic compounds, New Age International Pub. Ltd. & Wiley Eastern Ltd., 2nd Ed., 1995. 2. R.M. Silverstein, F. X. Webster, D.Kiemle, D. Bryce, S.Samant, V. S. Nadkarni,Spectrometric Identification of Organic compounds, An Indian Adaptation John Wiley & Sons Inc., 8th Ed., 2022. 3. D. L. Pavia, G. M. Lampman, G. S. Kriz, J. R. Vyvyan, Introduction to Spectroscopy, Brooks Cole, 5th Ed., 2015. 4. R.M. Silverstein, F. X. Webster, Spectrometric Identification of Organic compounds, John Wiley & Sons Inc., 7th Ed. (reprint), 2011. 5. V.M. Parikh, Absorption Spectroscopy of Organic Molecules, Addison Wesley Longman Publishing Co., 1974. 6. D.H Williams & I. Fleming, Spectroscopic Methods in Organic Chemistry, Tata Mcgraw Hill Education, 6th Ed., 2011.	

	7. W. Kemp, Organic Spectroscopy, Palgrave Macmillan, 3rd Ed., 1991. 8. W. Kemp, NMR in Chemistry: A Multinuclear Introduction, Macmillan, 1986. 9. J. R. Dyer, Applications of Absorption Spectroscopy of Organic compounds, Prentice Hall of India, 1987. 10. L. D. Field, H. L. Li., A. M. Magill, Organic Structures from 2D NMR Spectra, Wiley, 2015.
Course outcomes:	1. Students will be in a position to understand how spectral techniques can be used in structure elucidation. 2. Students will be able to deduce structures of simple to moderately complex molecules by combining the spectral data obtained using two or more spectral techniques. 3. Students will be in a position to apply various concepts in organic spectroscopy (PMR, CMR, MS and 2D NMR) and analyse/ predict PMR, CMR, MS and 2D NMR spectral data based on given structures of simple molecules. 4. Students will understand the fundamental difference between various spectroscopic techniques.

Name of the Programme: M. Sc -I (Organic Chemistry)

Course Code: CHO-502 **Title of the course:** Pericyclic and Organic Photochemical Reactions

Number of Credits: 04

Effective from AY: 2022-23

Prerequisites for the course:	Students should have studied organic chemistry courses at M.Sc. Chemistry in semester I	
Course Objective:	1. To introduce various concepts in pericyclic chemistry based on molecular orbital theory and apply for solving pericyclic reactions 2. To introduce analysis of pericyclic reactions using theoretical concepts. 3. To learn mechanistic aspects of pericyclic & photochemical reactions in organic synthesis.	
Content	**1. Pericyclic Reactions** a. Theory of pericyclic reactions i. Frontier Molecular Orbital (FMO) theory ii. Transition state aromaticity (Mobius-Huckel theory) concept iii. Orbital correlation diagram method. b. Analysis of pericyclic reactions (including stereochemistry) using the above concepts i. Cycloaddition reactions ii. Electrocyclic reactions iii.Sigmatropic rearrangements under thermal and photochemical conditions (Note: Various important features to be discussed taking examples important reactions of each type) c. Some synthetically useful reactions (examples via theory of pericyclic reaction). d. Diels–Alder and retro Diels-Alder reaction: Regiochemistry, stereochemistry and intramolecular reactions. e. 1, 3-dipolar additions f. [3, 3]-Shifts; Claisen and Cope, aza-Cope-, oxy-Cope rearrangements and fluxional molecules, variants of Claisen Rearrangement such as Johnson-Claisen, Eschenmoser-Claisen, Carroll- Claisen and Ireland-Claisen. g. [2,3]-Sigmatropic rearrangements such as Sommelet-Hauser rearrangement, Sulfonium ylide rearrangement, Meisenheimer rearrangement, Wittig rearrangement, Mislow-Evans rearrangement h. Ene reaction, hetero-ene, retro-ene reactions i. [1,5]-Thermal and [1,7]-photochemical sigmatropic hydrogen	No of hours 34

	shifts	
	2. Organic Photochemistry a. Interaction of electromagnetic radiation with matter, laws of photochemistry; fateof excited molecule; principles of energy transfer, types of photochemical reactions. Theoretical concepts in organic photochemistry w. r. t. cycloadditions, Electrocyclicreactions and sigmatropic reactions b. Photochemical reactions of alkenes, dienes, carbonyl compounds and arenes including the following- geometrical isomerisation: *Cis-trans* isomerization andphotostationary equilibrium; Paterno-Buchi reaction; Norrish Type cleavages; Di-pimethane rearrangement; bicycle rearrangement c. Photochemistry of aromatic compounds: valance isomerization; photostationary state of benzene and azabenzenes. [4+4]-photodimerization of derivatives of naphthalenes. cycloaddition reaction of benzene, naphthalene, pyrrole and indoles with alkenes and alkynes d. Reactions involving singlet and triplet oxygen: Photooxygenation reactions, examples of [2+2] and [4+2]-cycloaddition reaction with isocyclic, heterocyclic, dienes and polynuclear aromatic compounds e. Applications of Organic Photochemistry: Photochemical Reactions as Key Steps in Natural Product Synthesis (any four examples); example of photopolymerization; photochemical functionalization at unactivated carbon: Barton reaction, the hypohalite reaction and the Hofmann-Loffler-Freytag reaction	26
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. N. Turro, V. Ramamurthy, J.C. Scaiano, Modern Molecular Photochemistry of Organic molecules , University Science Books, 2010. 2. B. Dinda, Essentials of Pericyclic and Photochemical Reactions, Springer, 1st Ed. 2017. 3. S.Kumar, V. Kumar, S.P. Singh, Pericyclic Reactions: A Mechanistic and Problem-Solving Approach, Elsevier, 2016. 4. R. E. Lehr., A. P. Marchand, Orbital Symmetry: A Problem Solving Approach, Academic Press, 1972. 5. R. B. Woodward, R. Hoffmann, Conservation of Orbital Symmetry, Verlag chemie, Academic Press, NY, 1972. 6. I. Fleming, Frontier Orbitals and Organic Chemical Reactions, John Wiley & Sons, 1st Ed., 1991 7. T. L. Gilchrist, R. C. Storr, Pericyclic Reactions, Cambridge Univ. Press,	

	1972. 8. F. A. Carrey, R. J. Sundberg , Advanced Organic Chemistry Part A and B, Pelnum Pub., 3rd Ed. 1990. 9. T. Lowery, K. Richardson, Mechanisms and Theory in Organic Chemistry, Harper and Row Pub., NY, 3rd Ed., 1987. 10. C. H. DePay, Molecular Reactions and Photochemistry, Prentice Hall (I) Ltd, NewDelhi. 11. J. Kopecky, Organic Photochemistry- A Visual Approach, VCH Pub., 1992.
Course outcomes:	1. Students will be in a position to predict course of a given pericyclic reaction using the theoretical concepts. 2. Students will be able to apply knowledge of stereochemical output in a reaction. 3. Students will be able to understand and propose plausible mechanism of pericyclic/photochemical reactions. 4. Students will understand applications of organic photochemistry.

Name of the Programme: M. Sc -I (Organic Chemistry)

Course Code: CHO-503 **Title of the course:** Synthetic Methodologies in Organic Chemistry

Number of Credits: 04

Effective from AY: 2022-23

Prerequisites for the course:	Students should have studied organic chemistry courses at M.Sc. Chemistry in semester I	
Course Objective:	1. To study various concepts related to carbon-carbon bond formation. 2. To understand designing of organic synthesis to make molecules of interest. 3. To plan total synthesis based on protection-deprotection strategy.	
Content	**1. Chemistry of enols and enolates** a. Keto-enol tautomerism; Introduction, acidity, basicity concepts & pKa scale, neutral nitrogen and oxygen bases. Formation of enols by proton transfer, mechanism of enolization by acids & bases, types of enols & enolates, kinetically & thermodynamically stable enols, consequences of enolization, stable enolate equivalents, preparation and reactions of enol ethers. b. Formation of Enolates; Introduction, preparation & properties, non-nucleophilic bases, E / Z geometry in enolate formation, kinetic vs. thermodynamic control, other methods for the generation of enolates, issue of enolate ambidoselectivity. c. Alkylation of enolates; diverse reactivity of carbonyl groups, alkylation involving nitriles and nitroalkanes, choice of electrophile for alkylation, lithium enolates of carbonyl compounds and alkylation, specific enol equivalents to alkylate aldehydes and ketones, alkylation of β-dicarbonyl compounds, problem of regioselectivity during ketone alkylation and the remedy provided by enones. d. Reaction of enolates with aldehydes and ketones; Introduction, aldol reaction including cross & intramolecular version, enolisable substrates which are not electrophilic in nature, controlling aldol reactions with specific enol equivalents, specific enol equivalents for carboxylic acids, aldehydes and ketones. e. Acylation at carbon; Introduction, the Claisen ester condensation (intramolecular and inter / crossed), acylation of enolates by esters, preparation of keto-esters by the Claisen reaction, directed C-acylation of enols and enolates & acylation of enamines.	No of hours 22

	f. Conjugate addition of enolates; Introduction, thermodynamic control vs. conjugate addition, utility of various electrophilic alkenes in conjugate addition, formation of six-membered rings via conjugate addition and nitroalkanes as versatile synthons. g. Examples pertaining to the application of following condensation reactions in organic synthesis; Mukaiyama reaction, Perkin reaction, Dieckmann condensation, Michael addition, Robinson annulation, Sakurai reaction, Knoevenagel Reaction, Darzen, Stobbe, Benzoin, Pechmann condensation.	
	2. Synthetic utility of important name reactions / methodology a. Mannich Reaction, Nef Reaction, Mitsunobu and Appel Reaction, Baylis Hillman reaction, Mc. Murry coupling, vicarious nucleophilic substitution, Steglich and Yamaguchi esterification. b. Ring closing and cross metathesis; Grubb's various generation, Grubbs-Hoveyda, Schrock catalysts.	8
	3. The Ylides in Organic Synthesis a. Phosphorus Ylides; Nomenclature and Preparation. Wittig olefination: mechanism, stereoselectivity, cis- and trans selective reactions, Wittig reagents derived from α-halo carbonyl compounds. b. Modified Wittig, Horner – Wadsworth – Emmons, Stille-Gennari modification with achiral and chiral substrates, Peterson reaction, Julia Olefination. c. Sulfur Ylides; Sulfonium & sulfoxonium ylides in synthesis, diphenylcyclopropyl sulfonium ylides & their reactions with carbonyl compounds / Michael acceptors	8
	4. Protecting Groups in Organic Synthesis a. Introduction and effective use of protecting groups, umpolung of reactivity. b. Common protective groups namely acetals & ketals, dithio acetal/ketals, trialkylsilyl, TBDMS, THP, MOM, MEM, SEM & benzyl ether, methyl ether, benzyl amine, Cbz, *t*-Boc, Fmoc, *t*-butyl ester and methods for deprotection. Some examples of multistep synthesis using protection-deprotection procedures.	6
	5. Asymmetric Synthesis a. Chiral pool (chiron approach). b. Chiral auxiliary approach; Oxazolidinone & norephedrine-	12

	derived chiral auxiliary controlled Diels-Alder reaction and alkylation of chiral enolates and aldol reaction, Alkylation using SAMP and RAMP. c. Chiral Reagents - Use of (-)-sparteine. d. Asymmetric catalysis; CBS catalyst, Ruthenium catalyzed chiral reductions of ketones, Catalytic asymmetric hydrogenation of alkenes, Asymmetric epoxidation (Sharpless and Jacobson), Sharpless asymmetric dihydroxylation reaction, Organocatalyzed aldol reaction (Use of proline).	
	6. Halogenation and esterification reactions a. Formation of Carbon Halogen bonds; Substitution in saturated compounds, alcohols, carbonyl compounds, substitution at allylic and benzylic compounds, bromodecarboxylation (Hunsdiecker reaction), Finkelstein reaction, iodolactonisation. b. Acid and base catalyzed esterification and hydrolysis.	4
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 edition, 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, 1965, 2nd Ed. (revised with corrections). 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, 5th Ed, 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 explain how a carbon-carbon bond can be constructed along with the selectivity in bond formations. 2. Students will be able to apply knowledge of various reactions in	

	constructions of simple to complex organic molecules. 3. Students will be in a position to design protecting group strategies for synthesis of organic molecules. 4. Students will understand use of protecting groups in organic synthesis.

Name of the Programme: M. Sc -I (Organic Chemistry)

Course Code: CHO-504 **Title of the course:** Stereochemistry and Organic Transformations

Number of Credits: 04

Effective from AY: 2022-23

Prerequisites for the course:	Students should have studied organic chemistry courses at M.Sc. Chemistry in semester I	
Course Objective:	1. To study various principles of stereochemistry 2. To understand the importance of chirality in organic syntheses 3. To learn stereoselective reactions and toplan oxidation, reduction reactions	
Content	**1. Stereochemistry** a. Stereoselectivity in cyclic compounds: Introduction, stereochemical control in six membered rings, reactions on small rings, regiochemical control in cyclohexene epoxides, Stereoselectivity in bicyclic compounds b. Conformations, stability and reactivity of fused ring compounds: Fused bicyclic systems with small and medium rings: cis- and trans- decalones and decalols, Octahydronaphthalins (octalins), Bicyclo [4.3.0] nonane (cis- and trans-hydrindanes) c. Fused polycyclic systems: Perhydrophenanthrenes, Perhydroanthracenes, Perhydrocyclopentenophenanthrene system (steroids, triterpenoids and hormones). Conformations and reactivity towards esterification, hydrolysis, chromium trioxide oxidation, ionic additions of halogen (X_2) to double bonds, formation and opening of epoxide ring, epoxidation by peroxy acids. d. Spirocyclic compounds e. Reactions with cyclic intermediates or cyclic transition state f. Stereoisomerism due to axial chirality, planar chirality and helicity. g. Stereochemistry and configurational (*R/S*) nomenclature in appropriately substituted allenes, alkylidenecycloalkenes, spiranes, adamantoids, biaryls, trans-cycloalkenes, cyclophanes and ansa compounds. h. Atropisomerism in biphenyls and bridged biphenyls	No of hours 20
	2. Conformation of bridged ring compounds a. Bicyclo [2.2.1] heptane (norbornane): Geometry and topic relationship of hydrogens, solvolysis of bicycle [2.2.1]heptyl	10

	systems, formation, stability and reactivity of norbornylcation, relative stability and the rate of formation of endo and exo isomers in both bornane and norbornane systems. b. Bicyclo [2.2.2] octane system: Geometry and topic relationship of hydrogens, solvolysis of bicycle [2.2.2]octyl system. c. Other bridged ring systems: starting from bicycle [1.1.1]pentane to bicycle [3.3.3] undecane d. Bicyclo system with heteroatom: the relative stabilities of tropine, pseudotropine and benzoyl derivatives of norpseudotropine.	
	3. Dynamic Stereochemistry: Stereoselective Reactions a. Stereoselectivity: classification, terminology and principle. Selectivity in chemistry– substrate and product selectivity. b. Stereoselective reaction of cyclic compounds: Introduction, reactions of four, five and six-membered rings. Conformational control in the formation of six-membered ring. c. Diastereoselectivity: Introduction, making single diastereoisomers using stereospecific reactions of alkenes. d. 1,2-Addition to carbonyl compounds: Predicting various addition outcomes using different predictive models such as, Cram Chelate, Cornforth, Felkin-Anh. Specific reactions: allylation/crotylation by Brown, Roush, BINOL catalyzed. e. Stereoselective reaction of acyclic alkenes: The Houk model	14
	4. Oxidation and reduction reactions a. Oxidation reactions: Oxidation of organic compounds using Oppenauer oxidation, Swern oxidation. Other methods of oxidation such as selenium dioxide, $Pb(OAc)_4$, HIO_4, OsO_4, RuO_4, DMSO (Swern) sodium bromate / CAN &NaOCl, DDQ, Prevost's reagent and Woodward Conditions; Catalytic oxidation over Pt, Photosensitised oxidation of alkenes, oxidation with molecular oxygen, aromatization, silver based reagents. b. Reduction reactions: Reduction of organic compounds using hydride-transfer reagents and related reactions: MPV reduction, Trialkylborohydrides, LAH, mixed LAH-$AlCl_3$ reagents, enzymatic reduction involving liver alcohol dehydrogenase/NADH & Bakers' yeast, catalytic hydrogenation, dissolving metal reductions including acyloin condensation, other methods of reduction: Raney Ni desulphurisation, di-imide.	16
Pedagogy	Lectures & tutorials. Seminars / assignments / presentations / self-study or a combination of some of these could also be used to some extent. ICT	

	mode should be preferred. Sessions should be interactive in nature to enable peer group learning.
References / Readings	1. M. B. Smith, J. March, Advanced Organic Chemistry- 50 Reaction, Mechanism and Structure, Wiley, 2006, 6th Ed. 2. D. Nasipuri, Stereochemistry of Organic compounds, Principles and applications, New Age International Pvt. Ltd., 1994, 2nd Ed. 3. E.L. Eliel, Stereochemistry of Carbon Compound, Tata McGraw Hill, 1975. 4. W. Caruthers, I. Colddham, Modern Methods of Organic Synthesis, Cambridge University Press, 2016, 4th Ed. 5. J. Clayden, N. Greeves, S. Warren, Oxford, 2016. 6. I. L. Finar, Stereochemistry and the Chemistry of Natural Products, ELBS, Vol. 2, Longman Edn, 1975. 5th Ed. 7. E.S. Gould, Mechanism and Structure in Organic Chemistry, Holt, Reinhart and Winston, 1965. 8. F. A. Carey, R. J. Sundberg, Advanced Organic Chemistry: Part A and B, Springer India Private Limited, 2007, 5th Ed. 9. R. O. Norman J, M. Coxon, Principles of Organic Syntheses, CRC Press Inc, 1993, 3rd Ed. 10. V.M. Potapov, A. Beknazarov, Stereochemistry, Central Books Ltd., 1980. 11. D. G. Morris, Stereochemistry, Wiley-RSC, 2002, 1st Ed. 12. C., Greeves, W., Wothers, Organic Chemistry, Oxford University Press, 2002, 2nd Ed. 13. M. Nogradi, Stereoselective Synthesis, VCH Publishers, Inc., 1994, Revised and Enlarged Ed.
Course outcomes:	1. Students will be in a position to explain stereochemistry and organic transformations. 2. Students will be in a position to apply knowledge of various reactions in functional group manipulations. 3. Students will be in a position to apply stereoselective reactions for the synthesis of chiral organic molecules. 4. Students will understand conformations of bridged ring compounds.

M.Sc. Organic/Inorganic/Analytical/Physical Chemistry Part-II syllabus for AY 2023-24 (SEM III and SEM IV) based on NEP 2020

SEM III & IV			
Research Specific Elective (RSE) Courses			
Sr. No.	**Subject code**	**Paper title**	**Credits**
1.	CHO-600	Practical Course in Organic Chemistry-III	4
2.	CHO-601	Practical Course in Organic Chemistry-IV	4
3.	CHO-602	Retrosynthesis and Heterocyclic Chemistry	4
4.	CHO-603	Chemistry of Natural Products	4
5.	CHI-600	Practical Course in Inorganic Chemistry-III	4
6.	CHI-601	Practical Course in Inorganic Chemistry-IV	4
7.	CHI-602	Principles and applications in catalysis	4
8.	CHI-603	Selected Topics in Inorganic Chemistry	4
9.	CHA-600	Practical Course in Analytical Chemistry-III	4
10.	CHA-601	Practical Course in Analytical Chemistry-IV	4
11.	CHA-602	Advanced Mass Spectrometry	4
12.	CHA-603	Selected Topics in Analytical Chemistry	4
13.	CHP-600	Practical Course in Physical Chemistry-III	4
14.	CHP-601	Practical Course in Physical Chemistry-IV	4
15.	CHP-602	Heterogeneous Catalysis: Fundamentals and Applications	4
16.	CHP-603	Applied Electrochemistry	4
17.	CHC-600	Research Methodology and instrumental techniques-I	4
18.	CHC-601	Research Methodology and instrumental techniques-II	4
19.	CHC-651	Discipline Specific Dissertation	16
Generic Elective (GE) Courses			
Sr. No.	**Subject code**	**Paper title**	**Credits**
1.	CHO-621	Polymer Chemistry: Concepts, Synthesis and Processing of Polymers	4
2.	CHO-622	Concepts in Medicinal Chemistry	4
3.	CHO-623	Concepts in Green Chemistry	4
4.	CHO-624	Chemistry of Life	4
5.	CHO-625	Organometallic Chemistry and Rearrangement Reactions	4
6.	CHI-621	Bioinorganic Chemistry	4
7.	CHI-622	Chemistry of p-block elements & their compounds	4

8.	**CHI-623**	Environmental Chemistry	4
9.	**CHI-624**	Inorganic Chemistry: Industrial Perspective	4
10.	**CHA-621**	Fundamentals of Crystallography	4
11.	**CHA-622**	Advanced NMR and combined Spectroscopy	4
12.	**CHA-623**	Bioanalytical Techniques	4
13.	**CHA-624**	Calibration and Validation in Analytical Chemistry	4
14.	**CHP-621**	Solid State Chemistry: Concepts and Applications	4
15.	**CHP-622**	Nanoscience: Concepts and Applications	4
16.	**CHP-623**	Physical aspects of Polymer Chemistry	4
17.	**CHP-624**	Colloids and Surface Chemistry	4
		Dissertation	
1.	**CHC-651**	Discipline Specific Dissertation	16

M.Sc. Organic Chemistry Part-II syllabus for AY 2023-24 (SEM III and SEM IV)

SEM III ORGANIC CHEMISTRY			
Sr. No.	**Subject code**	**Paper title**	**Credits**
1	**CHO-600**	Practical Course in Organic Chemistry-III	4
2	**CHO-601**	Practical Course in Organic Chemistry-IV	4
3	**CHC-600**	Research Methodology and instrumental techniques-I	4
4	**CHC-601**	Research Methodology and instrumental techniques-II	4
5	**CHO-621**	Polymer Chemistry: Concepts, Synthesis and Processing of Polymers	4
6	**CHO-622**	Concepts in Medicinal Chemistry	4
7	**CHO-623**	Concepts in Green Chemistry	4
8	**CHO-624**	Chemistry of Life	4
9	**CHO-625**	Organometallic Chemistry and Rearrangement Reactions	4
SEM-IV ORGANIC CHEMISTRY			
Sr. No.	**Subject code**	**Paper title**	**Credits**
1	**CHO-602**	Retrosynthesis and Heterocyclic Chemistry	4
2	**CHO-603**	Chemistry of Natural Products	4
3	**CHC-651**	Discipline Specific Dissertation	16

Name of the Programme: M.Sc. Part-II (Organic Chemistry)

Course Code: CHO-600 **Title of the course:** Practical Course in Organic Chemistry-III

Number of Credits: 4

Effective from AY: 2023-24

Prerequisites for the course	Should have studied organic chemistry practical course 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 organic syntheses, organic mixture separations and purification.	
Content	**1. Organic ternary mixture separation** (*Minimum 10 experiments of 6h each*) Three component mixture separation based upon differences in the physical and the chemical properties of the components. Elemental and functional group analysis, determination of physical constant and derivative preparation-its recrystallization and melting point/boiling point of any one compound.	No of hours 60
	2. Organic synthesis (Any Six) a. Benzophenone oxime to benzanilide (Beckmann rearrangement) b. Benzil to hydrobenzoin ($NaBH_4$ reduction) c. Diels - Alder reaction of anthracene and maleic anhydride using microwave irradiation d. Friedel- Crafts acylation of anisole e. 2-methyl benzimidazole from *o*-phenylene diamine f. Dicoumarol from coumarin derivative g. Halogenation using NBS: preparation of 9-bromoanthracene (or benzylic bromides) h. Resolution of racemic phenyl ethylamine using tartaric acid i. Ferric chloride oxidative coupling of 2-naphthol to [1,1'-binaphthalene]-2,2'-diol] j. Dimedone from mesityl oxide (Dieckmann condensation) *k.* $KMnO_4$ oxidation of toluene assisted by microwave *l.* 2-phenylindole from acetophenone (Fisher indole synthesis)	36
	3. Polarimetry and column chromatography (*Any 4 experiments of 6h from '**sections a and b**'*) **a. Enantiomeric excess by Polarimetry** Determination of optical rotation and enantiomeric excess of enantiomers and unknown mixtures of: i. Amino acids	24

	ii. Drugs iii. Carbohydrates iv. Other readily available Chiral compounds **b. Purification of organic compounds by column chromatography** i. Mixture of ortho and para nitrophenols ii. Mixture of benzil and benzoin iii. Mixture of acetophenone and benzylideneacetophenone *iv.* Mixture of benzophenone and benzanilide *v.* Other Chiral natural product mixtures	
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. 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. N. K. Vishnoi, Advanced Practical Organic Chemistry, South Asia Books, 2010. 3. K. Tanaka, Solvent-free Organic Synthesis, 2nd Ed., Wiley-VCH, 2009. 4. L. F. Fieser, K. L. Williamson, Organic Experiments, 7th Ed., D. C. Heath, 1992. 5. K. L. Williamson, K. M. Masters, Macroscale and Microscale Organic Experiments, 6th Ed., Cengage Learning, 2010. 6. R. K. Bansal, Laboratory Manual in Organic Chemistry, 5th Ed. New Age International, 2016. 7. S. Delvin, Green Chemistry, Sarup & Sons, 2005. 8. O. R. Rodig, C. E. Bell Jr., A. K. Clark, Organic Chemistry Laboratory Standard and Microscale Experiments, 3rd Ed., Saunders College Publishing, 2009. 9. J. Mohan, Organic Analytical Chemistry, Narosa Publishing House, 2014. 10. G. J. Shugar, J. T. Ballinger, Chemical Technicians Ready Reference Handbook, McGraw-Hill, Inc. 1996. 11. D. P. Shoemaker, Experimental Physical Chemistry, McGraw-Hill, 1989.	
Course Outcome	1. Students will be in a position to perform separation of organic components based on chemical nature, solubility and boiling points. 2. Students will be in a position to understand stoichiometric requirements in organic syntheses. 3. Students will be able to monitor progress of reaction by chromatographic techniques. 4. Students will be able to carry out purification of reaction products by column chromatography.	

Name of the Programme: M.Sc. Part-II (Organic Chemistry)

Course Code: CHO-601 **Title of the course:** Practical Course in Organic Chemistry-IV

Number of Credits: 4

Effective from AY: 2023-24

Prerequisites for the course	Should have studied organic chemistry practical course 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 organic syntheses and organic mixture separations.	
Content	**1. Organic ternary mixture separation and identification** (Minimum 14 experiments of 6h each) Three component mixture separation based upon differences in the physical and the chemical properties of the components. Elemental and functional group analysis and determination of physical constants of the individual compounds. Derivative preparation, its recrystallization and m. p. of each component and characterization of each component and its derivative by m. p. comparison.	No of hours 84
	2. Organic synthesis (Any Six) a. 1,2,3,4 - tetrahydrocarbazole from cyclohexanone (Fischer indole synthesis). b. Resolution of racemic phenylethylamine using tartaric acid. c. Trans - Stilbene by Wittig reaction. d. Enamine alkylation: 2-methyl cyclohexanone pyrrolidine enamine with CH_3I. e. Chlorobenzylidene rhodanine (Perkin reaction). f. Diels-Alder reaction of anthracene and maleic anhydride using microwave irradiation. Oxidation of a primary / secondary alcohol to carbonyl compound by polymer supported chromic acid (Amberlyst A-26, chromate form). g. Phenytoin from benzil and urea. h. Isoborneol from camphor ($NaBH_4$ reduction) i. 3 -Methyl -2-phenyl-2-butanoI from 2-bromopropane and acetophenone j. Triphenyl carbinol from benzophenone or ethyl benzoate (Grignard reaction). k. Benzidine from hydrazobenzene (benzidine rearrangement). l. Methyl orange/red from sulphanilic acid/anthranilic acid	36

	(diazotization). m. Reduction of Nitrobenzene to aniline by Sn/HCl. n. LAH reduction of Anthranilic acid. o. Norborneol to norcarnphor using chromium trioxide/sulfuric acid *p.* Benzhydrol from benzaldehyde (Grignard reaction) *q.* Diethyl 4-butyl malonate by malonic ester condensation	
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. 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. N. K. Vishnoi, Advanced Practical Organic Chemistry, South Asia Books, 2010. 3. K. Tanaka, Solvent-free Organic Synthesis, Wiley-VCH, 2nd Ed., 2009. 4. L. F. Fieser, K. L. Williamson, Organic Experiments, 7th Ed. D. C. Heath, 1992. 5. K. L. Williamson, K. M. Masters, Macroscale and Microscale Organic Experiments, 6th Ed., Cengage Learning, 2010. 6. R. K. Bansal, Laboratory Manual in Organic Chemistry, 5th Ed., New Age International, 2016. 7. S. Delvin, Green Chemistry, Sarup & Sons, 2005. 8. O. R. Rodig, C. E. Bell Jr., A. K. Clark, Organic Chemistry Laboratory Standard and Microscale Experiments, Saunders College Publishing, 3rd Ed., 2009. 9. J. Mohan, Organic Analytical Chemistry, Narosa Publishing House, 2014.	
Course Outcome	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 separation of organic components based on chemical nature, solubility and boiling points. 4. Students will be able to identify organic compounds with chemical tests.	

Name of the Programme: M.Sc. Part-II (Organic Chemistry)

Course Code: CHO-602 **Title of the course:** Retrosynthesis and Heterocyclic Chemistry

Number of Credits: 4

Effective from AY: 2023-24

Prerequisites for the course	Students should have studied Organic Chemistry courses at M.Sc. Part-I level.	
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 in heterocyclic chemistry and its applications 4. To be able to propose routes for synthesis of heterocycles	
Content	**1. Disconnection approach – Introduction, types of disconnection** a. One-group disconnection b. Disconnection of simple alcohols and compounds derived from alcohols, disconnections of simple olefins, simple/aryl ketones and carboxylic acids c. Two-group disconnection d. Disconnection of 1,3-dioxygenated skeletons, *β*-hydroxy carbonyl compounds, α,β-unsaturated carbonyl compounds, 1,5-dicarbonyl compounds, Mannich reaction e. 'Illogical' Two-group disconnection f. Disconnection of the 1,2-dioxygenated skeleton, *α*-hydroxy carbonyl compounds, 1,2-diols, 'Illogical' electrophiles, disconnection for the 1,4-dioxygenated pattern in 1,4-dicarbonyl compounds, γ-hydroxy carbonyl compounds, Other 'Illogical' synthons, disconnection for the 1,6-dicarbonyl compounds, synthesis of lactones (*General review problems to be discussed for above approaches*)	No of hours 15
	2. Disconnection strategies a. Disconnection of heteroatom and heterocyclic compounds such as ethers, amines, heterocycles, amino acids b. Disconnection strategies of few pericyclic reactions c. Convergent and divergent synthesis d. Strategic devices for carbon-heteroatom bonds, polycyclic compounds: the common atom approach e. Considering all possible disconnections f. Alternative FGI's before disconnection- the cost of synthesis g. Features which dominate strategy, functional group addition and molecules with unrelated functional groups	15

	3. Heterocyclic compounds a. Introduction, classification and nomenclature of mono- and bicyclic heteroaromatic molecules b. Physical properties, dipole moment, acidity-basicity, aromaticity, electron density distribution and reactivity of furan, thiophene, pyrrole, indole, pyridine, pyridine-N-oxide, quinoline, isoquinoline, diazines and triazines, 1,3- and 1,2-azoles	15
	4. Synthetic strategies for heterocycle synthesis General methods of synthesis of the following: furan, thiophene, pyrrole, indole, pyridine, quinoline, isoquinoline, chromones, imidazoles, oxazoles, thiazoles	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. 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., 1995. 5. J. A. Joule & K. Mills, Heterocyclic Chemistry, Wiley-Blackwell, 5th Ed., 2010. 6. T. L. Gilchrist, Heterocyclic Chemistry, Pitman Publishing, 2005. 7. R. M. Acheson, An Introduction to Chemistry of Heterocyclic Compounds, John Wiley and Sons, 3rd Ed, 1977. 8. D. W. Young, Heterocyclic Chemistry, Longman Group Ltd., London, 1975. 9. R. O. C. Norman and J. M. Coxon. Principles of Organic Synthesis, CRC Press, 3rd Ed., 2009.	
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 organic molecules 3. Students will be in a position to apply retrosynthetic strategies and propose routes for synthesis of organic molecules and heterocycles 4. Students will be able to understand and apply the concepts of the reactivity of heterocycles towards electrophilic, nucleophilic, reducing and oxidizing reagents.	

Name of the Programme: M.Sc. Part-II (Organic Chemistry)

Course Code: CHO-603 **Title of the course:** Chemistry of Natural Products

Number of Credits: 4

Effective from AY: 2023-24

Prerequisites for the course	Students should have studied Organic Chemistry courses at M.Sc. Part-I level.	
Course Objectives	1. To study the main classes of natural products. 2. To understand the different methods that are used in natural product chemistry, including extraction, isolation and structural elucidation. 3. To understand the key biosynthetic pathways for the biosynthesis of terpenes, alkaloids and steroids.	
Content	**1. Source and isolation of natural products** General methods of isolation: The modern distillation process, maceration, enfleurage, extraction by cold pressing and extraction with solvents	No of hours 2
	2. General methods of purification and structure elucidation of Natural Products a. Fractionation of the crude extracts and purification of the individual compounds from the respective fractions using chemical and chromatographic techniques such as Column Chromatography, TLC, Preparative TLC, HPLC, etc. b. Chemical methods based on the functional groups present: Bicarbonate extraction, sodium bisulphite adduct formation, derivatization, etc. c. General approach to structure elucidation of the isolated pure compounds using UV, IR, NMR spectroscopy, MS spectrometry, optical polarimetry.	4
	3. Structure elucidation by classical chemical methods a. Terpenoids: α-cedrene b. Alkaloids: Morphine, thebaine and codeine c. Steroids: Cholesterol, bile acids	12
	4. Structure elucidation by combination of chemical and spectral methods a. Terpenoids: α- and β-vetivones, Ishwarone b. Hormones: Cecropia Juvenile hormone, brevicomin and frontalin c. Oxygen heterocycles: Aflatoxin-B1, rotenone	10
	5. Structure elucidation involving stereochemistry, spectral and chemical methods a. Terpenoids: Menthol and hardwickiic acid b. Alkaloids: Reserpene	8
	6. Synthesis of selected natural products, planning and execution a. Terpenoids: Longifolene (E. J. Corey), Caryophyllene (E J	14

	Corey) Nootkatone (A. Yoshikoshi), Menthol (Tagasago) b. Alkaloids: Reserpine (R. B. Woodward), Morphine (Marshall Gates) c. Hormones: Cecropia JH (Edward), Progesterone d. Prostaglandins: Prostaglandin E2 (E. J. Corey) e. Antibiotics: Cephalosporin (R. B. Woodward)	
	7. Biogenesis and biosynthesis of natural products a. Terpenoids and Steroids: General approach towards biosynthesis of mono-, sesqui-, di-, tri-, tetraterpenoids and steroids through mevalonate pathway with special reference to the biosynthesis of terpenoids and steroids included in topics 3 to 6 b. Alkaloids: The shikimate pathway formation of hydroxybenzoic acid derivatives, aromatic amino acids, L-phenylalanine, L-tyrosine, phenolic oxidative coupling, biosynthesis of thebaine, codeine and morphine.	10
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. I. L. Finar, Organic Chemistry: Stereochemistry and the Chemistry of Natural Products, Pearson Education India, 2002. 2. K. Nakanishi, Natural Product Chemistry, Academic Press, 2013. 3. D. R. Dalton, The Alkaloids. New York: M. Dekker, 1979 4. Barton and Olis, Comprehensive Organic Chemistry, Pergamon, 1979. 5. D. Paul, Medicinal Natural Products: A Biosynthetic Approach, John Wiley and Sons, 2002. 6. M. Paolo, Biosynthesis of Natural Products, Wiley, 2010 7. J. ApSimon, The Total Synthesis of Natural Products, John Wiley and Sons, 1992. 8. E. J. Corey & X-M. Cheng, The Logic of Chemical Synthesis, Wiley Interscience, a division of John Wiley and Sons Inc, 1995. 9. K. C. Nicolaou & E. J. Sorensen, Classics in Total Synthesis, Weinhem: VCH, 1996. 10. R. O. C. Norman and J. M. Coxon. Principles of Organic Synthesis, CRC Press, 3rd Ed., 2009.	
Course Outcomes	1. Students will be able to identify different types of natural products 2. Students will be able to describe the properties and structure of natural products, their occurrence, biosynthetic pathways 3. Students will be able to carry out independent investigations of plant materials and natural products 4. Students will be able to understand and explain the synthesis of some classes of natural products.	

Name of the Programme: M.Sc. Part-II (Organic Chemistry)

Course Code: CHO-621 **Title of the course:** Polymer Chemistry: Concepts, Synthesis and Processing

Number of Credits: 4

Effective from AY: 2023-24

Prerequisites for the course	Students should have studied M.Sc. Part-I Chemistry.	
Course Objective	1. To introduce various concepts in organic polymer chemistry. 2. To understand the synthesis, polymer processing and applications.	
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.	No of hours 5
	2. Methods and chemistry of polymerization Bulk, solution, suspension, emulsion, addition, condensation polymerizations. Free-radical, Ionic and coordination polymerization reactions. Introduction to controlled free radical polymerization. Carothers equation in condensation polymerizations.	12
	3. Properties of polymers a. Number and weight average molecular weights, Molecular weight distribution, polydispersity. b. Glassy state and glass transition temperature, crystallinity in polymers. c. Characterization of polymers.	10
	4. Resources for monomers, manufacture of important monomers and reagents Ethylene, propylene, butadiene, isoprene, styrene, divinyl benzene, acrylonitrile, vinyl chloride, adipic acid, urea, bisphenol-A, melamine, phthalates, glycol, glycerol, ethylene oxide, epichlorohydrin, ϵ-caprolactum, di-isocyanates, pentaerythritol, allylic carbonate monomers.	12
	5. Synthesis, properties and applications of polymers a. Vinyl polymers-LDPE, HDPE, PVC, PVA, polyvinyl acetate, polyacrylates, methacrylates, polystyrene, teflon, ABS, SBR, SAN. b. Condensation polymers- Nylons, polyesters, polyurethanes, polycarbonates. c. Thermoset polycarbonates like CR-39 Cellulose esters-cellulose acetate, nitrates and acetatebutyrates. d. Thermoset resins- phenol-formaldehyde, melamine-	14

	formaldehyde, epoxy resins - their curing. e. Natural rubber.	
	6. Additives in polymers and Polymer processing a. Lubricants, plasticizers, stabilizers, antioxidant, fire retardants, blowing agents, fillers, colorants, crosslinking agents, UV-Vis degradants etc. b. Introduction to compounding, and processing techniques like calendaring, casting, moulding and spinning in polymer processing.	7
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. 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 Aand B, Marcel Dekkar Inc., 1992. 6. R. P. Brown, Handbook of Plastic Test Methods, 2nd Ed., George Godwin Ltd., 1981. 7. M. P. Stevens, Polymer Chemistry- An Introduction, 2nd Ed., Oxford Univ. Press, 1990. 8. W. Y. Mijs, New Methods in Polymer Synthesis, PelnumPress Ltd., NY, 1992. 9. M. Arora, Polymer Chemistry, Anmol Publications 2001. 10. C. E. Carraher, Polymer Chemistry, New York M. Dekker 2005. 11. P.C. Hiemenz, Polymer Chemistry, CRC Press, 2007. 12. V. K. Selvaraj, Advanced Polymer Chemistry, New Delhi Campus books, CRC Press, 2008. 13. A. Ravve, Principles of polymer Chemistry, Springer 2012. 14. J. David, Polymers, Oxford University Press 2015.	
Course Outcome	1. Students will be in a position to understand and evaluate the differences in structures and properties of small molecules and macromolecules. 2. Students will be in a position to apply concepts involved in polymer synthesis, characterization and processing. 3. Students will be in a position to understand and apply concepts of synthesis and applications of organic polymers. 4. Students will understand properties of polymers	

Name of the Programme: M.Sc. Part-II (Organic Chemistry)

Course Code: CHO-622 **Title of the course:** Concepts in Medicinal Chemistry

Number of Credits: 4

Effective from AY: 2023-24

Prerequisites for the course:	Students should have studied the chemistry courses in M.Sc. Part I level.	
Course Objective:	1. To understand the concepts of drug discovery and development 2. To learn drug screening, target identification, lead discovery, optimization 3. To understand molecular basis of drug design and drug action	
Content	**1. Introduction to Drugs** Requirement of an ideal drug, sources of drugs, important terms used in chemistry of drugs, classification and nomenclature of drugs, drugs and the medicinal chemists. a. **Drug Design:** Analogues and pro-drugs, concept of lead compounds, features governing drug design – the method of variation, drug design through disjunction, conjunction, tailoring of drugs, cimetidine – a rational approach to drug design. b. **Drug Development:** Screening of natural products, isolation and purification, structure determination, structure-activity relationship, QSAR, synthetic analogues, natural products as leads for new pharmaceuticals, receptor theories, oxamniquine – a case study	No of hours 15
	2. Mechanism of drug action Introduction, enzyme stimulation, enzyme inhibition, membrane-active drugs, polymorphism and drug delivery.	10
	3. Study of Pharmacodynamic Agents (minimum two examples for each) a. Local anesthetics b. Analgesics : narcotic and non-steroidal anti-inflammatory, narcotic antagonists c. Antiepileptic drugs d. Antiparkinsonism drugs e. Antihistaminics f. Seditives and hypnotics g. Antipsychotics h. Cardiovascular agents : Cardiovascular diseases, Antianginal agents and vasodilators, Antihypertensive agents, Antiarrhythmic drugs, Adrenergic blocking agents	15

	i. Antihyperlipidemic and antiatherosclerotic agents j. Anticoagulants, blood coagulation and anticoagulant mechanism k. Diuretics l. Antidiabetic drugs : Synthetic hypoglycemic agents	
	4. Study of Chemotherapeutic Agents and Antibiotics **a. Chemotherapeutic Agents (with examples)** i. Sulfonamides ii. Antitubercular and Antilepral agents iii. Antiamoebics iv. Anthelmintics v. Antimalarials vi. Antiviral agents vii. Antineoplastic Agents **b. Antibiotics : General information, mode of action and applications** i. β-Lactam antibiotics : Penicillins and Cephalosporins ii. Aminoglycocides : Streptomycin, Neomycin iii. Tetracyclines iv. Macrolides : Erythromycin, Rifamycin, Lincomycin v. Polypeptides : Bacitracin vi. Unclassified antibiotics : Chloramphenicol	15
	5. New Developments in Drug Discovery Introduction, gene therapy, drug resistance, antisense drugs, cytokines, drugs to combat AIDS.	5
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. F. Doerge, J. B. Lippincott, Wilson and Gisvold's Text book of Organic Medicinal and Pharmaceutical Chemistry, 8th Ed, Philadelphia, USA, 2010 2. M. E. Wolff, Burger's Medicinal Chemistry, Part I and II, 4th Ed., John Wiley, 1980 3. W. O. Foye, Principles of Medicinal Chemistry, 7th Ed., K. M. Varghese and Co., Bombay, 2012. 4. Lednicer and Mitscher, Organic Chemistry of Drug Synthesis, Vols I and II, John Wiley, 1980. 5. G. Patrick, An Introduction to Medicinal Chemistry, Oxford University Press, Oxford, 1998. 6. D. J. Abraham, Burgers Medicinal Chemistry and Drug Discovery, Vol. I, 6th Ed., John Wiley and Sons, New Jersey, 2003. 7. J. Janata, Z. Kamenik, R. Gazak, S. Kadlcik and L. Najmanova, Nat. Prod. Rep., **2018**, 35, 257–289	

Course Outcome:	1. Students will be able to explain classes of drugs and their structure activity relationship with examples of some important class of drugs. 2. Students will be able to explain mechanism of action of the drugs. 3. Students will be able to describe the therapeutic uses of drugs and specific side effect of 'Drug Substances'. 4. Students will be able to explain physico-chemical properties related to QSAR. 5. Students will be able to describe various approaches in designing of drug molecules including prodrug and combinatorial chemistry.

Name of the Programme: M.Sc. Part-II (Organic Chemistry)

Course Code: CHO-623 **Title of the course:** Concepts in Green Chemistry

Number of Credits: 4

Effective from AY: 2023-24

Prerequisites for the course:	Students should have studied M.Sc. Part-I Chemistry/Biochemistry.	
Course Objective:	1. To understand various concepts involved in Green synthesis 2. To understand green technologies used in chemistry 3. To learn application of green chemistry approaches to chemical industry	
Content	**1. Principles and Concepts of Green Chemistry** a. Introduction, twelve green principles, sustainable development and green chemistry. b. Atom Economy: atom economic reactions- rearrangement and addition reactions. c. Atom un-economic reactions- substitution, elimination and Wittig reactions. Reducing toxicity.	No of hours 6
	2. Waste: Production, Problems and Prevention a. Introduction, Some problems caused by waste, sources of waste from the chemical industry and the cost of waste. b. Waste minimization techniques: the team approach and process design for waste minimization, minimizing waste from existing processes. c. On-site waste treatment: Physical, chemical and biotreatment. d. Design for degradation: degradation and surfactants, DDT, polymers and some rules for degradation. e. Polymer recycling: separation and sorting, incineration, mechanical recycling and chemical recycling to monomers.	6
	3. Measuring and Controlling Environmental Performance a. The importance of measurement: Lactic acid production, safer gasoline. b. Introduction to life cycle assessment and green process metrics. c. Environmental management systems: ISO and European Eco-Management and Audit Scheme, eco-labels, green chemical supply, Strategies, Legislation and integrated pollution prevention and control.	6
	4. Catalytic processes and Green Chemistry a. Introduction to catalysis and comparison of catalyst types. b. Heterogeneous catalysts: Basics of heterogeneous catalysis, Zeolites and the bulk chemical industry, heterogeneous	10

	catalysis in the fine chemical and pharmaceutical industries. Catalytic converters. c. Homogeneous catalysis: Transition metal catalysts with phosphine ligands, greener Lewis acids and asymmetric catalysis. d. Phase transfer catalysis: Hazard reduction, C – C bond formation and oxidation using hydrogen peroxide. e. Biocatalysis and photocatalysis.	
	5. Organic Solvents: Environmentally Benign Solutions a. Organic solvents and volatile organic components, solvent free systems. b. Supercritical fluids: supercritical carbon dioxide and supercritical water. c. Water as a reaction solvent and water-based coatings. d. Ionic liquids as catalysts and solvents. e. Fluorous biphase solvents. f. Deep eutectic solvents	10
	6. Renewable Resources a. Biomass as a renewable resource. Energy: Fossil fuels, biomass, solar power, fuel cells and other forms of renewable energy. b. Chemicals and polymers from renewable feedstock. c. Alternative economies: the syngas economy and the biorefinery.	6
	7. Greener Technologies and Alternative Energy Sources a. Design for energy efficiency b. Photochemical reactions: advantages of and challenges faced by photochemical processes, examples of photochemical reactions. c. Chemistry using Microwaves: microwave heating and microwave-assisted reactions. d. Sonochemistry and green chemistry examples. e. Electrochemical synthesis and examples. f. Flow chemistry	10
	8. Industrial case studies a. A brighter shade of green: synthesis of stilbene intermediates for optical brightners. b. Greening of acetic acid manufacture, EPDM rubbers and Vitamin C. c. Leather manufacture: tanning and fatliquoring. d. Dyeing to be green: some manufacturing and products improvement and dye application.	6

	e. Polyethene: Radical process, Ziegler – Natta and metallocene catalysis. f. Eco-friendly pesticides.	
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. 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, Ed. 1998. 5. R. Sanghi and M. M. Srivastava, Green Chemistry: Environment Friendly Alternatives, Narosa Publishing House, Ed. 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, Anamaya Publishers, New Delhi, 2004. 8. P. G. Jessop and W. Leitner, Chemical Synthesis using Supercritical fluids, Wiley – VCH, Verlag, Ed., Weinheim, 1999. 9. K. Tanaka, Solvent Free Organic Synthesis, Wiley – VCH GmbH and Co. KgaA, Weinheim, 2003. 10. P. T. Anastas and J. C. Warner, Green Chemistry, Theory and Practice, Oxford University Press, N. York, 1998. 11. C - Jun Li and T – Hang Chan, Organic Reactions in Aqueous Media, John Wiley and Sons INC., N. York, 2001. 12. F. Z. Dorwald, Organic Synthesis on Solid Phase, Wiley – VCH Verlag, Weinheim, 2002. 13. P. Wasserscheid and T. Welton, Ionic Liquids in Synthesis, Wiley – VCH Verlag, Ed., Weinheim, 2003. 14. A. Loupy, Microwaves in Organic Synthesis, Wiley – VCH Verlag, Weinheim, (Ed.), 2002. 15. R. V. Eldik and F. G. Klarner, High Pressure Chemistry, Wiley – VCH Verlag, (Eds.), Weinheim, 2002. 16. F. Darvas, G. Dorman, V. Hessel, Flow Chemistry - Fundamentals: Vol.1, De Gruyter, 1st Ed. 2014.	
Course Outcome:	1. Students will be in a position to understand how chemistry can be done using greener alternatives 2. Students will be in a position to apply green technologies as a sustainable solution for making molecules	

	3. Students will be able to understand and apply the concepts of green chemistry to develop scalable processes in industry 4. Students will understand various renewable resources

Name of the Programme: M.Sc. Part-II (Organic Chemistry)

Course Code: CHO-624 **Title of the course:** Chemistry of Life

Number of Credits: 4

Effective from AY: 2023-24

Prerequisites for the course	Students should have studied M.Sc. Part-I Chemistry/Biochemistry.	
Course Objective:	1. Introduction to the chemistry of amino acids, proteins, carbohydrates, lipids and their applicability in daily life. 2. Understanding chemicals used in food production through food processing, storage and cooking. 3. Understanding food analysis and the chemistry of the digestion of food and energy provided by food.	
Content	**1. Chemistry of Proteins: Structure, function and food analysis** a. Introduction to amino acids and role of polar, non-polar, acidic and basic side chains, their properties and Isoelectric point b. Introduction to peptides, dipeptides and proteins, types of proteins [primary (1˚), secondary (2˚), tertiary, (3˚) and Quaternary (4˚)]: hydrogen bonding, salt bridges, hydrophobic - non-polar interactions and disulfide linkages c. Protein folding, denaturation and functional properties of proteins. d. Food Proteins – Source of Proteins, Analysis of amino acids and proteins in food	No of hours 10
	2. Chemistry of Nucleic Acids Brief history of sugars and bases, conformation of sugar-phosphate backbone, hydrogen bonding by bases, the double helix: A,B, and Z double helices, stability of double helix, DNA intercalators, chemical synthesis of DNA, catalytic RNA, siRNA, micro RNA	15
	3. Chemistry of Carbohydrates and Lipids: Structure, function and food Analysis **a. Carbohydrates** i. Introduction to mono-, di- and oligosaccharides, polysaccharides: starch, dietary, fibre, their physical function. ii. Fischer projections, Haworth Projections, stereoisomerism in carbohydrates. iii. Food Carbohydrates – Source of carbohydrates, Analysis of carbohydrates in food iv. Sugars: Hydrolysis, thermal degradation, Maillard reaction (non-enzymic browning reaction between reducing carbohydrates and proteins), Amadori Rearrangement and Analysis of Sugars, Mutarotation	20

	b. Lipids i. Introduction to lipids, types of lipids and fatty acids ii. Monoglycerides, diglycerides, triglycerides, polar lipids iii. Reactions of fatty acids - Oxidative and hydrolytic rancidity iv. Sources of fats and analysis in food	
	4. Chemistry of Enzymes a. Introduction to Enzyme Catalysis and Kinetics b. The Catalytic Triad c. Enzyme Inhibition and Drug design d. Enzymes in Organic Synthesis e. Antibody Catalysed Organic Reaction f. Enzyme Models: Biomimetic Polyene Cyclisation and Squalene Biosynthesis	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. J. Clayden, N. Greeves, & S. Warren. Organic Chemistry, 2nd Ed., Oxford University Press, 2012. 2. T. P. Coultate, Food - The Chemistry of its Components, Royal Society of Chemistry, 5th Ed., 2009. 3. H. D. Belitz. & W. Grosch, Food Chemistry, 4th Ed., Springer, 2009. 4. B. Selinger, Chemistry in the Marketplace, 3rd Ed., Harcourt Brace, 1986. 5. O. R. Fennema, Food Chemistry, 4th Ed., Marcel Dekker, 2008. 6. H. Dugas, Bioorganic Chemistry - A Chemical Approach to Enzyme Action, 3rd Ed. Springer, 1999. 7. R. B. Silverman, The Organic Chemistry of Enzyme-catalyzed Reactions, Academic Press, San Diego, 717 pp., 2000. 8. J. S. Davies, Amino acids, Peptides and Proteins, Royal Society of Chemistry, UK, Vol. 35, 4, 2006. 9. L. Stryer, J. M. Berg, and J. L. Tymoczko, Biochemistry, 5th Ed., W. H. Freeman & Co Ltd, 2002.	
Course Outcome:	1. Students will be in a position to predict type of proteins, lipids and carbohydrates available in food. 2. Students will be in a position to explore the chemical structure and functionality for the macronutrient categories like carbohydrates, lipids, and proteins in food 3. Student will be able to design experiments through an inquiry-oriented, food chemistry focused laboratory program. 4. The students will be able to identify the essential chemical components of food and have knowledge of their analyses, and gain knowledge of the chemistry of lipids, carbohydrates and proteins	

Name of the Programme: M.Sc. Part-II (Organic Chemistry)

Course Code: CHO-625 **Title of the course:** Organometallic Chemistry and Rearrangement Reactions

Number of Credits: 4

Effective from AY: 2023-24

Prerequisites for the course:	Students should have studied chemistry courses at M.Sc. Part-I level.	
Course Objective:	1. To understand concepts and various strategies involved in organometallic chemistry. 2. To apply organometallic chemistry in the formation of carbon-carbon, carbon-hetero atom bonds. 3. To understand and apply molecular rearrangements for synthetic applications.	
Content	**1. Introduction to organometallic chemistry** a. Introduction to Organometallic Chemistry, Definitions, Types of Metal-carbon bonds with main-group metals and transition metals b. *Sigma* and *pi* bonds: linear pi system and cyclic pi system c. Organic ligands, Nomenclature, heptacity, Electron counting and 18-electron rule d. Orbital interactions and bonding e. Kinetic stability	No of hours 08
	2. Organometallic compounds of main group elements a. Preparation, properties and applications of Lithium Magnesium, Cadmium, Zinc, Cerium, Mercury and Chromium Compounds. b. Heteroatom directed lithiation reactions	12
	3. Role of transition metals in organic synthesis a. Preparation and properties of Copper, Palladium, Nickel, Rhodium, Ruthenium and Gold reagents/complexes. b. Mechanisms and applications of Mizoroki-Heck, Suzuki, Stille, Hiyama, Negishi, Sonogashira, Wacker, Kumada, Buchwald-Hartwig, carbonylation, homogenous hydrogenation, carbonylation, allylic substitution)	20
	4. Molecular rearrangements and their synthetic applications a. Unifying principles and mechanisms of rearrangements taking place at an electron deficient and electron rich substrates. b. Rearrangements taking place at carbon: Arndt-Eistert, Wagner-Meerwein, benzil-benzilic acid, Pinacol-pinacolone, semipinacol, Tiffeneau Demjanov, dienone-phenol, Wittig, Favorskii, Stevens, Wolff, Baker-Venkatraman, Barton	20

	decarboxylation, Pummerer rearrangement. c. Rearrangements at nitrogen: Hofmann, Curtius, Lossen, Schmidt, Beckmann, Neber, Stieglitz rearrangement. d. Rearrangements at oxygen: Payne (including aza- and thia-Payne) rearrangement, hydroperoxide rearrangement, Criegee rearrangement, Baeyer–Villiger oxidation e. Aromatic rearrangements: Benzidine, Fries, Von Richter, Sommelet-Hauser, Smile's, Jacobsen. Rearrangement on aniline derivatives- Bamberger rearrangement, Fischer-Hepp, Orton, Hofmann-Martius, Reilly-Hickinbottom, rearrangements of *N*-arylazoanilines, Phenylnitramines, Phenylsulfamines. f. Rearrangements involving fragmentations: Eschenmoser fragmentation.	
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. A. Edward, Comprehensive Organometallic Chemistry, 2nd Ed., 14 vols. Pergman, 1995. 2. F. R. Hartley, Chemistry of Metal-Carbon Bond, 6 vols. Wiley, 1982-83. 3. M. Schlosser, Organometallics in Synthesis - A Manual, John & Wiley, 1994. 4. R. H. CraJohn, The Organometallic Chemistry of the Transition Metals, Wiley, 1994. 5. G. R. Stephenson, Transition Metal Organometallics for Organic Synthesis, Cambridge University Press, 1991. 6. L. S. Liebeskind, Advances in Metal Organic Chemistry, Vols. 1 and 2 (Ed.), JAI Press, 1989. 7. J. P. Colliman, L. S. Hegedus, J. R. Norton & R. G. Finke, Principles and Applications of Organotransition Metal Chemistry, University Science Books, 1987. 8. A. Yamamoto, Organotransition Metal Chemistry - Fundamental Concepts and Applications, Wiley, 1986. 9. A. J. Pearson, Metallo-Organic Chemistry, John Wiley, 1985. 10. W. Caruthers & I. Colddham, Modern Methods of Organic Synthesis, 4th Ed., Cambridge University Press, 2016. 11. J. Clayden, N. Greeves and S. Warren, Organic Chemistry, Oxford, 2016. 12. F. A. Carey & R. J. Sundberg, Advanced Organic Chemistry: Part A and B, 5th Ed., Springer India Private Limited, 2007. 13. R. O. C. Norman & J. M. Coxon, Principles of Organic Syntheses, 3rd Ed. CRC Press Inc, 2009. 14. M. B. Smith & Jerry March, Advanced Organic Chemistry- 50 Reaction, Mechanism and Structure, 6th Ed., Wiley, 2006.	

Course Outcome:	1. Students will be in a position to understand how a carbon-carbon and carbon-hetero atom bonds can be constructed using organometallic chemistry. 2. Students will be able to understand and apply the concepts of organometallic chemistry in syntheses of organic molecules. 3. Students will be in a position to write synthetic routes for organic molecules using various molecular rearrangements.

Name of the Programme: M.Sc. Part-II (Chemistry)

Course Code: CHC-600 **Title of the course:** Research Methodology and instrumental techniques-I

Number of Credits: 4

Effective from AY: 2023-24

Prerequisites for the course:	Students should have studied chemistry courses at MSc-I level.	
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.	
Content	**1. Introduction to Research Methodology** 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
	2. Scientific conduct and ethics Ethics: definition, nature of moral judgements and reactions, Ethics with respect to science and research. Intellectual honesty and research integrity. Scientific misconducts: Falsification, Fabrication, and Plagiarism (FFP). Redundant publications: duplicate and overlapping publications. Selective reporting and misrepresentation of data.	5
	3. Academic writing Publication ethics: definition, introduction and importance Conflicts of interest Publication misconduct: definition, concept, problems that lead to unethical behaviour and vice versa Violation of publication ethics, authorship and contributorship Identification of publication misconduct, complaints and appeals Predatory publishers and journals	5

	4. 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
	5. Safety aspects in Chemistry Good laboratory practices. Handling of various chemicals, solvents & glassware. Fires and fighting with fires. Hazardous substances, classification and handling Safety Data Sheet	5
	6. Softwares in Chemistry Data plotting Structure Drawing Reference management software	7
	7. Instrumental methods of analysis: Demonstration and/ or data analysis in following techniques: Elemental analysis: CHNS analysis and AES Infrared (IR), Raman, Ultraviolet-Visible (UV-Vis) Nuclear magnetic resonance (^{1}H, ^{13}C) Chromatographic techniques: HPLC, GC, Hyphenated Techniques: LC-MS & GC-MS, Diffraction methods: XRD Thermal analysis: DSC Microscopy: SEM, TEM Methods for determination of magnetic & dielectric properties. Cyclic voltammetry	30
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, Philosophy of Science, Routledge, 2006. 3. M. Coghill & L. R. Garson, The ACS Style Guide: Effective Communication of Scientific Information, American Chemical Society Washington, DC & OXFORD University Press New York, 2006. 4. Y. K. Singh, Fundamentals of Research Methodology & Statistics, New Age International Pvt. Ltd., 2006. 5. National Research Council, Prudent practices in the laboratory: handling and management of chemical hazards, The National	

	Academies Press, USA, 2011. 6. B. S. Furniss, A. J. Hannaford, P. W. G. Smith & A. R. Tatchell, Vogel's Text book of Practical Organic Chemistry, 5th Ed.; Longmann, 1989 7. E. A. V. Ebsworth, D. W. H. Rankin & S. Craddock, Structural Methods in Inorganic Chemistry, Blackwell Scientific Publishers. 1986. 8. R. S. Drago, Physical Methods in Chemistry, 2nd Ed. W. B. Saunders Co. Ltd. 2016 9. R. M. Silverstein, F. X. Webster; Spectrometric identification of Organic Compounds; 6th Ed, Wiley, 2011. 10. J. Mendham, R. C. Denny, J. D. Barnes & M. Thomas, Vogel's Textbook of Quantitative Chemical Analysis, 6th Ed.; Pearson Education Asia, 2002. 11. H. V. Keer, Principles of the Solid State, 1st Ed. New Age International (P) Ltd., 2005. 12. G. D. Christian, Analytical Chemistry, 6th Ed.; Wiley, 2004. 13. Skoog, D. M. West, F. J. Holler, S. R. Crouch, Fundamentals of Analytical Chemistry, 9th Ed.; Cengage learning. 14. Skoog, F. J. Holler, S. R. Crouch, Principles of Instrumental Analysis, 7th Ed.; Cengage learning. 15. P. G. Lampman, G. Kriz and J. Vyvyan, Introduction to Organic Spectroscopy, 5th Ed.; Cengage Learning, 2015. 16. N. Elgrishi,´ K. J. Rountree, B. D. McCarthy, E. S. Rountree, T. T. Eisenhart, and J. L. Dempsey, A Practical Beginner's Guide to Cyclic Voltammetry, J. Chem. Educ. ACS, 2018, 95, 197−206. 17. V. Rajaraman, Computer Programming in Fortran 90 And 95, PHI Learning Pvt. Ltd., 2013. 18. Szabo, N. S. Ostlund, Modern Quantum Chemistry: Introduction to Advanced Electronic Structure Theory, Dover Publications, Inc. Mineola, 1989.
Course Outcome:	1. Students will be able to apply research methodology concepts. 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.

Name of the Programme: M.Sc. Part-II (Chemistry)

Course Code: CHC-601 **Title of the course:** Research Methodology and instrumental techniques-II

Number of Credits: 4

Effective from AY: 2023-24

Prerequisites for the course:	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.	
Content	**1. Research Methodology, Scientific conduct, ethics & academic writing** 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. Ethics: definition, nature of moral judgements and reactions, Ethics with respect to science and research. Intellectual honesty and research integrity. Scientific misconducts: Falsification, Fabrication, and Plagiarism (FFP). Redundant publications: duplicate and overlapping publications. Selective reporting and misrepresentation of data. Publication ethics: definition, introduction and importance Conflicts of interest Publication misconduct: definition, concept, problems that lead to unethical behaviour and vice versa Violation of publication ethics, authorship and contributorship Identification of publication misconduct, complaints and appeals Predatory publishers and journals	No of hours 15
	2. Softwares in chemistry, Data bases and Research metrics	10

	Data plotting using GNU plot; Structure Drawing using ChemSktech; Reference management software such as Mendeley and Zotero. Databases: Indexing databases, Citation databases: Web of Science, Scopus, UGC-Care List, Scimago etc. Research Metrics: Impact Factor of journal as per Journal Citation Report, SNIP, SJR, IPP, Cite Score; Metrics: h-index, g-index, i10-index etc Molecular Docking software	
	3. Safety practices in Chemical research Introduction to lab safety. Handling of various chemicals, solvents & glassware. Fires and fighting with fires. Hazardous substances, classification and handling Safety Data Sheet	5
	4. Instrumental methods UV-Visible spectroscopy in elucidation of mechanisms of C-H activation reactions, epoxidation etc by transition metal catalyst. Understanding water oxidation reaction using Cyclic voltammetry (CV) & Linear Sweep voltammetry (LSV) Determining capacity of supercapacitors using Galvanostatic Charge-Discharge (GCD) Electrochemical Impedance Spectroscopy (EIS) Resonance Raman and isotope labelling studies. Infrared (IR) spectroscopy applications ^{1}H, ^{13}C- NMR spectroscopy and applications Selected chromatographic techniques such as HPLC, GC. Hyphenated Techniques/applications: LC-MS, GC-MS, LC-NMR-MS, GC-IR, ICP-MS Diffraction methods: High temperature XRD Thermal analysis: TG/DTA/DSC Microscopy: Fe-SEM, HR-TEM Methods for determination Ms, Mr, Hc, Tc, ε^{l} and Tanδ. Potentiometry	30
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, Philosophy of Science, Routledge, 2006. 3. M. Coghill & L. R. Garson, The ACS Style Guide: Effective Communication of Scientific Information, American Chemical Society Washington, DC & OXFORD University Press New	

	York, 2006. 4. Y. K. Singh, Fundamentals of Research Methodology & Statistics, New Age International Pvt. Ltd., 2006. 5. National Research Council, Prudent practices in the laboratory: handling and management of chemical hazards, The National Academies Press, USA, 2011. 6. B. S. Furniss, A. J. Hannaford, P. W. G. Smith & A. R. Tatchell, Vogel's Text book of Practical Organic Chemistry, 5th Ed.; Longmann, 1989 7. E. A. V. Ebsworth, D. W. H. Rankin & S. Craddock, Structural Methods in Inorganic Chemistry, Blackwell Scientific Publishers. 1986. 8. R. S. Drago, Physical Methods in Chemistry, 2nd Ed. W. B. Saunders Co. Ltd. 2016 9. R. M. Silverstein, F. X. Webster; Spectrometric identification of Organic Compounds; 6th Ed, Wiley, 2011. 10. J. Mendham, R. C. Denny, J. D. Barnes & M. Thomas, Vogel's Textbook of Quantitative Chemical Analysis, 6th Ed.; Pearson Education Asia, 2002. 11. H. V. Keer, Principles of the Solid State, 1st Ed. New Age International (P) Ltd., 2005. 12. G. D. Christian, Analytical Chemistry, 6th Ed.; Wiley, 2004. 13. Skoog, D. M. West, F. J. Holler, S. R. Crouch, Fundamentals of Analytical Chemistry, 9th Ed.; Cengage learning. 14. Skoog, F. J. Holler, S. R. Crouch, Principles of Instrumental Analysis, 7th Ed.; Cengage learning. 15. Pavia, G. Lampman, G. Kriz and J. Vyvyan, Introduction to Organic Spectroscopy, 5th Ed.; Cengage Learning, 2015. 16. N. Elgrishi,´ K. J. Rountree, B. D. McCarthy, E. S. Rountree, T. T. Eisenhart, and J. L. Dempsey, A Practical Beginner's Guide to Cyclic Voltammetry, J. Chem. Educ. ACS, 2018, 95, 197−206. 17. V. Rajaraman, Computer Programming in Fortran 90 And 95, PHI Learning Pvt. Ltd., 2013. 18. Attila Szabo, Neil S. Ostlund, Modern Quantum Chemistry: Introduction to Advanced Electronic Structure Theory, Dover Publications, Inc. Mineola, 1989. 19. Leach, Molecular Modelling, Principles and applications, Longman, 1998. 20. W. Nam et al, Dioxygen activation by Metalloenzymes & models, Accounts of Chemical Research, 2007, Volume 40 & references cited therein.
Course Outcome:	1. Students will be familiar with research methodology concepts. 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.

Name of the Programme: M.Sc. Part-II (Chemistry)

Course Code: CHC-651 **Title of the course:** Discipline Specific Dissertation

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.	