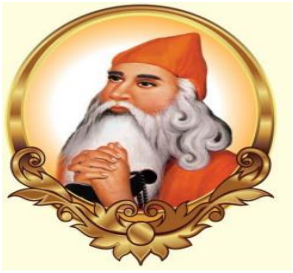

Department of Chemistry

Scheme and Syllabi of Master of Science Chemistry Programme SEMESTER SYSTEM

Under Learning Outcome Based Curriculum Framework-Choice Based Credit System (LOCF-CBCS) as per NEP-2020 for UTD and Affiliated Colleges

(*w.e.f.* Session 2025-26)

Guru Jambheshwar University of Science &Technology
Hisar-125001, Haryana

(A^+ NAAC Accredited State Govt. University)

DEPARTMENT OF CHEMISTRY
GURU JAMBHESHWAR UNIVERSITY OF SCIENCE AND TECHNOLOGY, HISAR

Scheme and Syllabi of
Master of Science Chemistry Programme
(*w.e.f.* Session 2025-26)

Name of the Programme: Master of Science Chemistry
Under Learning Outcome Based Curriculum Framework-Choice Based Credit System (LOCF-CBCS) as per NEP-2020

Duration of the Programme: Two Years (Four Semesters)
Total Credits for the Programme: 100 Credits

Sr. No	Course	Credits								Total Credits	Total Marks
		First Semester		Second Semester		Third Semester		Fourth Semester			
		Theory	Practical	Theory	Practical	Theory	Practical	Theory	Practical / Project		
1.	Discipline Specific Course (DSC)	12	12	12	12	4	-	-	-	52	1300
2.	Discipline Elective Course (DEC)	-	-	-	-	8	8	12* / 8#	8* / 12#	36	900
3.	Open Elective Course (OEC)/ Value Added Course (VAC)/ Skill Enhancement Course (SEC)/ Employability and Entrepreneurship Skills Course (EEC)	2	-	-	-	2	-	2	-	06	150
4.	Seminar	-	-	2	-	-	-	-	-	02	50
5.	Internship	-	-	-	-	4	-	-	-	04	100
Grand Total		**26**		**26**		**26**		**22**		**100**	**2500**

***For Option A (for the students who opt Practicum).**
 # For Option B (for the students who opt Project work).

SEMESTER - I

Sr. No	Type of Course	Course Code	Nomenclature	Credits	Hours/ Week	Marks			Exam Hrs
						External	Internal	Total	
1.	Discipline Specific Course (DSC)	U25CHE101T	Bonding and Properties of Inorganic Compounds	4	4	70	30	100	3
2.	Discipline Specific Course (DSC)	U25CHE102T	Structure and Mechanism in Organic Chemistry-1	4	4	70	30	100	3
3.	Discipline Specific Course (DSC)	U25CHE103T	Thermodynamics and Electrochemistry	4	4	70	30	100	3
4.	Discipline Specific Course (DSC)	U25CHE104P	Inorganic Chemistry Practical-I	4	8	70	30	100	6
5.	Discipline Specific Course (DSC)	U25CHE105P	Organic Chemistry Practical-I	4	8	70	30	100	6
6.	Discipline Specific Course (DSC)	U25CHE106P	Physical Chemistry Practical-I	4	8	70	30	100	6
7.	Value Added Course (VAC)		To be opted from Pool of VAC	2	2	35	15	50	2
				26	**38**	**455**	**195**	**650**	

SEMESTER - II

Sr. No	Type of Course	Course Code	Nomenclature	Credits	Hours/ Week	Marks			Exam Hrs
						External	Internal	Total	
1.	Discipline Specific Course (DSC)	U25CHE201T	Transition Metal Chemistry	4	4	70	30	100	3
2.	Discipline Specific Course (DSC)	U25CHE202T	Structure and Mechanism in Organic Chemistry-II	4	4	70	30	100	3
3.	Discipline Specific Course (DSC)	U25CHE203T	Quantum Chemistry and Chemical Kinetics	4	4	70	30	100	3
4.	Discipline Specific Course (DSC)	U25CHE204P	Inorganic Chemistry Practical-II	4	8	70	30	100	6
5.	Discipline Specific Course (DSC)	U25CHE205P	Organic Chemistry Practical-II	4	8	70	30	100	6
6.	Discipline Specific Course (DSC)	U25CHE206P	Physical Chemistry Practical-II	4	8	70	30	100	6
7.	Seminar	U25CHE201S	Seminar	2	2	50	---	50	----
8.	**Internship**	**U25CHE201I**	**Internship**	**4[#]**	**4 Weeks (Total 120 Hrs.) [#]**	**100[#]**	**---**	**100[#]**	----
				26 + 4[#]		**470 + 100[#]**	**180**	**650 + 100[#]**	

Note: **Internship of 4 credits of 4 weeks (120 Hrs.) duration after 2nd semester is mandatory for each student either for enhancing the employability or for developing research aptitude.**

[#]Four credits of internship, earned by a student during summer internship after 2nd semester, will be taken into account in 3rd semester of a student who pursue 2 years PG (Master of Science Chemistry) Programme without taking exit option.

SEMESTER - III

Sr. No	Type of Course	Course Code	Nomenclature	Credits	Hours/ Week	Marks			Exam Hrs
						External	Internal	Total	
1.	Discipline Specific Course (DSC)	U25CHE301T	Applications of Spectroscopy	4	4	70	30	100	3
2.	Discipline Elective Course (DEC)	U25CHE311T (IC)*	Organometallic Chemistry	4	4	70	30	100	3
		OR							
		U25CHE311T (OC) **	Heterocyclic and Photochemistry						
		OR							
		U25CHE311T (PC) ***	Surface Chemistry and Non-Equilibrium Thermodynamics						
3.	Discipline Elective Course (DEC)	U25CHE312T (IC) *	Chemical Analysis and Inorganic Spectroscopy	4	4	70	30	100	3
		OR							
		U25CHE312T (OC) **	Bioorganic and Natural Products Chemistry						
		OR							
		U25CHE312T (PC) ***	Quantum Chemistry and Group Theory						
4.	Discipline Elective Course (DEC)	U25CHE313P (IC) *	Inorganic Chemistry Practical-III	4	8	70	30	100	6
		OR							
		U25CHE313P (OC) **	Organic Chemistry Practical-III						
		OR							
		U25CHE313P (PC) ***	Physical Chemistry Practical-III						
5.	Discipline Elective Course (DEC)	U25CHE314P (IC) *	Inorganic Chemistry Practical-IV	4	8	70	30	100	6
		OR							
		U25CHE314P (OC) **	Organic Chemistry Practical-IV						
		OR							
		U25CHE314P (PC) ***	Physical Chemistry Practical-IV						
6.	Open Elective Course (OEC)		To be opted from Pool of Open Elective Course (OEC)	2	2	35	15	50	2
				22	**30**	**385 + 100[#] = 485**	**165**	**650**	**---**

[#]100 Marks of internship, earned by a student during summer internship after 2nd semester, will be taken into account in 3rd semester of a student who pursue 2 years PG (Master of Science Chemistry) Programme without taking exit option.

SEMESTER – IV

OPTION A#

Sr. No	Type of Course	Course Code	Nomenclature	Credits	Hours/ Week	Marks			Exam Hrs
						External	Internal	Total	
1.	Discipline Specific Course (DSC)	U25CHE401T	Instrumental Methods of Analysis	4	4	70	30	100	3
2.	Discipline Elective Course (DEC)	U25CHE411T (IC) *	Photo and Bioinorganic Chemistry	4	4	70	30	100	3
		OR							
		U25CHE411T (OC) **	Organic Synthesis						
		OR							
		U25CHE411T (PC) ***	Solid State and Biophysical Chemistry						
3.	Discipline Elective Course (DEC)	U25CHE412T (IC) *	Chemistry of Materials	4	4	70	30	100	3
		OR							
		U25CHE412T (OC) **	Medicinal Chemistry						
		OR							
		U25CHE412T (PC) ***	Physical Polymer Chemistry						
4.	Discipline Elective Course (DEC)	U25CHE413P (IC) *	Inorganic Chemistry Practical-V	4	8	70	30	100	6
		OR							
		U25CHE413P (OC) **	Organic Chemistry Practical-V						
		OR							
		U25CHE413P (PC) ***	Physical Chemistry Practical-V						
5.	Discipline Elective Course (DEC)	U25CHE414P (IC) *	Inorganic Chemistry Practical-VI	4	8	70	30	100	6
		OR							
		U25CHE414P (OC) **	Organic Chemistry Practical-VI						
		OR							
		U25CHE414P (PC) ***	Physical Chemistry Practical-VI						
6	Skill Enhancement Course (SEC)/ Employability and Entrepreneurship Skills Course (EEC)/ Vocational Course (VOC)		*To be opted from Pool of SEC/ EEC/ VOC*	2	2	35	15	50	2
				22	**30**	**385**	**165**	**550**	

OPTION B#

Sr. No	Type of Course	Course Code	Nomenclature	Credits	Hours/ Week	Marks			Exam Hrs
						External	Internal	Total	
1.	Discipline Elective Course (DEC)	U25CHE411T (IC) *	Photo and Bioinorganic Chemistry	4	4	70	30	100	3
		OR							
		U25CHE411T (OC) **	Organic Synthesis						
		OR							
		U25CHE411T (PC) ***	Solid State and Biophysical Chemistry						
2.	Discipline Elective Course (DEC)	U25CHE412T (IC) *	Chemistry of Materials	4	4	70	30	100	3
		OR							
		U25CHE412T (OC) **	Medicinal Chemistry						
		OR							
		U25CHE412T (PC) ***	Physical Polymer Chemistry						
3.	Discipline Elective Course (DEC)	U25CHE401R	Project Work	12	24	300	---	300	----
4.	Skill Enhancement Course (SEC)/ Employability and Entrepreneurship Skills Course (EEC)/ Vocational Course (VOC)		*To be opted from Pool of SEC/ EEC/ VOC*	2	2	35	15	50	2
				22	**34**	**475**	**75**	**550**	

*** = SET-A; ** = SET-B; *** = SET-C.**

In SEMESTER – III and SEMESTER – IV, the candidates will opt only one SET i.e. SET-A *or* ***SET-B*** *or* ***SET-C*** *as per the procedure adopted/ decided/ implemented by the department.*

\# *In* ***SEMESTER-IV****, students will opt only one option i.e.* ***OPTION A*** *or* ***OPTION B****.*

Notes:

(i) A student for the PG Programme shall be required to undergo 4 credits internship of minimum of 4-6 weeks duration during summer vacation after second semester examination. If she/he opts to exit with 1-year PG Diploma after second semester of 2-year PG Programme, then she/he has to complete Internship course before exit. However, the student, who has taken lateral entry into the 2nd year (i.e. 3rd semester) of PG Programme, need not to repeat the Internship course, if already completed.

(i) A student will be allowed an exit option after passing first academic year of the PG Programme with requisite 56 credits including the 4 credits of internship of minimum of 4 weeks duration as per scheme of the programme and will be awarded a Post Graduate Diploma in Chemistry.

(ii) A student will be awarded with Master of Science Chemistry after successfully completing two academic years of PG Programme and earning requisite 100 credits including the 4 credits of internship of minimum of 4 weeks duration as per scheme of the programme.

(iii) A student will be awarded with Master of Science Chemistry after successful completion of two semesters of 1-year PG Programme by earning 44-52 credits in the case of lateral entry to second year of PG programme after 4-year Bachelor Degree (Honours) or 4-year Bachelor Degree (Honours with Research) or after 1-year PG Diploma in the concerned subject as per the eligibility conditions.

(iv). The internship will be governed by the prevailing rules of the University from time to time.

(v). A student who opts for Dissertation/Project work of 12 credits in 4th /2nd semester of 2-year/1-year PG Programme will be required to do the research work based on systematic, scientific and rigorous investigations on the chosen and approved topic utilizing relevant research methods/techniques/innovations.

(vi) A student, who opts for Dissertation/Project work in 4th semester of PG Programme, shall submit a request for allotment of supervisor mentioning her/his research areas of interest in order of preference to the Chairperson/Principal/Director during 3rd semester. The Department shall allot a qualified supervisor to guide the student for doing research during Project/Dissertation work. A regular full-time teacher of that Department, who is eligible to supervise Ph.D. scholars as per ordinance of Doctor of Philosophy of the university, will be eligible to guide the students for Dissertation/Project work.

(vii) The student will submit the synopsis to the supervisor. In case of University Teaching Department (UTD), the synopsis will be approved by the Departmental Research Committee (DRC) after recommendation of the supervisor. External experts may be involved wherever sufficient qualified regular teachers are not available. The Chairperson shall constitute a committee of at least three members of the concerned subject for this purpose at the Department level. The committee will consist of at least one subject expert from Guru Jambheshwar University of Science and Technology, Hisar to be nominated by the Chairperson. The request for external expert should reach to the Dean of the Faculty before 30th November of the concerned year. The list of students, their approved topics, and names of supervisors along with their synopsis will have to be submitted by the Department to the respective Dean of the Faculty latest by 31st January of the concerned year.

(viii) The student shall be required to submit three hard copies of her/his dissertation along with soft copy as PDF file to the Department by 30th May of the concerned year. The late submission can be allowed with late fees as decided by the university from time to time.

(ix) The Anti-plagiarism policy of the university is to be strictly followed by the candidate and the supervisor. Similarity report as per anti-plagiarism policy of the university is to be annexed with the dissertation/project report.

(x) Evaluation of the dissertation shall be done by an external examiner. The panel of examiners for evaluation of dissertations/project reports will be approved by the respective PGBOS. The dissertation work will be of total 12 credits (300 marks) and evaluation will be done in two components; report of dissertation (200 marks) and open viva-voce examination (100 marks).

(xi) The schedule as specified above is to be strictly followed by the student and DCI and any relaxation will not be allowed. However, in exceptional and genuine cases, late submission may be allowed with a late fee, as decided by the University from time to time.

(xii). Internal Assessment (30%) shall be broadly based on the following defined components: Class Participation; Seminar/ Presentation/ Assignment/Quiz/Class Test, etc. in case of Theory examination and Seminar/Demonstration/Viva-Voce/Lab record, etc. in case of Practical examination; Mid-Term Exam.

Internal Assessment Marks will be further distributed as per following tables:

Total Internal Marks (Theory)	Class participation	Seminar/Presentation/Assignment/ Quiz/Class Test, etc.	Mid-term exam
15	5	-------	10
20	5	5	10
25	5	5	10
30	5	10	15

Total Internal Marks (Practicum)	Class participation	Seminar/Presentation/Assignment/ Quiz/Class Test, etc.	Mid-term exam
10	5	5	----
15	5	10	---
25	5	10	10
30	5	10	15

(xii). The students who have failed in Internal Assessment/Minor Test will have to get aggregate forty percent marks in the End-Semester examination with no option of improvement of internal assessment.

(xiii) The medium of instructions shall be mainly English. Hindi medium may be offered wherever feasible and approved by the university. The question paper shall be set in English. Bilingual question paper (s) will be provided, wherever feasible and approved by the university. The certificate for medium of instruction if required by the student will be issued by the Chairperson of the concerned Department.

Guru Jambheshwar University of Science and Technology Hisar-125001, Haryana
('A^{+}' NAAC Accredited State Govt. University)

Scheme and Syllabi of Open Elective Courses (OEC), Value Added Courses (VAC)/ Skill Enhancement Courses (SEC)/ Employability and Entrepreneurship Skills Courses (EEC)

Under Learning Outcome Based Curriculum Framework- Choice Based Credit System

(LOCF-CBCS) as per NEP-2020 for UTD and Affiliated Colleges

offered by

Department of Chemistry
***w.e.f.* Session 2025-26**

Subject: Chemistry
(1st and 2nd Year)

Value Added Courses (VAC)

Semester	Course Code	Nomenclature	Credits	Hours/ Week	Marks			Exam Hours
					External	Internal	Total	
Semester - I	U25VAC107T	Role of Chemistry in Society	2	2	35	15	50	2

Open Elective Courses (OEC)

Semester	Course Code	Nomenclature	Credits	Hours/ Week	Marks			Exam Hours
					External	Internal	Total	
Semester - III	U25OEC307T	Introduction to Spectroscopy	2	2	35	15	50	2

Skill Enhancement Courses (SEC)

Semester	Course Code	Nomenclature	Credits	Hours/ Week	Marks			Exam Hours
					External	Internal	Total	
Semester - IV	U25SEC407P	Water Analysis Lab	2	2	35	15	50	2

Vocational Courses (VOC)

Semester	Course Code	Nomenclature	Credits	Hours/ Week	Marks			Exam Hours
					External	Internal	Total	
Semester - IV	U25VOC407P	Extraction of Natural Products Lab	2	2	35	15	50	2

Employability and Entrepreneurship Skills Courses (EEC)

Semester	Course Code	Nomenclature	Credits	Hours/ Week	Marks			Exam Hours
					External	Internal	Total	
Semester - IV	U25EEC407T	General Polymer Chemistry	2	2	35	15	50	2

Master of Science Chemistry
1st Semester
Bonding and Properties of Inorganic Compounds

Course code: U25CHE101T

60 Hrs (4Hrs /week)	**Marks for Major Test (External): 70**
Credits: 4	**Marks for Internal Exam: 30**
Time of Examination: 3 Hrs	**Total Marks: 100**

Note: *The examiner is required to set nine questions in all. The first question will be compulsory consisting of seven short questions covering the entire syllabus consisting of 2 marks each. In addition to this, eight more questions (each question may be of 2-3 parts) will be set consisting of two questions from each unit. The student/candidate is required to attempt five questions in all, selecting one from each unit consisting of 14 marks and the compulsory Question No.1.*

Objectives: This course enables the students to develop an in-depth understanding of bonding theories in coordination complexes, chemistry of f-block and non-transition elements, and chemical behavior in non-aqueous solvents, with emphasis on structural, electronic, and magnetic properties, as well as reactivity patterns.

Unit-I **15 Hrs**

Theories of Bonding in Co-ordination Complexes
Valence bond theory, electro neutrality principle and limitations, crystal field theory splitting of d-orbitals in cubic, octahedral, tetragonal, tetrahedral and square planar ligand environments. Structural consequences of splitting of d-orbitals, Jahn Teller theorem, trends in ionic radii, lattice energy and heat of ligation. Structure of spinels. MOT with σ and π bonding.

Unit-II **15 Hrs**

Chemistry of Lanthanides and Actinides
Extraction and applications, colour and spectra, magnetic properties, binary and ternary compounds, oxo salts, cyclopentadienyl compounds, Low oxidation state compounds, Lanthanide contraction, Use of lanthanide compounds as shift reagents.
General properties, oxidation states, dioxoions, chemistry of actinium, thorium, protactinium, uranium, uranyl and cyclopentadienyl compounds, transuranic elements, later actinide elements.

Unit-III **15 Hrs**

Chemistry of Non-Transition Elements
General discussion on the properties of the non-transition elements, special features of individual elements, synthesis, properties and structure of their halides and oxides, polymorphism of carbon, phosphorus and sulphur, Synthesis, properties and structure of boranes, carboranes, borazines, silicates, phosphazenes, sulphur-nitrogen compounds, oxy acids of nitrogen, phosphorus, sulphur and halogens, interhalogens, pseudohalides and noble gas compounds.

Unit-IV **15 Hrs**

Non-aqueous Solvents
Concepts of acids and bases, Hard-Soft acid base concept. Solvent system definition, reactions in non-aqueous media with respect to sulphuric acid, ammonia, sulphur trioxide, bromine trifluoride, dinitrogen tetraoxide, hydrogen fluoride, thionyl chloride and phosphoryl chloride. Mechanism of coordination reactions in non-aqueous media.

Books Suggested:

1. Advanced Inorganic Chemistry, F.A. Cotton and Wilkinson, John Wiley, 6th Ed., 1999.
2. Inorganic Chemistry, J.E. Huheey and H. Collins, 4th Ed., 1993.
3. Chemistry of the Elements, N.N. Greenwood and A. Earnshaw, Pergamon, 2nd Ed., 2011.
4. Magnetochemistry, R.L. Carlin, Springer Verlog, 1st Ed., 1986.
5. Inorganic Chemistry, G. Wulf'sburg, 4th Ed., 2000.
6. Introduction to ligand fields, B.N. Figgis, Wiley Eastern, 1st Ed., 1966.

Course outcomes:

Upon successful completion of the course, students will be able to:

CO1 Explain fundamental bonding theories including Valence Bond Theory (VBT), Molecular Orbital Theory (MOT), and Crystal Field Theory (CFT) to describe bonding in coordination and non-coordination inorganic compounds.

CO2 Analyze the electronic structure and geometry of transition metal complexes using ligand field theory and predict magnetic and spectral properties.

CO3 Correlate structure with properties such as color, magnetism, and reactivity of main group and transition metal compounds.

CO4 Interpret spectroscopic data (UV-Vis, IR, NMR) to deduce the structure and bonding characteristics of inorganic molecules and complexes.

CO5 Compare and contrast periodic trends in bonding, acid-base behavior, and oxidation states across the periodic table.

CO6 Apply symmetry and group theory concepts to assess molecular structures and predict vibrational modes.

Master of Science Chemistry
1st Semester
Structure and Mechanism in Organic Chemistry-I

Course code: U25CHE102T

60 Hrs (4Hrs /week)	**Marks for Major Test (External): 70**
Credits: 4	**Marks for Internal Exam: 30**
Time of Examination: 3 Hrs	**Total Marks: 100**

Note: *The examiner is required to set nine questions in all. The first question will be compulsory consisting of seven short questions covering the entire syllabus consisting of 2 marks each. In addition to this, eight more questions (each question may be of 2-3 parts) will be set consisting of two questions from each unit. The student/candidate is required to attempt five questions in all, selecting one from each unit consisting of 14 marks and the compulsory Question No.1.*

Objectives: This course enables the students to develop a detailed understanding of chemical bonding, stereochemistry, reaction mechanisms, and the principles governing nucleophilic substitution and elimination reactions in organic molecules, with emphasis on structural effects, reactivity, and stereoelectronic factors.

Unit-I **15 Hrs**

Nature of Bonding in Organic Molecules
Delocalized chemical bonding, conjugation, cross conjugation, resonance, hyperconjugation, tautomerism. Aromaticity in benzenoid and non-benzenoid compounds, alternant and non-alternant hydrocarbons, Hückel's rule, annulenes, anti-aromaticity, homo-aromaticity. Bonding weaker than covalent – EDA Complexes, addition compounds, crown ether complexes and cryptates, inclusion compounds, cyclodextrins, catenanes and rotaxanes.

Unit-II **15 Hrs**

Stereochemistry
Optical activity and chirality, methods of determining configuration, molecules with more than one stereogenic center, asymmetric synthesis (basic principle, auxiliary, substrate, reagent and catalyst controlled). Methods of resolution, optical purity, enantiotopic and diastereotopic atoms, groups and faces, stereospecific and stereoselective synthesis. Conformational analysis of cycloalkanes, decalins, effect of conformation on reactivity, conformation of sugars, Optical activity in the absence of chiral carbon (biphenyls, allenes and spiranes); Stereochemistry of the compounds containing nitrogen, sulphur and phosphorus.

Unit-III **15 Hrs**

Reaction Mechanism: Structure and Reactivity
Types of mechanism, types of reaction, thermodynamic and kinetic requirements for reaction, Potential energy diagrams, kinetic and thermodynamic control, the Hammond postulate, Curtin-Hammett principle, methods of determining mechanisms, Generation, structure, stability and reactivity of carbocations, carbanions free radicals, carbenes and nitrenes. Effect of structure on reactivity – resonance and field effects, steric effect. Quantitative treatments of the effect of structure on reactivity - Hammett equation and linear free energy relationship.

Unit-IV **15 Hrs**

Aliphatic Nucleophilic Substitution

The S_N2, S_N1 and SET Mechanisms; The neighbouring group mechanism, neighbouring group participation by σ and π bonds; nonclassical carbocations, phenonium ions, norbornyl system, common carbocation rearrangements; The S_Ni mechanism. Nucleophilic substitution at an allylic carbon: allylic rearrangement, aliphatic trigonal carbon: the tetrahedral mechanism. Reactivity - effects of substrate structure, attacking nucleophile, leaving group and reaction medium, phase-transfer catalysis and regioselectivity.

Elimination Reactions

The E2, E1 and E1cB mechanisms. Reactivity – effects of substrate structures, attacking base, the leaving group and the medium.

Books Suggested:

1. March's Advanced Organic Chemistry: Reactions, Mechanisms and Structure, Michael B. Smith, Wiley, 8th Ed., 2019.
2. Advanced Organic Chemistry Part A: Structure and Mechanisms, F.A. Carey and R.J. Sundberg, Springer, 5th Ed., 2008.
3. Advanced Organic Chemistry Part B: Reactions and Synthesis, F.A. Carey and R.J. Sundberg, Springer, 5th Ed., 2007.
4. A Guide Book to Mechanism in Organic Chemistry, Peter Sykes, Pearson, 6th Ed.,2003.
5. Structure and Mechanism in Organic Chemistry, C.K. Ingold, CBC Publisher & Distributors, 2nd Ed., 2018.
6. Organic Chemistry, R.T. Morrison, R.N. Boyd and S. K. Bhattacharjee, Pearson, 7th Ed., 2010.
7. Reaction Mechanism in Organic Chemistry, S.M. Mukherji and S.P. Singh revised by S.P. Singh and Om Prakash, Trinity, Revised Ed., 2015.
8. Organic Chemistry, P.Y. Bruice, Pearson, 8th Ed., 2020.
9. Organic Chemistry, J. Clayden, N. Geeves and S. Warren, Oxford University Press, 2nd Ed., 2012.
10. Organic Chemistry, T.W.G. Solomon, W.B. Fryhl and S.A. Snyder, Wiley, 12th Ed., 2017.
11. Stereochemistry of Organic Compounds, D. Nasipuri, New Age International, 3rd Ed., 2018.
12. Stereochemistry, Conformation and Mechanism, P.S. Kalsi, New Age International, 8th Ed., 2015.
13. Stereochemistry of Organic Compounds, E.L. Eliel and S.H. Wilen, Wiley Interscience, 1st Ed., 1994.
14. Organic Mechanisms: Reaction, Stereochemistry and Synthesis, R. Bruckner, Springer, 3rd Ed., 2010.

Course outcomes:

Upon successful completion of the course, students will be able to:

CO1 Understand the nature of bonding in organic molecules, basics of intermediates, principles of asymmetric synthesis and classify reaction types and mechanisms and distinguish between kinetic and thermodynamic control.

CO2 Apply concepts of stereochemistry to organic molecules for identifying chiral centers, assign absolute configurations, and apply methods for enantiomeric resolution,

CO3 Analyze organic reaction mechanisms in terms of structure and reactivity; analyze aromaticity; conformational isomerism and explain its effect on chemical reactivity, optical activity; influence of molecular structure, nucleophilicity, leaving groups, and solvent effects on substitution reactions.

CO4 Use potential energy diagrams to rationalize reaction outcomes, apply structure-reactivity relationships using resonance, inductive effects, and quantitative models such as the Hammett equation.

CO5 Describe non-covalent interactions, stereochemical features of compounds containing nitrogen, sulfur, and phosphorus, explaining complex rearrangements and non-classical carbocation intermediates in nucleophilic substitution, and differentiate between SN1, SN2, SNi, SET, and neighboring group mechanisms; distinguish E1, E2, and E1cB elimination mechanisms.

CO6 Evaluate how substrate structure, base strength, leaving group, and solvent affect elimination reactions, predict the outcome and regioselectivity of elimination reactions.

Master of Science Chemistry
1st Semester
Thermodynamics and Electrochemistry

Course code: U25CHE103T

60 Hrs (4Hrs /week)	**Marks for Major Test (External): 70**
Credits: 4	**Marks for Internal Exam: 30**
Time of Examination: 3 Hrs	**Total Marks: 100**

Note: *The examiner is required to set nine questions in all. The first question will be compulsory consisting of seven short questions covering the entire syllabus consisting of 2 marks each. In addition to this, eight more questions (each question may be of 2-3 parts) will be set consisting of two questions from each unit. The student/candidate is required to attempt five questions in all, selecting one from each unit consisting of 14 marks and the compulsory Question No.1.*

Objectives: This course enables the students to get a thorough understanding of classical and statistical thermodynamics, electrochemical principles, and their applications in chemical systems, with emphasis on energy transformations, non-ideal behavior, phase equilibria, thermodynamic properties, and electrochemical processes including interfaces, batteries, and fuel cells.

Unit-I **15 Hrs**

Classical Thermodynamics

Brief resume of concepts of laws of thermodynamics, free energy, chemical potential and entropies. Partial molar properties- partial molar free energy, partial molar volume and partial molar heat content and their significance, determination of these quantities. Concept of fugacity and determination of fugacity.

Non-ideal systems: Excess functions for non-ideal solutions. Activity, activity coefficient, Debye-Hückel theory for activity coefficient of electrolytic solutions, determination of activity and activity coefficients, ionic strength.

Application of phase rule to three component systems; second order phase transitions.

Unit-II **15 Hrs**

Statistical Thermodynamics

Concept of distribution, thermodynamic probability and most probable distribution. Ensemble averaging, postulates of ensemble averaging. Canonical, grand canonical and microcanonical ensembles, corresponding distribution laws (using Lagrange's method of undetermined multipliers).

Partition functions– translational, rotational, vibrational and electronic partition functions, calculation of thermodynamic properties in terms of partition functions. Applications of partition functions.

Heat capacity, behavior of solids – chemical equilibria and equilibrium constant in terms of partition functions, Fermi-Dirac statistics, distribution law and applications to metal. Bose–Einstein statistics-distribution law and application to helium.

Unit-III **15 Hrs**

Electrochemistry-I

Electrochemistry of solutions: Debye-Hückel–Onsager treatment and its extension, ion-ion interactions, electrode/electrolyte interface, potential difference across electrified interfaces, nonpolarizable interface and equilibrium, concept of surface excess; thermodynamics of electrified interfaces- interfacial tension, electro-capillarity curves, thermodynamic treatment of polarizable interfaces, Lippmann equation, determination of charge density on electrode, capacitance of interface and surface excess.

Structure of electrified interfaces: Helmholtz-Perin, Guoy-Chapman, Stern and Devanathan models.

Unit-IV **15 Hrs**

Electrochemistry-II

Semiconductor-electrolyte interface– theory of double layer at semiconductor, Effect of light on semiconductor solution interface.

Electron transfer under interfacial electric field: exchange current density, over potentials, derivation of Butler-Volmer equation, Tafel plot.

Polarography theory, Ilkovic equation, half wave potential and its significance.

Fuel Cells and Batteries: Energy conversion, theoretical consideration of fuel cells, maximum intrinsic efficiency, Hydrogen–Oxygen cell and Hydrocarbon –Air cells.

Battery characteristics specification, components, battery systems, Lead storage battery, Dry cell, Silver-Zinc cell, Ni-Cd and Li battery.

Books Suggested:

1. Physical Chemistry, P.W. Atkins, Oxford University Press, 12th Ed., 2023.
2. Physical Chemistry, G.W. Castellan, Narosa Publishers, 3rd Ed., 2004.
3. Introduction to Electrochemistry, S. Glasstone, 3rd Ed., 2007.
4. Modern Electrochemistry Vol.1 and Vol. II, J.O.M. *Bockris* and A.K.N. Reddy, Plenum, 2nd Ed., 1998.
5. Thermodynamics for Chemists, S. Glasstone, Affiliated East-West Press,6th Ed. 2008.
6. Chemical Thermodynamics, I.M. Klotz and R.M. Rosenberg, Benzamin, 7th Ed. 2010.
7. Introduction to Chemical Thermodynamics, R. P. Rastogi and R.R. Mishra, Vikas Publication, 7th Ed., 2009,

Course outcomes:

Upon successful completion of the course, students will be able to:

CO1 Understand the laws of classical thermodynamics, electrochemical phenomena at the interface of electrodes and electrolytes, and working and characteristics of batteries and fuel cells.

CO2 Apply phase rule concepts to multi-component systems and classify phase transitions.

CO3 Analyze models of the electrical double layer and evaluate structure and thermodynamics of electrified interfaces.

CO4 Derive and apply Butler-Volmer equation to describe electrode kinetics.

CO5 Evaluate activity and activity coefficients for ideal and non-ideal systems.

CO6 Employ the principles of statistical thermodynamics to relate microscopic molecular behavior to macroscopic thermodynamic properties using different ensembles.

CO7 Interpret and determine partial molar properties and understand their physical significance.

CO8 Calculate thermodynamic properties using partition functions and their applications in determining equilibrium constants and analyzing solid-state behavior.

Master of Science Chemistry
1st Semester
Inorganic Chemistry Practical-I

Course code: U25CHE104P

120 Hrs (8Hrs /week)	**Marks for Major Test (External): 70**
Credits: 4	**Marks for Internal Exam: 30**
Time of Examination: 6 Hrs	**Total Marks: 100**

Objectives: This course enables the students to develop skills for analytical techniques for assessing the physicochemical quality of water to evaluate water suitability for environmental and public health standards.

1. Determination of dissolved oxygen in a water sample.
2. Determination of free CO_2 in a sample of water.
3. Determination of acidity of a water sample.
4. Determination of alkalinity of a water sample.
5. Determination of hardness of water by EDTA.
6. Determination of total suspended solids dried at 103-105°C.
7. Determination of total dissolved solids dried at 180°C.
8. Determination of fixed and volatile solids.
9. Determination of chemical oxygen demand of a waste water sample.
10. Determination of the amount of bleaching powder required to disinfect a water sample by Horrock's test.
11. Determination of total chlorine residuals.
12. Determination of free and combined chlorine residuals.
13. To determine the minimum dose of a coagulant required to coagulate a given sample by Jar test and to compare the effectiveness of aluminium sulphate and ferric sulphate as coagulants for a given sample at room temperature.
14. Determination of chloride content of a water sample by Mohr's method.

Books Suggested:

1. Vogel's Textbook of Quantitative Analysis, revised, J. Bassett, R. C. Denney, G.H. Jeffery and J. Mendham, ELBS, 5th Ed., 1989.
2. Vogel's Textbook of Macro and Semimicro Qualitative Inorganic Analysis, revised, G. Svehla, Longman, 5th Ed., 1979.
3. Practical Inorganic Chemistry, Marr and Rocket, 2nd Ed., 1987.
4. Applied Chemistry by O.P. Virmani and A.K. Narula, New Age International, 1st Ed., 1989.

Course outcomes:

Upon successful completion of the course, students will be able to:

CO1 Understand the principles and significance of various physicochemical parameters in water quality analysis.
CO2 Apply various methods to determine the quality of water.
CO3 Analyze the waste water samples to assess organic pollution levels.
CO4 Evaluate the various parameters of water sample.
CO5 Compile interpreted information in the form of lab record. Face /defend viva-voce examination.

Master of Science Chemistry
1st Semester
Organic Chemistry Practical-I

Course code: U25CHE105P

120 Hrs (8Hrs /week)	**Marks for Major Test (External): 70**
Credits: 4	**Marks for Internal Exam: 30**
Time of Examination: 6 Hrs	**Total Marks: 100**

Objectives: This course aims to develop skills for separation and purification of organic compounds, and qualitative analysis techniques of binary organic mixtures.

I Separation and Purification Techniques

Recrystallisation, Distillation: simple, fractional, steam and vacuum distillation, extraction, chromatography: thin-layer and column chromatography and Gas Chromatography.

II Qualitative Analysis

Analysis of an organic mixture containing two solid components using water, $NaHCO_3$, NaOH for separation and preparation of suitable derivatives.

Books Suggested:

1. Experiments and Techniques in Organic Chemistry, D. Pasto, C.R. Johnson and M.J. Miller, Prentice Hall, Pearson, 1st Ed., 1991.
2. Macroscale and Microscale Organic Experiments, K.L. Williamson, K.M. Masters, Cengage Learning, 8th Ed., 2023.
3. Systematic Qualitative Organic Analysis, H. Middleton, Adward Arnold & Co., 1948.
4. A Handbook of Organic Analysis-Qualitative and Quantitative, H. Clark, Adward Arnold, 5th Ed., 1975.
5. Vogel's Textbook of Practical Organic Chemistry, B.S. Furniss, A.J. Hannaford, P.W.G. Smith and A.R. Tatchell, Pearson India, 5th Ed., 2003.
6. Advance Practical Organic Chemistry, M, Casey, J. Leonard, B. Lygo and G. Procter, Nelson Thornes Ltd., 1989.

Course outcomes:

Upon successful completion of the course, students will be able to:

CO1 Understand and explain the principles behind various separation and purification techniques.
CO2 Demonstrate the ability to choose appropriate purification methods based on the physical and chemical properties of organic compounds.
CO3 Perform hands-on experiments involving recrystallization, different types of distillation, and chromatography to isolate and purify organic substances effectively.
CO4 Apply solvent extraction techniques using water, $NaHCO_3$, and NaOH for the separation of solid binary organic mixtures.
CO5 Analyze binary organic mixtures and identify the components based on physical properties, solubility differences, and functional group tests.
CO6 Synthesize suitable derivatives of organic compounds to aid in their identification and confirmation.
CO7 Interpret chromatographic data (TLC and GC) to assess the purity and identity of organic compounds.
CO8 Develop a systematic and scientific approach to qualitative organic analysis, including the design of separation schemes and derivative preparation.

Master of Science Chemistry
1st Semester
Physical Chemistry Practical-I

Course code: U25CHE106P
120 Hrs (8Hrs /week) **Marks for Major Test (External): 70**
Credits: 4 **Marks for Internal Exam: 30**
Time of Examination: 6 Hrs **Total Marks: 100**

Objectives: This course is designed to develop skills for statistical analysis of chemical data, and the ability to draw scientifically sound conclusions from laboratory experiments like viscosity measurements, conductometry, pH-metry, and refractometry.

I Error Analysis and Statistical Data Analysis

1. Errors, types of errors, minimization of errors, error distribution curves, precision, accuracy and combination;
2. Statistical treatment for error analysis, student 't' test, null hypothesis, rejection criteria, F& Q test; linear regression analysis, curve fitting.
   Calibration of volumetric apparatus, burette, pipette and standard flask.

II Partition Coefficient

3. Equilibrium constant of $KI + I_2 \rightleftharpoons KI_3$ by distribution method.

III Adsorption

4. To investigate the adsorption of oxalic acid from aqueous solutions by activated charcoal and examine the validity of Langmuir's adsorption isotherm.

IV Viscosity

5. To study the variation of viscosity of a liquid with composition of the mixture of liquids.

V Conductometry

6. Determination of the equivalent conductance of strong electrolytes such as HCl, KCl, KNO_3, $AgNO_3$, and NaCl and the validity of Onsager equation.
7. Study conductometeric titration of (1) HCl / NaOH (2) CH_3COOH / NaOH and comment on nature of graph.

VI pH– metry

8. Determine the strength of strong acid by titrating against strong base.
9. Determine the strength of strong acid by titrating against weak base.
10. Determine the strength of weak acid by titrating against strong base.

VII Chemical Kinetics

11. Determine the rate constant of hydrolysis of an ester (methyl acetate) catalyzed by an acid.

VIII Refractrometer

12. To determine the refractive index of few liquids.

Books Suggested:

1. Practical Chemistry, A.M. James and F.E. Pricherd, Longman, 3rd Ed.,1974.
2. Practical Physical Chemistry, B.P. Levitt and Findley's, Longman, 9th Ed., 1973.
3. Practical Physical Chemistry, S.R. Palit and S.K. De, Science Book Agency, 2nd Ed., 1938.
4. Experimental Physical Chemistry, R.C. Das and B. Behra, McGraw Hill, 1983.
5. Experiments in Physical Chemistry, Shoemaker and Gailand McGraw Hill, 8th Ed., 2008.

Course outcomes:

Upon successful completion of the course, students will be able to:

CO1 Understand and analyze types of experimental errors, classify different types of experimental errors, apply error minimization techniques, and use statistical tools to analyze experimental data effectively, and understand how to assess precision, accuracy, and fit curves to data.

CO2 Analyze solution properties using instrumental techniques such as viscosity measurements, conductometry, pH-metry, and refractometry to determine physical and chemical properties of solutions and evaluate theoretical relationships.

CO3 Investigate physicochemical properties and equilibrium systems to determine partition coefficients, adsorption behavior, and reaction kinetics.

CO4 Interpret experimental results and evaluate theoretical models to critically assess experimental data through curve fitting and theoretical models to draw meaningful conclusions and validate scientific hypotheses.

For Students of other Departments

1st Semester
Value Added Course (VAC)
Role of Chemistry in Society

Course code: U25VAC107T
30 Hrs (2Hrs /week) **Marks for Major Test (External): 35**
Credits: 2 **Marks for Internal Exam: 15**
Time of Examination: 2 Hrs **Total Marks: 50**

Note: *The examiner is required to set five questions in all. The first question will be compulsory consisting of five short questions covering the entire syllabus consisting of 3 marks each. In addition to this, four more questions (each question may be of 2-3 parts) will be set consisting of two questions from each unit. The student/candidate is required to attempt three questions in all, selecting one from each unit consisting of 10 marks and the compulsory Question No.1.*

Objectives: This paper deals with the basic concepts of green chemistry, waste managements, industry products in daily use, IPR and weapons of mass destruction.

Unit-I **15 Hrs**

Green Chemistry
Introduction, different tools for green synthesis (elementary idea of green reagent, green solvent, green catalyst, solid phase, microwave and ultrasound assisted), atom economy.
Renewable energy resources: fossil fuels, biomass, solar power, fuel cell; chemical from renewable feedstocks and fatty acid, polymer from renewable resources, some other chemicals from natural resource.
Role of biocatalysts in green synthesis- enzyme catalyzed oxidation, reduction and hydrolytic reactions, synthesis involving basic principle of green chemistry- synthesis of adipic acid and BHC.

Unit-III **15 Hrs**

Waste management
Production, problem and prevention- Introduction, source of waste from chemical industry, waste minimization techniques, onsite waste treatment, design for degradation of DDT & surfactant, polymer recycling.
Industry products in daily use
Introduction to industry products in daily use- perfumes, deodorants, skin care creams, hair colours and tooth pastes.
IPR for Chemists
Brief introduction to IPR, need for patenting, conditions for invention to be patentable.
Weapons of mass destruction
Introduction, disarmament and peace.

Books Suggested:

1. Green Chemistry: An introductory Text, M. Lancaster, Royal Society of Chemistry, 2nd Ed., 2010.
2. Green Chemistry and Catalysis, R.A. Sheldon, I. Arends and V. Hanefeld, Wiley-VCH, 1st Ed., 2007.
3. IPR Handbook for Pharma Students and Researchers, P. Bansal, BSP Books Private Ltd., 2015.
4. Weapons of Mass Destruction: The No-Nonsense Guide to Nuclear, Biological and Chemical Weapons, Eric Croddy, 1st Ed., 2018.
5. Cosmetic Science and Technology: Theoretical Principles and Applications, Barel, Paye, and Maibach, 1st Ed., 2017.
6. The Chemistry and Manufacture of Cosmetics, M. S. Balsam, 1st Ed., 2009.

7. Disarmament, Peace and Development (Contributions to Conflict Management, Peace Economics and Development Book 27), R. Braun, C. Archer, I. Breines, M. Chatterji, A. Skiljan, Emerald Publishing Limited, 2015.

Course outcomes:

Upon successful completion of the course, students will be able to:

CO1 Understand the fundamental principles of Green Chemistry, problems associated with industrial chemical waste, and understanding of Intellectual Property Rights (IPR).
CO2 Identify and describe various green synthesis tools in chemical synthesis.
CO3 Analyze the concept of atom economy and apply it to evaluate the efficiency of chemical reactions.
CO4 Demonstrate knowledge of renewable energy and their relevance in sustainable development.
CO5 Explain the role of biocatalysts in green synthesis.
CO6 Recognize the green chemistry principles impact of industry products used in daily life.
CO7 Gain awareness of the ethical and environmental issues related to weapons of mass destruction and understand the importance of disarmament and peace initiatives.

Master of Science Chemistry
2nd Semester
Transition Metal Chemistry

Course code: U25CHE201T

60 Hrs (4Hrs /week)	**Marks for Major Test (External): 70**
Credits: 4	**Marks for Internal Exam: 30**
Time of Examination: 3 Hrs	**Total Marks: 100**

Note: *The examiner is required to set nine questions in all. The first question will be compulsory consisting of seven short questions covering the entire syllabus consisting of 2 marks each. In addition to this, eight more questions (each question may be of 2-3 parts) will be set consisting of two questions from each unit. The student/candidate is required to attempt five questions in all, selecting one from each unit consisting of 14 marks and the compulsory Question No.1.*

Objectives: This course aims to develop an advanced understanding of the electronic structure, spectral behavior, magnetic properties, and reaction mechanisms of transition metal complexes, including interpretation of electronic spectra using Orgel and Tanabe-Sugano diagrams, analysis of metal-ligand equilibria, and the kinetics of substitution and redox reactions.

Unit-I **15 Hrs**

Electronic Spectra of Transition Metal Complexes
Microstates, Spectroscopic ground states (Term symbols) and the evaluation of energies of various J states of free ions, Coupling Schemes, Term symbols for excited states, Energies of Terms, Racah Parameters, Selection rules, splitting of S, P, D and F terms under octahedral and tetrahedral electrostatic potential, Orgel and Tanabe-Sugano diagrams for transition metal complexes (d^1-d^9 states), calculations of Dq, B, β and x parameters.

Unit-II **15 Hrs**

Charge Transfer Spectra and Magnetic Properties of Transition Metal Complexes
Charge transfer spectra of complexes (both metal to ligand and ligand to metal), Magnetic moment, various types of magnetism: Diamagnetism, Paramagnetism, Ferro and Anti ferromagnetism, effect of temperature and magnetic field on various types of magnetism
Metal-Ligand Equilibria in Solution
Stepwise and overall formation constants and their interaction, trends in stepwise constants, factors affecting the stability of metal complexes with reference to the nature of metal ion and ligand, chelate effect and its thermodynamic origin.

Unit-III **15 Hrs**

Reaction Mechanism of Transition Metal Complexes - I
Energy profile of a reaction, reactivity of metal complexes, inert and labile complexes, kinetic application of valence bond and crystal field theories, kinetics of octahedral substitution, acid hydrolysis, factors affecting acid hydrolysis, base hydrolysis, conjugate base mechanism, direct and indirect evidences in favour of conjugate mechanism, anation reactions, reactions without metal ligand bond cleavage.

Unit-IV **15 Hrs**

Reaction Mechanism of Transition Metal Complexes - II
Substitution reaction in square planar complexes, the trans effect, theories of trans effect, Redox reactions or electron transfer reactions, complementary and non-complementary reactions, mechanism of one electron transfer reactions, outer sphere type reactions, outer sphere mechanism, factors affecting rate of outer sphere reactions, inner sphere type reactions, bridge mechanism and its consequences, evidences in favour of bridge mechanism.

Books Suggested:

1. Advanced Inorganic Chemistry, F.A. Cotton and Wilkinson, John Wiley, 6th Ed., 1999.
2. Inorganic Chemistry, J.E. Huheey, Harper Collins, 4th Ed., 1993.
3. Chemistry of the Elements, N.N. Greenwood and A. Earnshaw, Pergamon, 2nd Ed., 2011.
4. Magnetochemistry, R.L. Carlin, Springer Verlog, 4th Ed., 2000.
5. Introduction to Magnetochemistry, A. Earnshaw, Academic press, 1st Ed., 1968.
6. Inorganic chemistry, G. Wulf'sburg, University science books, 1st Ed., 1966.
7. Introduction to ligand fields, B.N. Figgis, Wiley Eastern, 1st Ed., 1986.

Course outcomes:

Upon successful completion of the course, students will be able to:

CO1 Understand the fundamental principles governing the electronic structure and spectra of transition metal complexes.

CO2 Explain the reaction mechanism and stability of metal-ligand complexes.

CO3 Apply the different kind of theories to interpret spectroscopic transitions and calculate various spectral parameters.

CO4 Analyze the stability of various metal complexes.

CO5 Explain the mechanism of acid and base hydrolysis.

CO6 Evaluate chemical and magnetic properties of transition metal complexes.

Master of Science Chemistry
2nd Semester
Structure and Mechanism in Organic Chemistry-II

Course code: U25CHE202T

60 Hrs (4Hrs /week)	**Marks for Major Test (External): 70**
Credits: 4	**Marks for Internal Exam: 30**
Time of Examination: 3 Hrs	**Total Marks: 100**

Note: *The examiner is required to set nine questions in all. The first question will be compulsory consisting of seven short questions covering the entire syllabus consisting of 2 marks each. In addition to this, eight more questions (each question may be of 2-3 parts) will be set consisting of two questions from each unit. The student/candidate is required to attempt five questions in all, selecting one from each unit consisting of 14 marks and the compulsory Question No.1.*

Objectives: This aims to develop a deep understanding of the mechanisms, reactivity, and stereochemical aspects of aromatic and aliphatic substitution, free radical, addition, and pericyclic reactions, enabling students to predict reaction outcomes and rationalize organic transformations.

Unit-I **15 Hrs**

Aromatic Electrophilic Substitution
The arenium ion mechanism, orientation and reactivity, ipso attack, Diazonium coupling, Vilsmeir reaction, Gattermann-Koch reaction.
Aromatic Nucleophilic Substitution
The S_N^{Ar}, S_N1, benzyne and $S_{RN}1$ mechanisms. Reactivity – effect of substrate structure, leaving group and attacking nucleophile. The von Richter, Sommelet-Hauser, and Smiles rearrangements.
Aliphatic Electrophilic Substitution
Bimolecular mechanisms – S_E2 and S_E^i. The S_E1 mechanism, electrophilic substitution accompanied by double bound shifts. Effect of substrates, leaving group and the solvent polarity on the reactivity.

Unit-II **15 Hrs**

Free Radical Reactions
Types of free radical reactions, free radical substitution mechanism, mechanism at an aromatic substrate, neighbouring group assistance. Reactivity in the attacking radicals. The effect of solvents on reactivity.
Allylic halogenation (NBS), oxidation of aldehydes to carboxylic acids, auto-oxidation, coupling of alkynes and arylation of aromatic compounds by diazonium salts. Sandmeyer reaction. Free radical rearrangement. Hunsdiecker reaction.
Addition to Carbon-Carbon Multiple Bonds
Mechanistic and stereochemical aspects of addition reactions involving electrophiles, nucleophiles and free radicals. Hydrogenation of double and triple bonds. Hydroboration. Michael reaction. Sharpless asymmetric epoxidation.

Unit-III **15 Hrs**

Addition to Carbon-Hetero Multiple Bonds
Mechanism of metal hydride reduction of carbonyl compounds, acids and esters. Addition of Grignard reagents, organozinc and organolithium reagents to carbonyl compounds. Mechanism of condensation reactions involving enolates – Aldol, Knoevenagel, Claisen, Mannich, Benzoin, Perkin and Stobbe reactions. Hydrolysis of esters and amides.
Pericyclic Reactions - I
Molecular orbital symmetry, Frontier orbitals of ethylene, 1,3-butadiene, 1,3,5- hexatriene and allyl system. Classification of pericyclic reactions. Woodward-Hoffmann correlation diagrams, FMO and PMO approach for Electrocyclic reactions, conrotatory and disrotatory motions, 4n, 4n +2 and allyl systems.

Unit-IV **15 Hrs**

Pericyclic Reactions - II

Woodward-Hoffmann correlation diagrams, FMO and PMO approach for Cycloaddition reactions, antarafacial and suprafacial additions, 4n and 4n+2 systems, 2+2 addition of ketenes. FMO and PMO approach for Sigmatropic rearrangements, suprafacial and antarafacial shifts of H, sigmatropic shifts involving carbon moieties, 3,3-and 5,5-sigmatropic rearrangements. Claisen, Cope and aza-Cope rearrangements. Ene reaction.

Books Suggested:

1. March's Advanced Organic Chemistry: Reactions, Mechanisms and Structure, Michael B. Smith, Wiley, 8th Ed., 2019.
2. Advanced Organic Chemistry Part A: Structure and Mechanisms, F.A. Carey and R.J. Sundberg, Springer, 5th Ed., 2008.
3. Advanced Organic Chemistry Part B: Reactions and Synthesis, F.A. Carey and R.J. Sundberg, Springer, 5th Ed., 2007.
4. A Guide Book to Mechanism in Organic Chemistry, Peter Sykes, Pearson, 6th Ed.,2003.
5. Structure and Mechanism in Organic Chemistry, C.K. Ingold, CBC Publisher & Distributors, 2nd Ed., 2018.
6. Organic Chemistry, R.T. Morrison, R.N. Boyd and S. K. Bhattacharjee, Pearson, 7th Ed., 2010.
7. Reaction Mechanism in Organic Chemistry, S.M. Mukherji and S.P. Singh revised by S.P. Singh and Om Prakash, Trinity, Revised Ed., 2015.
8. Organic Chemistry, P.Y. Bruice, Pearson, 8th Ed., 2020.
9. Organic Chemistry, J. Clayden, N. Geeves and S. Warren, Oxford University Press, 2nd Ed., 2012.
10. Organic Chemistry, T.W.G. Solomon, W.B. Fryhl and S.A. Snyder, Wiley, 12th Ed., 2017.
11. Stereochemistry of Organic Compounds, D. Nasipuri, New Age International, 3rd Ed., 2018.
12. Stereochemistry, Conformation and Mechanism, P.S. Kalsi, New Age International, 8th Ed., 2015.
13. Stereochemistry of Organic Compounds, E.L. Eliel and S.H. Wilen, Wiley Interscience, 1st Ed., 1994.
14. Organic Mechanisms: Reaction, Stereochemistry and Synthesis, R. Bruckner, Springer, 3rd Ed., 2010.
15. Pericyclic Reactions, S.M. Mukherji, Macmillan, India, 1st Ed., 1980.
16. Pericyclic Reactions: A Mechanistic and Problem-Solving Appproach, S. Kumar, V. Kumar and S.P. Singh, Academic Press, 2015.
17. Organic Reaction Mechanism, V.K. Ahluwalia and R.K. Prasher, Narosa Publishing House, 5th Ed., 2024.

Course outcomes:

Upon successful completion of the course, students will be able to:

CO1 Understand molecular orbital symmetry and classify pericyclic reactions using Frontier Molecular Orbital (FMO) and Perturbation Molecular Orbital (PMO) theories; classify different types of free radical reactions.

CO2 Analyze aromatic nucleophilic substitution, aromatic electrophilic substitution, aliphatic electrophilic substitution, and some special reactions, and mechanisms and orbital symmetry in sigmatropic rearrangements.

CO3 Apply mechanistic principles to allylic halogenation, autooxidation, coupling reactions, and addition reactions.

CO4 Describe named rearrangement reactions and explain their mechanistic pathways.

CO5 Elucidate mechanisms including substitution, rearrangements, condensation, hydrolysis of esters and amides, reduction, addition reactions, and synthetic transformations highlighting stereoselectivity.

CO6 Predict the stereochemical outcomes of electrocyclic and cycloaddition reactions.

Master of Science Chemistry
2nd Semester
Quantum Chemistry and Chemical Kinetics

Course code: U25CHE203T
60 Hrs (4Hrs /week) **Marks for Major Test (External): 70**
Credits: 4 **Marks for Internal Exam: 30**
Time of Examination: 3 Hrs **Total Marks: 100**

Note: *The examiner is required to set nine questions in all. The first question will be compulsory consisting of seven short questions covering the entire syllabus consisting of 2 marks each. In addition to this, eight more questions (each question may be of 2-3 parts) will be set consisting of two questions from each unit. The student/candidate is required to attempt five questions in all, selecting one from each unit consisting of 14 marks and the compulsory Question No.1.*

Objectives: This course aims to build proficiency for comprehensive understanding of quantum chemistry principles and their application to molecular systems, and develop an in-depth understanding of chemical kinetics and reaction dynamics.

Unit-I **15 Hrs**

Quantum Chemistry
The origins of quantum mechanics, Postulates of quantum mechanics, operators, Wave–particle duality The Schrödinger equation, The Born interpretation of the wavefunction, The uncertainty principle, Translational motion: A particle in a box, Motion in two and more dimensions, Tunnelling, Vibrational motion, The energy levels, The wavefunctions, Rotational motion, Rotation in two dimensions: a particle on a ring, Rotation in three dimensions: the particle on a sphere, simple harmonic oscillator, The structure and spectra of hydrogenic atoms: The structure of hydrogenic atoms, Atomic orbitals and their energies, Spectroscopic transitions and selection rules.

Unit-II **15 Hrs**

Quantum Chemistry and symmetry
Approximate Methods: Approximate methods of quantum mechanics, Variation principle, perturbation theory up to second order in energy, applications.
Angular momentum: Commutation rules, quantization of square of total angular momentum and z-component.
Symmetry: Symmetry elements and symmetry operation, Point symmetry group, The Great Orthogonality theorem (without proof) and its importance. Character tables, selection rules.

Unit-III **15 Hrs**

Chemical Kinetics - I
Methods of determining rate laws, collision theory of reaction rates, steric factor, activated complex theory, Arrhenius equation and the activated complex theory; ionic reactions, kinetic salt effects, steady state kinetics, kinetic and thermodynamic control of reactions, treatment of unimolecular reactions.
Dynamic chain (hydrogen-bromine reaction, pyrolysis of acetaldehyde, decomposition of ethane), photochemical (hydrogen-bromine and hydrogen-McLorin reactions) and oscillatory reactions, homogenous catalysis, kinetics of enzyme reactions.

Unit -IV **15 Hrs**

Chemical Kinetics - II
Dynamics of unimolecular reactions (Lindemann–Hinshelwood and Rice - Ramsperger–Kassel – Marcus [RRKM] theories of unimolecular reactions).
General features of fast reactions, study of fast reactions by flow method, relaxation method, flash photolysis and the nuclear magnetic resonance method.

Books Suggested:

1. Physical Chemistry, P.W. Atkins, Oxford University Press, 11th Ed., 2018.
2. Introductory Quantum Chemistry, A.K. Chandra, Tata McGraw Hill, 4th Ed., 2017.
3. Quantum Chemistry, I.M. Levine, Prentice Hall, 7th Ed., 2013.
4. Chemical Applications of Group Theory, F.A. Cotton, Wiley, 3rd Ed., 1990.
5. Quantum Chemistry D.A. McQuarrie, Viva Books, 2nd ed., 2007.
6. Physical Chemistry, G.W. Castellan, Narosa Publishers, 3rd Ed., 2004.
7. Quantum Mechanics, M.L. Strause, Prentice – Hall, 1st Ed., 1968.
8. Chemical Kinetics, K.J. Laidler, McGraw Hill, 3rd Ed., 2003.
9. Chemical Kinetic Methods: Principles of Fast Reaction Techniques and Applications, C. Kalidas, New Age International, 2nd Ed.,2018.

Course outcomes:

Upon successful completion of the course, students will be able to:

CO1 Understand the foundational principles and mathematical framework of quantum mechanics.
CO2 Analyze molecular motion using quantum mechanical models.
CO3 Demonstrate the use of variation principle and perturbation theory.
CO4 Evaluate symmetry elements and operations.
CO5 Determine rate laws, and distinguish between kinetic and thermodynamic control in various types of chemical reactions.
CO6 Explain the dynamics of unimolecular reactions and study fast reactions using modern techniques, correlating theoretical concepts with real-time reaction monitoring.

Master of Science Chemistry
2nd Semester
Inorganic Chemistry Practical-II

Course code: U25CHE204P
120 Hrs (8Hrs /week) **Marks for Major Test (External): 70**
Credits: 4 **Marks for Internal Exam: 30**
Time of Examination: 6 Hrs **Total Marks: 100**

Objectives: This course is designed to develop skills in both qualitative and quantitative chemical analysis through systematic experimentation.

I Qualitative Analysis

Ten unknown mixtures will be given containing four radicals out of which one must be an insoluble and one may be an acid radical and two metal ions.

(a) Less common metal ions – Tl, Mo, W, Ti, Zr, Th, V, U (two metal ions in cationic/anionic forms)

(b) Insolubles– oxides (Al_2O_3, Cr_2O_3, SnO_2, TiO_2, SiO_2), sulphates ($PbSO_4$, $BaSO_4$) halides (AgCl, AgBr, AgI).

(c) Acid radicals CO_3^{2-}, HCO_3^-, SO_3^{2-}, SO_4^{2-}, CH_3COO^-, S^{2-}, PO_4^{3-}, NO_3^-, NO_2^-, Cl^-, Br^-, I^-, $C_2O_4^{2-}$ etc.

II Quantitative Analysis

(a) Iodimetry and iodometry Titrations

i. [I_2-$Na_2S_2O_3.5H_2O$] Titration
ii. [$CuSO_4$-$Na_2S_2O_3.5H_2O$] Titration

(b) Precipitation Titrations

iii. [$AgNO_3$-NH_4CNS] Titration
iv. [NaCl-$AgNO_3$] Titration

(c) Complexometric Titrations

v. [Mg^{2+}-EDTA] Titration
vi. [Ca^{2+}-EDTA] Titration.

Books Suggested:

1. Vogel's Textbook of Quantitative Analysis, revised, J. Bassett, R.C. Denney, G.H. Jeffery and J. Mendham, ELBS, 5th Ed., 1989.
2. Synthesis and Characterization of Inorganic Compounds, W.L. Jolly, Prentice Hall, 1st Ed., 1970.
3. Inorganic Synthesis, Vol. 1-12, McGraw Hill, 6th Ed., 1999.
4. Practical Inorganic Chemistry, Marr and Rocket, 2nd Ed., 1987.

Course outcomes:

Upon successful completion of the course, students will be able to:

CO1 Understand the concepts of qualitative and quantitative analysis.
CO2 Apply laboratory techniques in performing wet and dry tests for mixture analysis.
CO3 Analyze and determine the strength of solutions.
CO4 Evaluate experimental data and report findings with appropriate calculations, units, and error analysis.

Master of Science Chemistry
2nd Semester
Organic Chemistry Practical-II

Course code: U25CHE205P

120 Hrs (8Hrs /week)	**Marks for Major Test (External): 70**
Credits: 4	**Marks for Internal Exam: 30**
Time of Examination: 6 Hrs	**Total Marks: 100**

Objectives: This course is designed to provide students with hands-on experience in qualitative organic analysis and foundational organic synthesis techniques.

I Qualitative Analysis

Analysis of an organic mixture containing two solid components using HCl and ether for separation and preparation of suitable derivatives.

II Organic Synthesis

Preparation of organic compounds involving one step.
Acetylation: Acetylation of cholesterol.
Oxidation: Adipic acid from cyclohexanol.
Aldol condensation: Dibenzal acetone from benzaldehyde.
Sandmeyer reaction: *p*-Chlorotoluene from *p*-toluidine.
Other preparations involving one/two steps may be included.

Books Suggested:

1. Experiments and Techniques in Organic Chemistry, D. Pasto, C.R. Johnson and M.J. Miller, Prentice Hall, Pearson, 1st Ed., 1991.
2. Macroscale and Microscale Organic Experiments, K.L. Williamson, K.M. Masters, Cengage Learning, 8th Ed., 2023.
3. Systematic Qualitative Organic Analysis, H. Middleton, Adward Arnold & Co., 1948.
4. A Handbook of Organic Analysis-Qualitative and Quantitative, H. Clark, Adward Arnold, 5th Ed., 1975.
5. Vogel's Textbook of Practical Organic Chemistry, B.S. Furniss, A.J. Hannaford, P.W.G. Smith and A.R. Tatchell, Pearson India, 5th Ed., 2003.
6. Advance Practical Organic Chemistry, M, Casey, J. Leonard, B. Lygo and G. Procter, Nelson Thornes Ltd., 1989.
7. Experiments in Organic Chemistry, L.F. Fieser, D.C. Heath & Co., 1941 (Digitized 2024).

Course outcomes:

Upon successful completion of the course, students will be able to:

CO1 Analyze and identify the components of a binary organic mixture using systematic qualitative analysis, and understand the underlying principles of enolate chemistry.
CO2 Gain hands-on experience in functional group transformations, and reagent handling.
CO3 Execute acetylation reactions, oxidation reactions and understand their relevance in green chemistry and industrial applications.
CO4 Develop proficiency in organic synthesis planning and execution, including possible additional one- or two-step synthetic procedures, with a focus on yield, purity, and characterization.
CO5 Develop the skill of performing experiments, analysing data and compile experimental information in the form of lab record and defend *viva-voce*.

Master of Science Chemistry
2nd Semester
Physical Chemistry Practical-II

Course code: U25CHE206P
120 Hrs (8Hrs /week) **Marks for Major Test (External): 70**
Credits: 4 **Marks for Internal Exam: 30**
Time of Examination: 6 Hrs **Total Marks: 100**

Objectives: To provide students with practical exposure to instrumental methods such as potentiometry, conductometry, pH-metry, colorimetry, polarimetry, and refractometry for quantitative and qualitative analysis, and understanding of chemical kinetics and equilibrium.

I Potentiometry

1. Titrate potentiometrically (1) HCl / NaOH, (2) HCl / NH_4OH and (3) oxalic acid/ NaOH.
2. Titrate Mohr's salt against $KMnO_4$ potentiometrically.

II Chemical Kinetics

3. Determine energy of activation of hydrolysis of methyl acetate catalyzed by an acid.
4. Determine the velocity constant of hydrolysis of ethyl acetate using sodium hydroxide solution.

III Conductometry

5. Study conductometeric titration of (1) HCl / NH_4OH; (2) CH_3COOH / NH_4OH and comment on nature of graph
6. Study conductometric titration of (1) NH_4Cl / NaOH (2) CH_3COONa / HCl and comment on nature of graph.

IV pH– metry

7. Determine the hydrolysis constant of aniline hydrochloride.
8. Find out the dissociation constant of weak acid.

V Colorimetry/Spectrophotometry

9. Verification of the Lambert-Beer's law using solutions such as $K_2Cr_2O_7$, $KMnO_4$, $CuSO_4$ in water, I_2 in CCl_4.
10. Determine the concentration of $K_2Cr_2O_7$ and $KMnO_4$ in mixture of ($K_2Cr_2O_7$ + $KMnO_4$) solution.

VI Polarimetery

11. Determine specific and molecular rotation of an optically active substance.
12. Determine the concentration of an optically active substance.

VII Refractrometer

13. Determine the molar refrectivity of CH_3OH, CH_3COOH, $CH_3COOC_2H_5$ and CCl_4 and calculate the refractive equivalent of C, H and Cl atoms.

Books Suggested:

1. Practical Chemistry, A.M. James and F.E. Pricherd, Longman, 3rd Ed.,1974.
2. Practical Physical Chemistry, B.P. Levitt and Findley's, Longman, 9th Ed., 1973.
3. Practical Physical Chemistry, S.R. Palit and S.K. De, Science Book Agency, 2nd Ed., 1938.
4. Experimental Physical Chemistry, R.C. Das and B. Behra, McGraw Hill, 1983.
5. Experiments in Physical Chemistry, Shoemaker and Gailand McGraw Hill, 8th Ed., 2008.

Course outcomes:

Upon successful completion of the course, students will be able to:

CO1 Perform potentiometric titrations to analyze acid-base and redox systems.

CO2 Determine rate constants and activation energies for acid- and base-catalyzed ester hydrolysis reactions, applying kinetic theories to understand reaction mechanisms.

CO3 Analyze conductometric titration data to distinguish between different ionic reactions

CO4 Evaluate acid-base properties using pH-metric techniques and analyze their significance in acid-base equilibria.

CO5 Apply colorimetric and spectrophotometric methods for quantitative analysis, and enhancing their understanding of molecular absorption and instrumental analysis.

CO6 Determine optical and refractive properties of compounds using polarimetry and refractometry, and study of light-matter interactions.

Master of Science Chemistry
2nd Semester
Seminar

Course code: U25CHE201S
30 Hrs (2 Hrs/week) **Total Marks: 50**
Credit: 2
Time of Examination: Presentation/ *viva-voce*

Note: *The Committee/ examiners is required to evaluate the seminar through power point presentation on the selected topic made by the candidate and viva-voce as per university rules.*

Objectives: This course develops profiency to learn a specific topic through in-depth exploration and analysis of facts about the topic in a set-up that involves presentation, interactive discussions, and collaborative learning under the supervision of a teacher.

All the students will submit the topic (Topic should be from Master of Science Chemistry/UGC-CSIR NET/GATE syllabus) for the seminar in the begining of 2nd semester. The Committee constituted by the Chairperson for the evaluation of seminar will notify the schedule/dates of seminar. The student is required to present the seminar on the selected topic through power point presentation and submit the hard copy of the same to the committee.

Books Suggested/ Links:
As per "Seminar" topic.

Course outcomes:
Upon successful completion of the course, students will be able to:

CO1 Critically assess the relevance, reliability, and impact of research findings in chemistry.
CO2 Identify, analyze, and interpret scientific literature related to contemporary topics in chemistry.
CO3 Apply and execute the skill of graphical/ pictorial presentations/ sketching structures/ graphs/ figures by employing softwares like ChemDraw, compilation of literature, presentation of the findings, etc..
CO4 Demonstrate the ability to communicate scientific ideas effectively through oral presentations and visual aids (e.g., PowerPoint, posters).
CO5 Gain confidence in delivering scientific content to an audience, managing time, and handling questions during seminars and defend *viva-voce.*
CO6 Foster independent learning and research aptitude, cultivate the habit of self-directed learning and enhance their ability to independently explore new areas of chemical science.
CO7 Promote ethical and professional conduct, awareness of academic integrity, proper citation practices, and professional behavior during scientific discussions.

Master of Science Chemistry
2nd Semester

Internship

Course code: U25CHE201I
120 Hrs (4 Weeks) **Marks for Major Test (External): 100**
Credits: 4 **Total Marks: 100**
Time of Examination: Presentation/ *viva-voce*

Note: *(i) A student shall be required to undergo 4 credits internship of minimum of 4-6 weeks duration during summer vacation after second semester examination or after the fourth semester examination. If she/he opts to exit with 1-year PG Diploma after second semester of 2-year PG Programme, then she/he has to complete Internship course before exit. However, the student, who has taken lateral entry into the 2nd year (i.e. 3rd semester) of PG Programme, need not to repeat the Internship course.*

(ii) A student will inform and get approval from the Chairperson of the Department before going for an internship. The internship will involve working with local industry (Government or Private organizations/ Institutions), business establishments, artists, craft persons, or a professional (individual/organization). Student will submit a copy of the report (a hard copy and a soft copy in PDF) to the Department within 15 days after the completion of internship. A student must submit a certificate of attendance and work done report from the organization/professional where the internship was done. The evaluation of the internship shall be done by a committee comprising of at least two senior teachers appointed by the Chairperson of the Department. Marks will be awarded by the committee out of 100 marks on the basis of the report and viva-voce examination.

(iii) The internship will be governed by the prevailing rules of the University from time to time.

Objectives: To provide students with practical exposure to real-world chemical research or industrial processes, enabling them to apply theoretical knowledge, develop professional skills, and gain insights into career pathways in chemical sciences.

Books Suggested/ Links:
As per "Internship" topic.

Course outcomes:
Upon successful completion of the course, students will be able to:

- CO1 Understand the multidisciplinary areas of physical sciences, hazards, safety data of materials for safe-guard of living beings and environment.and their applications and gain chemical information from various sources through self-learning.
- CO2 Sound knowledge of fundamentals of Chemical Sciences and skills through knowledge of various techniques for qualitative and quantitative analysis.
- CO3 Apply better approach using Green Chemistry methodologies in Chemical Sciences and industrial processes.
- CO4 Have capability for design, synthesis, isolation, separation, purification and characterization of natural and synthetic compounds.
- CO5 Solve scientific and socio-economic problems.
- CO6 Draw logical conclusion based on theoretical knowledge and practical observations.
- CO7 Have proficiency for effective communication, critical thinking, teamwork and ethics as a life-long learner, and defend *viva-voce*.

Master of Science Chemistry
3rd Semester
Applications of Spectroscopy

Course code: U25CHE301T

60 Hrs (4Hrs /week)	**Marks for Major Test (External): 70**
Credits: 4	**Marks for Internal Exam: 30**
Time of Examination: 3 Hrs	**Total Marks: 100**

Note: *The examiner is required to set nine questions in all. The first question will be compulsory consisting of seven short questions covering the entire syllabus consisting of 2 marks each. In addition to this, eight more questions (each question may be of 2-3 parts) will be set consisting of two questions from each unit. The student/candidate is required to attempt five questions in all, selecting one from each unit consisting of 14 marks and the compulsory Question No.1.*

Objectives: This course enables students to get understanding of the principles and applications of molecular spectroscopy techniques—UV-Vis, IR, NMR and Mass Spectrometry, and also introduces advanced concepts such as 2D-NMR, fluorescence, phosphorescence, ORD and CD to provide a holistic view of modern spectroscopic analysis in organic chemistry.

Unit-I **15 Hrs**

Ultraviolet and Visible Spectroscopy
Various electronic transitions, Beer-Lambert law, visible spectrum & colour, factors effecting electronic transitions, ultraviolet bands for carbonyl compounds, unsaturated carbonyl compounds, dienes, conjugated polyenes. Fieser-Woodward rules for conjugated dienes and carbonyl compounds, ultraviolet spectra of aromatic compounds, heterocyclic compounds and charge transfer complexes. Elementary ideas about phosphorescence, fluorescence, Optical Rotatory Dispersion (ORD) and Circular Dichroism (CD).

Unit-II **15 Hrs**

Infrared Spectroscopy
Instrumentation and sample handling, Fermi resonance, Factors effecting vibrational frequencies of organic compounds, Characteristic vibrational frequencies of alkanes, alkenes, alkynes, aromatic compounds, alcohols, ethers, phenols, amines and nitro compounds. Detailed study of vibrational frequencies of carbonyl compounds (ketones, aldehydes, esters, amides, acids, anhydrides, lactones, lactams and conjugated carbonyl compounds).

Unit-III **15 Hrs**

Nuclear Magnetic Resonance Spectroscopy
Introduction, chemical shift, spin-spin interaction, chemical shift values and correlation for protons bonded to carbon (aliphatic, olefinic, aldehydic and aromatic) and other nuclei (alcohols, phenols, enols, carboxylic acids, amines, amides & mercapto), complex spin-spin interaction between two, three, four and five nuclei (first order spectra), Karplus curve-variation of coupling constant with dihedral angle. Simplification of complex spectra- nuclear magnetic double resonance, contact shift reagents and nuclear Overhauser effect (nOe).

Unit- IV **15 Hrs**

Carbon-13 NMR Spectroscopy
General considerations, chemical shift (aliphatic, olefinic, alkyne, aromatic, heteroarmatic and carbonyl carbon), coupling constants and DEPT ^{13}C NMR spectra. General introduction to two-dimensional NMR spectroscopy - COSY. HSQC, HMBC, INADEQUATE and NOESY.

Mass Spectrometry

Introduction, ion production – EI, CI, FD and FAB, factors affecting fragmentation, McLafferty rearrangement, Nitrogen rule. Mass spectral fragmentation of organic compounds, common functional groups, molecular High-resolution mass spectrometry (HRMS).

Combined problems relating to structure elucidation by UV, IR, NMR Spectroscopy and Mass Spectrometry.

Books Suggested:

1. Spectrometric Identification of Organic Compounds, R.M. Silverstein, G.C. Bassler and T.C. Morrill, John Wiley, 8th Ed., 2014.
2. Introduction to NMR Spectroscopy, R.J. Abraham, J. Fisher and P. Loftus, Wiley, 2014.
3. Application of Spectroscopy of Organic Compounds, J.R. Dyer, Prentice Hall, 2007.
4. Spectroscopic Methods in Organic Chemistry, D.H. Williams, I. Fleming, Tata McGraw-Hill, 7th Ed., 2019.
5. Organic Chemistry, William Kemp, John Wiley, 3rd Ed., 2017.
6. Organic Spectroscopy, Jag Mohan, Narosa Publishers, New Delhi, 2nd Ed. 2009.
7. Introduction to Spectroscopy, G.M. Lampman, D.L. Pavia, G.S. Kriz and J.M. Vyvyan, Cengage Learning, 5th Ed., 2015.

Course outcomes:

Upon successful completion of the course, students will be able to:

CO1 Understand and interpret electronic transitions in organic molecules, IR analysis, basic NMR concepts, principles of fluorescence, phosphorescence, and mass spectrometry for structure determination.

CO2 Apply Beer-Lambert Law to determine concentration and absorbance, Fieser-Woodward rules to estimate λ_{max}, double resonance, shift reagents, and nOe to simplify and analyze spectra.

CO3 Analyze vibrational modes and frequency shifts, mass spectra for characteristic fragmentation patterns and functional group identification.

CO4 Predict and explain UV absorption bands for carbonyl compounds, conjugated systems, and aromatic/heterocyclic compounds, NMR- chemical shift, spin-spin coupling, integration, MS- ionization techniques (EI, CI, FD, FAB) and their applications.

CO5 Correlate molecular structure with visible spectrum, chemical shift values with various proton environments in organic compounds in NMR, use high-resolution mass spectrometry (HRMS) to determine molecular formulas.

CO6 Introduce DEPT experiments, 2D-NMR techniques, Optical Rotatory Dispersion (ORD), and Circular Dichroism (CD) for structural analysis.

CO7 Combine data from UV, IR, NMR (^{1}H and ^{13}C), and MS to determine the structure of unknown organic compounds.

Elective: SET-A
Inorganic Chemistry (IC)

Master of Science Chemistry
3rd Semester
Organometallic Chemistry

Course code: U25CHE311T (IC)
60 Hrs (4Hrs /week) **Marks for Major Test (External): 70**
Credits: 4 **Marks for Internal Exam: 30**
Time of Examination: 3 Hrs **Total Marks: 100**

Note: *The examiner is required to set nine questions in all. The first question will be compulsory consisting of seven short questions covering the entire syllabus consisting of 2 marks each. In addition to this, eight more questions (each question may be of 2-3 parts) will be set consisting of two questions from each unit. The student/candidate is required to attempt five questions in all, selecting one from each unit consisting of 14 marks and the compulsory Question No.1.*

Objectives: This course aims to develop in-depth understanding of the chemistry of organotransition metal compounds, π-complexes, fluxional behavior, role of hydride and dihydrogen complexes as key catalytic processes and homogeneous catalysis relevant to industrial and synthetic chemistry.

Unit-I **15 Hrs**

Alkyls and Aryls of Transition Metals
Types, routes of synthesis, stability and decomposition pathways, organocopper in organic synthesis.
Compounds of Transition Metal-Carbon Multiple Bonds
Alkylidenes, alkylidynes, low valent carbenes and carbynes- synthesis, nature of bond, structural characteristics, nucleophilic and electrophilic reactions on the ligands, role in organic synthesis.

Unit-II **15 Hrs**

Transition Metal- π-Complexes
Transition metal π-complexes with unsaturated organic molecules, alkenes, alkynes, allyl, diene, cyclopentadienyl (nature of bonding of ferrocene, MO description and aromatic character), arene and trienyl complexes, preparations, properties, nature of bonding and structural features.

Unit-III **15 Hrs**

Fluxional Organometallic Compounds
Fluxionality and dynamic equilibria in compounds such as olefins, allyl and dienyl complexes.
Transition Metal Compounds with Bonds to Hydrogen
Bridging hydrides, dihydrogen complexes, synthesis and reactivity of hydride complexes.

Unit-IV **15 Hrs**

Homogeneous Catalysis
Homogeneous catalytic hydrogenation, Zeigler-Natta polymerization of olefins, catalytic reactions involving carbon monoxide such as hydrocarbonylation of olefins (oxo reaction), water gas shift reaction, Fischer tropsch process, oxopalladation reactions.

Books Suggested:

1. Principles and Application of Organotransition Metal Chemistry, J.P. Collman, L.S. Hegsdus, J.R. Norton and R.G. Finke, University Science Books, 1st Ed., 1987.
2. The Organometallic Chemistry of the Transition Metals, R.H. Crabtree, John Wiley, 6th Ed., 2014.
3. Organometallic Chemistry, R.C. Mehrotra and A. Singh, New Age International, 4th Ed., 2005.
4. Organometallics, A. Salzer, Ch. Elschenbrioch.VCH Publications, 2nd Ed., 1992.

Course outcomes:

Upon successful completion of the course, students will be able to:

CO1 Understand the types, synthesis methods, and decomposition pathways of transition metals complexes.

CO2 Explain the structure, bonding, and reactivity of transition metal complexes.

CO3 Apply knowledge of organometallic chemistry to predict reactivity patterns and design catalytic cycles involving transition metal complexes.

CO4 Analyze the nature of bonding and structural features of π-complexes.

CO5 Examine fluxional behavior of organometallic compounds.

CO6 Evaluate the mechanisms and applications of homogeneous catalytic processes.

Elective: SET-A
Inorganic Chemistry (IC)

Master of Science Chemistry
3rd Semester
Chemical Analysis and Inorganic Spectroscopy

Course code: U25CHE312T (IC)
60 Hrs (4Hrs /week) **Marks for Major Test (External): 70**
Credits: 4 **Marks for Internal Exam: 30**
Time of Examination: 3 Hrs **Total Marks: 100**

Note: *The examiner is required to set nine questions in all. The first question will be compulsory consisting of seven short questions covering the entire syllabus consisting of 2 marks each. In addition to this, eight more questions (each question may be of 2-3 parts) will be set consisting of two questions from each unit. The student/candidate is required to attempt five questions in all, selecting one from each unit consisting of 14 marks and the compulsory Question No.1.*

Objectives: This course builds proficiecy for foundational and practical understanding of modern chemical analysis and students will gain hands-on insight into instrument operation, analytical data evaluation, and safety in the chemical laboratory while learning to critically assess the reliability and validity of analytical results.

Unit-I **15 Hrs**

Practical Aspects of Chemical Analysis
Role of analytical chemistry, classification of analytical methods-classical and instrumental, types of instrumental analysis, selecting an analytical method, volumetric glassware-cleaning and calibration of glassware, sample preparations - dissolution and decompositions, desiccators and desiccants, filtration and ignition of solids, selecting and handling of reagents and other chemicals, safety in the analytical laboratory.
Errors and Evaluation- Definition of terms - mean and median, precision, standard deviation, accuracy. Errors – systematic (determinate), random (indeterminate), gross, errors in measurement, sources of errors and the effects upon the analytical results and its minimization.
Methods for reporting analytical data, Statistical evaluation of data, uses of statistics.

Unit-II **15 Hrs**

Atomic Absorption Spectroscopy
General principle, instrumental set up and analytical set up, measurement of atomic absorption and emission, analytical procedures of absorption and emission spectroscopy, sensitivity, detection limits, interference, applications.
Flame Photometry
Principles of flame photometry (flame emission spectroscopy), type of instruments, experimental technique, chemical reactions in flame, ionization in flames, spectra of metals in flames and applications.

Unit-III **15 Hrs**

Molecular Fluorescence Spectroscopy
Theory of molecular fluorescence, effect of concentration on fluorescence intensity, fluorescence instruments, application of fluorescence methods.
Molecular phosphorescence spectroscopy, chemiluminescence methods.

Unit-IV **15 Hrs**

Electron Spin Resonance Spectroscopy

Theory of ESR, instrumentation, ESR Spectra of DPPH, g value and factors affecting ESR lines, Hyperfine coupling, Hyperfine splitting constant, zero field splitting and Kramer's degeneracy, applications of ESR, study of free radicals and inorganic compounds.

Mossbauer Spectroscopy

Basic principles, spectral parameters and spectrum display. Application of the technique to the studies of (i) bonding and structures of Fe^{+2} and Fe^{+3} compounds including those of intermediate spin, (ii) Sn^{+2} and Sn^{+4} compounds – nature M-L bond, coordination number, structure and (iii) detection of oxidation state and inequivalent MB atoms.

Books suggested:

1. Analytical Chemistry, G.D. Christian, J. Wiley, 7th Ed., 2013.
2. Skoog and West's Fundamentals of Analytical Chemistry, D.A. Skoog, D.M. West and F.J. Holler, W.B. Saunders, Cengage Technology, 9th Ed., 2013.
3. Analytical Chemistry-Principles, J.H. Kennedy, Cengage Technology, 2011.
4. Analytical Chemistry-Principles and Techniques, L.G. Hargis, Prentice Hall, 1988.
5. Principles of Instrumental Analysis, D.A. Skoog, F.J. Holler, S.R. Crouch, Brooks/Cole Pub Co., 7th Ed., 2017.
6. Instrumental Methods of Analysis, H.H. Willard, L.L. Merrit, J.A. Dean, F.A. Settle, CBS Publishers & Distributors, 7th Ed., 2004.
7. NMR, NQR, EPR and Mossbauer Spectroscopy in Inorganic Chemistry, R.V. Parish, Ellis Horwood Ltd. Publisher, 1990.
8. Instrumental Methods of Chemical Analysis, V.K. Ahluwalia, Springer Nature, 2023.
9. Practical Instrumental Analysis, S. Petrozzi, Wiley-VCH Verlag GmbH, 1st Ed., 2012.
10. Analytical Methods in Chemical Analysis: An Introduction, S. Kaushik and B. Kumar, De Gruyter, 2023.
11. Atomic and Molecular Spectroscopy, S. svanberg, Springer, 5th Ed., 2022.

Course outcomes:

Upon successful completion of the course, students will be able to:

CO1 Understand the role of analytical chemistry in various fields.

CO2 Describe the principles and instrumentation of various spectroscopic techniques.

CO3 Analyze the applications of different techniques in different branches of chemistry.

CO4 Interpret various spectral data for structure determination.

CO5 Evaluate analytical data, and minimize various types of errors in measurements.

Elective: SET-A
Inorganic Chemistry (IC)

Master of Science Chemistry
3rd Semester
Inorganic Chemistry Practical-III

Course code: U25CHE313P (IC)

120 Hrs (8Hrs /week)	**Marks for Major Test (External): 70**
Credits: 4	**Marks for Internal Exam: 30**
Time of Examination: 6 Hrs	**Total Marks: 100**

Objectives: This course equip students with performing qualitative separation and quantitative estimation of metal ion mixtures using both volumetric and gravimetric analysis techniques.

Quantitative Analysis:

To carry out separation of

1. Copper and Nickel and estimation of Copper volumetrically and Nickel gravimetrically.
2. Copper and Zinc and estimation of Copper gravimetrically and Zinc volumetrically.
3. Iron and Magnesium and estimation of Iron volumetrically and Magnesium gravimetrically.
4. Iron and Nickel and estimation of Iron gravimetrically Nickel gravimetrically.
5. Silver and Nickel and estimation of Silver volumetrically and Nickel gravimetrically.
6. Copper and Barium and estimation of Copper gravimetrically and Barium gravimetrically.
7. Silver and Magnesium and estimation of Silver gravimetrically and Magnesium gravimetrically.
8. Copper and Magnesium and estimation of Copper gravimetrically and Magnesium gravimetrically.
9. Silver and Zinc and estimation of Silver volumetrically and Zinc gravimetrically.
10. Silver and Copper and estimation of Silver gravimetrically and Copper gravimetrically.

Books Suggested:

1. Synthesis and Characterization of Inorganic Compounds. W.L. Jolly, Prentice Hall, 1st Ed., 1970.
2. Synthesis and Physical studies of Inorganic compounds C.F. Bell, Pergamon Press, 1st Ed., 1972.
3. A Textbook of Quantitative Analysis. A.I. Vogel, ELBS, London, 5th Ed., 1989.

Course outcomes:

Upon successful completion of the course, students will be able to:

CO1 Understand the concepts of gravimetric and volumetric analysis.
CO2 Perform quantitative estimation of metal ions using appropriate gravimetric and volumetric techniques.
CO3 Apply principles of selective precipitation and complexation to achieve effective separation of metal ions.
CO4 Calculate the amount of metal ions in mixtures.
CO5 Interpret data, validate results, and defend *viva-voce* examination.

Elective: SET-A
Inorganic Chemistry (IC)

Master of Science Chemistry
3rd Semester
Inorganic Chemistry Practical-IV

Course code: U25CHE314P (IC)
120 Hrs (8Hrs /week) **Marks for Major Test (External): 70**
Credits: 4 **Marks for Internal Exam: 30**
Time of Examination: 6 Hrs **Total Marks: 100**

Objectives: This course aims to provide students practical exposure to modern analytical techniques through the quantitative determination and separation of various inorganic species using spectrophotometric, chromatographic, flame photometric, and polarographic methods.

I Spectrophotometric/Colorimetric determinations

1. To determine the strength of Cu(II) using EDTA.
2. To determine the strength of Fe(III) using EDTA.
3. Titration of Fe(II) against potassium permanganate.
4. To determine the concentration of nickel in given solution.
5. To analyse the given mixture of Cu(II) and Bi(III).
6. To determine simultaneously the As(III) and Sb(III) in the given mixture.
7. To determine the concentration of chloride ion.
8. To determine the concentration of sulphate ion.

II Chromatographic separations

9. Thin- layer chromatography-separation of nickel, manganese, cobalt and zinc. Determination of R_f values.
10. Separation and identification of the sugars present in the given mixture of glucose, fructose and sucrose by paper chromatography and determination of R_f value.

III Flame photometric determinations

11. To determine the concentration of sodium in the given solution.
12. To determine the concentration of potassium in the given solution.
13. To determine the concentration of calcium in the given solution.
14. To determine the concentration of lithium in the given solution.
15. To determine the concentration of sodium and potassium when present together.

IV Polarography

16. Determination of iodide using Hg(II) nitrate.
17. Determination of sulphate using lead nitrate.

Books Suggested:

1. Synthesis and Characterization of Inorganic Compounds, W.L. Jolly, Prentice Hall, 1st Ed., 1970.
2. Synthesis and Physical studies of Inorganic compounds C.F. Bell, Pergamon Press, 1st Ed., 1972.
3. A Textbook of Quantitative Analysis. A.I. Vogel, ELBS, 5th Ed., 1989.

Course outcomes:

Upon successful completion of the course, students will be able to:

CO1 Understand the concepts of various spectroscopic techniques.
CO2 Determine the concentration of metal ions and anions in solutions using various techniques.
CO3 Analyze mixtures of metal ions and metal compounds chromatographically.
CO4 Interpret instrumental data from various analytical techniques
CO5 Develop practical skills in operating analytical instruments, preparing samples, and following safety protocols for precise and reproducible analysis.
CO6 Compile interpreted information in the form of lab record and defend viva-voce examination.

Elective: SET-B
Organic Chemistry (OC)

Master of Science Chemistry
3rd Semester
Heterocyclic Chemistry and Photochemistry

Course code: U25CHE311T (OC)

60 Hrs (4Hrs /week)	**Marks for Major Test (External): 70**
Credits: 4	**Marks for Internal Exam: 30**
Time of Examination: 3 Hrs	**Total Marks: 100**

Note: *The examiner is required to set nine questions in all. The first question will be compulsory consisting of seven short questions covering the entire syllabus consisting of 2 marks each. In addition to this, eight more questions (each question may be of 2-3 parts) will be set consisting of two questions from each unit. The student/candidate is required to attempt five questions in all, selecting one from each unit consisting of 14 marks and the compulsory Question No.1.*

Objectives: The course aims to build proficiency for nomenclature, methods of synthesis and reactions of smaller ring heterocyclic systems containing one/ two heteroatoms, and basics of photochemistry, photochemical reactions of organic compounds and several photochemical name reactions.

Unit-I **15 Hrs**

Nomenclature of heterocyclic compounds
Systematic (Hantzsch-Widman) and replacement nomenclature for monocylic and fused ring systems containing heteroatom(s).
Three-membered heterocyclic compounds
General methods of synthesis and reactions including mechanism of aziridines, oxiranes and thiiranes.
Four-membered heterocyclic compounds
General methods of synthesis and reactions including mechanism of azetidines, oxetanes and thietanes.

Unit-II **15 Hrs**

Five-membered heterocycles containing two heteroatoms
Structures, comparison of basicity, general methods of synthesis and reactions (including mechanism) of pyrazoles, imidazoles, oxazoles, isoxazoles, thiazoles and isothiazoles.

Unit-III **15 Hrs**

Photochemical Reactions
Interaction of electromagnetic radiation with matter, excitations and excited states, fate of excited molecule (Jablonski diagram), quantum yield, transfer of excitation energy- sensitization and quenching.
Photochemistry of Alkenes
Intramolecular reactions of the olefinic bond– geometrical isomerization, sensitized cyclization reactions and rearrangement of 1,4-dienes (Di-π-methane rearrangement).

Unit-IV **15 Hrs**

Photochemistry of Carbonyl Compounds
Intramolecular reactions of carbonyl compounds– saturated, cyclic and acyclic, β, γ-unsaturated and α, β-unsaturated compounds. Cycloaddition to alkenes (Paterno-Buchi reaction).

Miscellaneous Photochemical Reactions
Photo-Fries rearrangement, Barton reaction, and Hofmann-Loffler-Freytag reaction.

Books Suggested:

1. Heterocyclic Chemistry Vol. 1-3, R.R. Gupta, M. Kumar and V. Gupta, Springer Verlag, 1998.
2. Heterocyclic Chemistry, J.A. Joule and K. Mills, John Wiley, 5th Ed., 2010.
3. The Chemistry of Heterocycles, T. Eicher, S. Hauptmann and A. Spiecher, Wiley-VCH Verlag GmbH, 3rd Ed., 2012.
4. Heterocyclic Chemistry, T.L. Gilchrist, Longman Scientific Technical, 2nd Ed., 1992.
5. Contemporary Heterocyclic Chemistry, G.R. Newkome and W.W. Paudler, Wiley-Inter Science, 1st Ed., 1982.
6. An Introduction to Heterocyclic Chemistry, R.M. Acheson, John Wiley, 3rd Ed., 2008.
7. Comprehensive Heterocyclic Chemistry (All Volumes), A.R. Katritzky and C.W. Rees, Pergamon Press.
8. Fundamentals of Photochemistry, K.K. Rohtagi-Mukherji, New Age Publishers, 3rd Ed., 2017.
9. Introductory Photochemistry, A. Cox and T.J. Camp, McGraw-Hill, 1971.
10. Organic Photochemistry, J. Coxon and B. Halton, Cambridge University Press, 2nd Ed., 2011.
11. Photochemistry of Organic Synthesis, J. D. Coyle, Royal Society of Chemistry, 1986.

Course outcomes:

Upon successful completion of the course, students will be able to:

CO1 Understand the general concepts of heterocyclic compounds and photochemistry.

CO2 Apply the integrated concepts for nomenclature of monocylic and fused ring systems containing heteroatom(s), different types of organic reactions for the synthesis of three-membered, four-membered and five-membered (containing two heteroatoms) heterocyclic compounds and photochemical transformations with mechanistic details thereof.

CO3 Illustrate the general processes involved in a photochemical change

CO4 Analyse the course of organic photochemical reactions and identification of the product(s) with the type of functional group(s) presents in the organic molecules, and describe the mechanistic details of some important photochemical name reactions.

CO5 Evaluate the formation of various products on the basis of the theoretical models, equilibrium and molecular behaviour, to propose scientifically valid conclusions.

Organic Chemistry (OC)

Master of Science Chemistry
3rd Semester
Bioorganic and Natural Products Chemistry

Course code: U25CHE312T (OC)

60 Hrs (4Hrs /week)	**Marks for Major Test (External): 70**
Credits: 4	**Marks for Internal Exam: 30**
Time of Examination: 3 Hrs	**Total Marks: 100**

Note: *The examiner is required to set nine questions in all. The first question will be compulsory consisting of seven short questions covering the entire syllabus consisting of 2 marks each. In addition to this, eight more questions (each question may be of 2-3 parts) will be set consisting of two questions from each unit. The student/candidate is required to attempt five questions in all, selecting one from each unit consisting of 14 marks and the compulsory Question No.1.*

Objectives: This course provides a comprehensive understanding of enzymatic catalysis and natural product chemistry, with a focus on enzyme mechanisms, kinetics, and applications, as well as the classification, structure determination, synthesis, and biosynthesis of major classes of natural compounds.

Unit-I **15 Hrs**

Enzymes
Introduction, chemical and biological catalysis, remarkable properties of enzymes like catalytic power, specificity and regulation. classification of enzymes (suitable examples of reactions), Fischer's lock and key and Koshland's induced fit hypothesis, identification of active site by the use of inhibitors, affinity labeling. Enzyme kinetics, reversible and irreversible inhibition.

Unit-II **15 Hrs**

Mechanism of Enzyme Action
Transition-state theory, proximity and orientation effect, acid-base catalysis, covalent catalysis. Enzymatic mechanisms for chymotrypsin, and carboxypeptidase A.
Biotechnological Applications of Enzymes
Extraction and purification of enzymes, methods for immobilization of enzymes, application of immobilized enzymes.

Unit-III **15 Hrs**

Terpenoids and Carotenoids
Classification, nomenclature, occurrence, isolation, general methods of structure determination, isoprene rule. Stereochemistry, synthesis and biosynthesis of the following representative molecules: Citral, α-Terpeneol, Farnesol and β-carotene.
Steroids
Occurrence, nomenclature, basic skeleton, Diel's hydrocarbon and stereochemistry, synthesis of Cholesterol, Testorosterone and Progesterone.

Unit-IV **15 Hrs**

Alkaloids
Introduction, nomenclature, occurrence, isolation, general methods of structure elucidation, degradation, classification based on nitrogen Heterocyclic ring.
Stereochemistry, synthesis and biosynthesis of the following: Nicotine, Atropine and Quinine.

Books Suggested:

1. Understanding Enzymes, T. Palmer, Prentice Hall, 4th Ed.,1995.
2. Enzyme Chemistry: Impact and Applications, Collin J. Suckling, C. Gibson and A. Pitt, Chapman and Hall. 3rd Ed., 1998.
3. Enzyme Mechanisms, M.I. Page and A. Williams, Royal Society of Chemistry, 1987.
4. Immobilized Enzymes: An Introduction and Applications in Biotechnology, M.D. Trevan, Wiley Blackwell, 1980.
5. Enzymatic Reaction Mechanisms, C. Walsh, W.H. Freeman & Co. ltd., 1995.
6. Biochemistry: The Chemical Reactions of Living Cells, D.E. Metzler, Academic Press, 2nd Ed., 2003.
7. Voets Principles of Biochemistry, D. Voet, J. G. Voet and C. W. Pratt, John Wiley, 5th Ed., 2018.
8. Natural products: Chemistry and Biological Significance, J. Mann, R.S. Davidson, J.B. Hobbs, D.V. Banthrope and J.B. Harborne, Prentice Hall, 1994.
9. Organic Chemistry, Vol. 2, Stereochemistry and Chemistry Natural Products, I.L. Finar, Pearson, 5th Ed., 2002.
10. Stereoselective Synthesis: A Practical Approach, M. Nogradi, Wiley-VCH, 2nd Ed., 1994.
11. Introduction to Flavonoids, B.A. Bohm, CRC Press, 1st Ed., 1999.
12. Principles of Biochemistry, L. Moran, R. Horton, G. Scrimgeour and M. Perry, Pearson, 5th Ed., 2011.
13. Biochemistry, S.C. Rastogi, New Age International Publishers, 4th Ed., 2019.

Course outcomes:

Upon successful completion of the course, students will be able to:

CO1 Understand the chemical and biological catalysis, classification, properties, enzyme kinetics and inhibition of enzymes, and isoprene rule and general methods of structure determination of terpenoids and alkaloids.

CO2 Illustrate the mechanisms of enzyme catalyzed reactions along with mechanism of action of chymotrypsin and carboxypeptidase A.

CO3 Apply the various processes of extraction, purification and immobilization of enzymes.

CO4 Apply various approches for the synthesis of natural products like citral, α-terpineol, β-carotene, cholesterol, testosterone, progesterone, nicotine, atropine and quinine.

CO5 Evaluate the formation of various natural products on the basis of the theoretical models, equilibrium and molecular behaviour, to propose scientifically valid conclusions.

Elective: SET-B
Organic Chemistry (OC)

Master of Science Chemistry
3rd Semester
Organic Chemistry Practical-III

Course code: U25CHE313P (OC)

120 Hrs (8Hrs /week)	**Marks for Major Test (External): 70**
Credits: 4	**Marks for Internal Exam: 30**
Time of Examination: 6 Hrs	**Total Marks: 100**

Objectives: This course develops practical skills in the separation, identification, and structural elucidation of components of binary mixtures and applying spectroscopic techniques (IR, NMR, MS) to confirm the structures of the separated compounds.

1. Qualitative Analysis
Separation of components of a binary (solid+solid, liquid+solid or liquid+liquid) organic mixture using physical and chemical methods. Characterization of the separated components with the help of chemical analysis and derivative formation.

2. Confirmation of the structures by spectral data
Confirmation of the structures of separated components of binary mixture using IR, NMR and MS spectral data (IR, NMR and MS spectra will be provided).

Books Suggested:

1. Experiments and Techniques in Organic Chemistry, D. Pasto, C.R. Johnson and M.J. Miller, Prentice Hall, Pearson, 1st Ed., 1991.
2. Macroscale and Microscale Organic Experiments, K.L. Williamson, K.M. Masters, Cengage Learning, 8th Ed., 2023.
3. Systematic Qualitative Organic Analysis, H. Middleton, Adward Arnold & Co., 1948.
4. A Handbook of Organic Analysis-Qualitative and Quantitative, H. Clark, Adward Arnold, 5th Ed., 1975.
5. Vogel's Textbook of Practical Organic Chemistry, B.S. Furniss, A.J. Hannaford, P.W.G. Smith and A.R. Tatchell, Pearson India, 5th Ed., 2003.
6. Advance Practical Organic Chemistry, M, Casey, J. Leonard, B. Lygo and G. Procter, Nelson Thornes Ltd., 1989.
7. Experiments in Organic Chemistry, L.F. Fieser, D.C. Heath & Co., 1941 (Digitized 2024).
8. Elementary Practical Organic Chemistry, A.I. Vogel, Pearson India, 2nd Ed., 2010.
9. Practical Organic Chemistry, F.G. Mann and B.C. Saunders, Pearson India, 4th Ed., 2009.
10. Laboratory Manual of Organic Chemistry, R.K. Bansal, New Age International Pvt. Ltd., 5th Ed., 2008.
11. Organic Analytical Chemistry: Theory and Practice, Jag Mohan, Alpha Science International Ltd., 2003.
12. Introduction to Spectroscopy, D. L. Pavia, Cengage India Private Limited, 5th Ed., 2015.
13. Spectrometric Identification of Organic Compounds, R.M. Silverstein, F.X. Webster, D.J. Kiemle, D.L. Bryce, Wiley, 8th Ed.,2014.
14. Organic Spectroscopy, William Kamp, Bloomsbury Publishing India Pvt. Ltd., 3rd Ed., 2022.
15. Spectroscopic Methods in Organic Chemistry, D.H. William and Ian Fleming., McGraw-Hill Education, 6th Ed., 2007.

Course outcomes:
Upon successful completion of the course, students will be able to:

CO1	Perform the separation of binary organic mixtures using suitable physical and chemical methods.
CO2	Identify different functional groups using qualitative analysis.
CO3	Prepare characteristic derivatives of organic compounds to support identification and confirm purity.
CO4	Interpret IR, NMR), and MS data to deduce structural features of organic compounds.
CO5	Correlate experimental chemical analysis with spectral data to confirm the complete structure of organic molecules in a mixture.
CO6	Develop the skill of performing experiments, analysing data and compile experimental information in the form of lab record and defend *viva-voce.*

Elective: SET-B
Organic Chemistry (OC)

Master of Science Chemistry
3rd Semester
Organic Chemistry Practical-IV

Course code: U25CHE314P (OC)

120 Hrs (8Hrs /week)	**Marks for Major Test (External): 70**
Credits: 4	**Marks for Internal Exam: 30**
Time of Examination: 6 Hrs	**Total Marks: 100**

Objectives: This course develops practical skills in the extraction, isolation, purification, and structural identification of organic compounds from natural sources, and provides hands-on experience with chromatographic techniques for separation and analysis of organic mixtures, integrating chemical and spectroscopic methods for compound identification.

I Extraction of organic compounds from natural sources:

Isolation of caffeine from tea leaves.
Isolation of casein from milk.
Isolation of lactose from milk.
Isolation of piperine from black pepper.
Isolation of β-carotene from carrots.

II Analytical techniques:

(a) Separation of an organic mixture by column chromatography. Identification of structure of the compounds after separation by spectroscopic data (IR and NMR) and Chemical analysis.
(b) High Performance Liquid Chromatography, Gas Chromatography and Flash Chromatography for qualitative/quantitative analysis of organic compounds.

Books Suggested:

1. Experiments and Techniques in Organic Chemistry, D. Pasto, C.R. Johnson and M.J. Miller, Prentice Hall, Pearson, 1st Ed., 1991.
2. Macroscale and Microscale Organic Experiments, K.L. Williamson, K.M. Masters, Cengage Learning, 8th Ed., 2023.
3. Systematic Qualitative Organic Analysis, H. Middleton, Adward Arnold & Co., 1948.
4. A Handbook of Organic Analysis-Qualitative and Quantitative, H. Clark, Adward Arnold, 5th Ed., 1975.
5. Vogel's Textbook of Practical Organic Chemistry, B.S. Furniss, A.J. Hannaford, P.W.G. Smith and A.R. Tatchell, Pearson India, 5th Ed., 2003.
6. Advance Practical Organic Chemistry, M, Casey, J. Leonard, B. Lygo and G. Procter, Nelson Thornes Ltd., 1989.
7. Experiments in Organic Chemistry, L.F. Fieser, D.C. Heath & Co., 1941 (Digitized 2024).
8. Elementary Practical Organic Chemistry, A.I. Vogel, Pearson India, 2nd Ed., 2010.
9. Practical Organic Chemistry, F.G. Mann and B.C. Saunders, Pearson India, 4th Ed., 2009.
10. Laboratory Manual of Organic Chemistry, R.K. Bansal, New Age International Pvt. Ltd., 5th Ed., 2008.
11. Organic Analytical Chemistry: Theory and Practice, Jag Mohan, Alpha Science International Ltd., 2003.
12. Introduction to Spectroscopy, D. L. Pavia, Cengage India Private Limited, 5th Ed., 2015.
13. Spectrometric Identification of Organic Compounds, R.M. Silverstein, F.X. Webster, D.J. Kiemle, D.L. Bryce, Wiley, 8th Ed.,2014.
14. Organic Spectroscopy, William Kamp, Bloomsbury Publishing India Pvt. Ltd., 3rd Ed., 2022.
15. Spectroscopic Methods in Organic Chemistry, D.H. William and Ian Fleming., McGraw-Hill Education, 6th Ed., 2007.

Course outcomes:

Upon successful completion of the course, students will be able to:

CO1 Isolate and purify naturally occurring organic compounds using standard extraction and separation techniques.

CO2 Demonstrate understanding of the chemical nature and functional groups of isolated natural products through classical characterization methods.

CO3 Separate components of an organic mixture using column chromatography and identify them using spectroscopic techniques (IR and NMR) and chemical analysis.

CO4 Explain the principles and instrumentation of modern chromatographic techniques including HPLC, GC, and Flash Chromatography.

CO5 Apply chromatographic methods for qualitative and quantitative analysis of organic compounds, interpreting output data for compound identification and purity assessment.

CO6 Develop the skill of performing experiments, analysing data and compile experimental information in the form of lab record and defend *viva-voce*. `

Elective: SET-C
Physical Chemistry (PC)

Master of Science Chemistry
3rd Semester
Surface Chemistry and Non-Equilibrium Thermodynamics

Course code: U25CHE311T (PC)

60 Hrs (4Hrs /week)	**Marks for Major Test (External): 70**
Credits: 4	**Marks for Internal Exam: 30**
Time of Examination: 3 Hrs	**Total Marks: 100**

Note: *The examiner is required to set nine questions in all. The first question will be compulsory consisting of seven short questions covering the entire syllabus consisting of 2 marks each. In addition to this, eight more questions (each question may be of 2-3 parts) will be set consisting of two questions from each unit. The student/candidate is required to attempt five questions in all, selecting one from each unit consisting of 14 marks and the compulsory Question No.1.*

Objectives: This course imparts fundamental and applied understanding of surface chemistry and non-equilibrium thermodynamic principles, with an emphasis on physical phenomena at interfaces, catalytic mechanisms, surfactant behavior, and transport processes.

Unit-I **15 Hrs**

Surface Chemistry-I

Adsorption: The extent of adsorption: Physisorption and Chemisorption, adsorption isotherms (Langmuir, BET, Freundlich isotherms), rates of surface processes (adsorption and desorption), mobility on surfaces, biosensor analysis. Surface tension, capillary action, pressure difference across curved surface (Laplace equation), vapour pressure of droplets (Kelvin equation), surface films on liquids (Electro-kinetic phenomenon).

Unit-II **15 Hrs**

Heterogeneous catalysis: Mechanisms of heterogeneous catalysis– Langmuir-Hinshelwood mechanism, Eley-Rideal Mechanism, catalytic activity at surfaces, Catalysis in chemical industry.
General features, structure of surfactants in solution, influence of chain length and salt concentration, surfactant parameters, surface active agents, classification of surface-active agents, micellisation, hydrophobic interactions, critical micellar concentration, factors affecting CMC of surfactants, CMC temperature dependence, counter ions binding to micelles, thermodynamics of micellization-phase, solubilization, microemulsion, reverse micelles.

Unit-III **15 Hrs**

Non-Equilibrium Thermodynamics-I

Introduction to non-equilibrium thermodynamics: Basic concept of entropy production and uncompensated heat and their relation to various thermodynamic functions, Entropy production in closed and open systems, entropy balance in continuous and discontinuous systems, transformation properties of fluxes and forces, coupled and uncoupled reactions and conditions, relaxation process.

Unit-IV **15 Hrs**

Non-Equilibrium Thermodynamics-II

Transport phenomena across membranes, thermochemical effects, thermal osmosis, electro-kinetic effect, thermo-mechanical and electrical effects.

Onsager theory and reciprocal relations, Onsager's formalism of non-equilibrium thermodynamics for multicomponent diffusion-Fick's law of diffusion, conductivity of electrolyte solutions, Onsager's formalism for transport phenomenon in electrochemical systems.

Books Suggested:

1. An Introduction to Chemical Thermodynamics, R.P. Rastogi and R.R. Misra, Vikas Publication, 1978.
2. Physical Chemistry, P.W. Atkins, Oxford University Press, 11th Ed., 2018.
3. Thermodynamics for Chemists, S. Glasstone, Affiliated East-West Press.
4. Non-Equilibrium Thermodynamics-principles and applications, C. Kalidas and M.V. Sangaranarayanan, McMillan, 2002.
5. Chemical Kinetics, K.J. Laidler, McGraw Hill, 3rd Ed., 2003.
6. Physical Chemistry of Surfaces, A.W. Adamson, John Wiley and Sons.

Course outcomes:

Upon successful completion of the course, students will be able to:

CO1 Understand and explain the different types of adsorption, adsorption isotherms, and analyze the kinetics of adsorption and desorption processes on surfaces.

CO2 Understand the basic principles of non-equilibrium thermodynamics: entropy production, uncompensated heat, and coupled and uncoupled reactions.

CO3 Analyze surface tension and interfacial phenomena.

CO4 Explain heterogeneous catalysis and surfactant chemistry: surfactants, micellization, critical micellar concentration (CMC), and thermodynamics of micelle formation.

CO5 Apply Onsager's formalism and transport phenomena concepts for multicomponent diffusion and electrochemical systems.

Elective: SET-C
Physical Chemistry (PC)

Master of Science Chemistry
3rd Semester
Quantum Chemistry and Group Theory

Course code: U25CHE312T (PC)
60 Hrs (4Hrs /week) **Marks for Major Test (External): 70**
Credits: 4 **Marks for Internal Exam: 30**
Time of Examination: 3 Hrs **Total Marks: 100**

Note: *The examiner is required to set nine questions in all. The first question will be compulsory consisting of seven short questions covering the entire syllabus consisting of 2 marks each. In addition to this, eight more questions (each question may be of 2-3 parts) will be set consisting of two questions from each unit. The student/candidate is required to attempt five questions in all, selecting one from each unit consisting of 14 marks and the compulsory Question No.1.*

Objectives: This course provides a comprehensive understanding of the theoretical foundations and applications of quantum chemistry and group theory in chemical bonding, molecular structure, spectroscopy, and reactivity.

Unit-I **15 Hrs**

Quantum Chemistry-I
The structures of many-electron atoms, VB Theory: Homonuclear diatomic molecules and Polyatomic molecules MO theory: The hydrogen molecule-ion, Homonuclear diatomic molecules, Heteronuclear diatomic molecules Impact on biochemistry: The biochemical reactivity of O_2, N_2, and NO, The Hückel approximation.

Unit-II **15 Hrs**

Quantum Chemistry-II
Electron density distribution in a molecule, determination of its stability, geometry and reactivity. SCF theory, Born-Oppenheimer approximation, Hartree method, Hartree Fock method, Roothan's equation, Hellmann-Feynman theorem and its applications to chemical bonding.

Unit-III **15 Hrs**

Group Theory-I
Elements of Group theory, point groups, theory of representation, reducible & irreducible representations, construction of character tables, (review of Great Orthogonality theorem) cyclic groups, SALC, Projection operators, Carbocyclic systems and MO calculation using symmetry group theoretical methods for $(CH)_n$ systems, Viz, $C_3H_3^+$, C_4H_4, C_6H_6, C_8H_8.

Unit-IV **15 Hrs**

Group Theory-II
Symmetry simplification of Huckel MO method taking Hydrocarbon naphthalene, tetra methylenecyclobutane, Group theory and normal modes of vibration of polyatomic molecules, viz. H_2O, NH_3, BF_3 etc. IR and Raman activity of modes of vibration of molecules, symmetry control of electrocyclic reaction, cycloaddition reactions and sigmatropic reactions.

Books Suggested:

1. Quantum Chemistry D.A. McQuarrie, Viva Books, 2nd Ed., 2007.
2. Quantum Mechanics, M.L. Strause, Prentice – Hall, 1st Ed., 1968.
3. Introductory Quantum Chemistry, A.K. Chandra, Tata McGraw Hill, 4th Ed., 2017.
4. Quantum Chemistry, I.M. Levine, Prentice Hall, 7th Ed., 2013.
5. Chemical Application of Group Theory, F.A. Cotton Interscience 3rd Ed., 2008.
6. Methods in Molecular Orbital Theory, A.G. Turner, Prentice Hall of India, 1974.
7. Group Theory and Symmetry in Chemistry, L.H. Hall, McGraw Hill, 1969.
8. Symmetry and Spectroscopy of Molecules, K.V. Reddy, New Age International2nd Ed., 2020.

Course outcomes:

Upon successful completion of the course, students will be able to:

CO1 Explain the electronic structure of many-electron atoms and apply valence bond and molecular orbital theories to describe bonding in diatomic and polyatomic molecules.

CO2 Analyze electron density distribution and apply self-consistent field (SCF) methods to determine molecular stability, geometry, and chemical reactivity.

CO3 Apply the fundamentals of group theory, including point groups, representations, and character tables, to understand molecular symmetry and construct symmetry-adapted linear combinations (SALCs) for molecular orbital calculations.

CO4 Use symmetry principles to simplify Hückel molecular orbital calculations and determine vibrational modes in polyatomic molecules; identify IR and Raman active modes using group theory.

CO5 Interpret the role of molecular symmetry in organic reaction mechanisms using group theoretical approaches.

Elective: SET-C
Physical Chemistry (PC)

Master of Science Chemistry
3rd Semester
Physical Chemistry Practical-III

Course code: U25CHE313P (PC)

120 Hrs (8Hrs /week)	**Marks for Major Test (External): 70**
Credits: 4	**Marks for Internal Exam: 30**
Time of Examination: 6 Hrs	**Total Marks: 100**

Objectives: This course trains students to analyze redox systems, study reaction kinetics, and evaluate optical activity in chemical mixtures using standard laboratory methods.

I Potentiometry

1. Set up a calomel electrode (saturated) and measure its potential using the quinhydrone electrode as a reference.
2. Set up the following electrodes and measure their potentials. Obtain values for their standard electrode potentials.
   (a) Zn / $ZnSO_4$ (0.1M); (b) Cu / $CuSO_4$ (0.1M).
3. Titrate ($HCl+CH_3COOH$) solution potentiometrically and determine the concentration of each component in a mixture.
4. Titrate solution of (a) KCl / KI / KBr and (b) Mixture (KCl+KI+KBr) potentiometrically. Determine the concentration of each component in a mixture.
5. Titrate potentiometrically a solution of ferrous ions against $K_2Cr_2O_7$ carry out the titration in reverse order.
6. Titrate phosphoric acid potentiometrically and comment on graph.

II Chemical Kinetics

7. Investigate the muta rotation of Glucose catalysed by (a) an acid (b) base.
8. Investigate the inversion of cane sugar in presence of an acid.
9. Investigation of the reaction between hydrogen peroxide and hydrogen iodide.
10. Investigate the reaction between acetone and iodine.
11. Determine the order and velocity constant of the reaction between potassium persulphate and potassium iodide.

III Polarimetery

12. To determine the percentage of two optically active substances in a given mixture.

Books Suggested:

1. Practical Chemistry, A.M. James and F.E. Pricherd, Longman, 3rd Ed.,1974.
2. Practical Physical Chemistry, B.P. Levitt and Findley's, Longman, 9th Ed., 1973.
3. Practical Physical Chemistry, S.R. Palit and S.K. De, Science Book Agency, 2nd Ed., 1938.
4. Experimental Physical Chemistry, R.C. Das and B. Behra, McGraw Hill, 1983.
5. Experiments in Physical Chemistry, Shoemaker and Gailand McGraw Hill, 8th Ed., 2008.

Course outcomes:

Upon successful completion of the course, students will be able to:

CO1 Understand behaviour of various components in chemical systems through kinetics, electrochemical and polarimetric studies.
CO2 Apply the concepts of kinetics, electrochemistry and polarimetry to solve numerical and conceptual problems.
CO3 Compare experimental data to interpret the behaviour of components in solution systems.
CO4 Defend questions or kinetical, electrochemical and polarimetry related problems.

Elective: SET-C
Physical Chemistry (PC)

Master of Science Chemistry
3rd Semester
Physical Chemistry Practical -IV

Course code: U25CHE314P (PC)

120 Hrs (8Hrs /week)	**Marks for Major Test (External): 70**
Credits: 4	**Marks for Internal Exam: 30**
Time of Examination: 6 Hrs	**Total Marks: 100**

Objectives: This course enables hands-on experience in physicochemical techniques for analyzing ionic conductance, light absorption, electrochemical behavior, and refractive properties of solutions.

I Conductometry

1. Study conductometric titration of (1) $MgSO_4$ / $Ba(OH)_2$ (2) $BaCl_2$ / K_2SO_4 and comment on nature of graph.
2. Determine the equivalent conductance at infinite dilution for acetic acid by applying Kohlrausch's law of independent migration of ions.
3. To study stepwise neutralization of polybasic acid i,e oxalic acid, citric acid, succinic acid by conductometric titration and explain the variation in the graph.
4. Determine the hydrolysis constant of aniline hydrochloride.

II Spectrophotometry

5. Determine the concentration of Crystal violet and Aurine in mixture of (crystal violet + aurine) solution.
6. Determine of strength of Fe (II) titrating against $KMnO_4$.
7. Determine of strength of Fe (II) titrating against EDTA solution.
8. Study of absorption of picric acid on charcoal by using colorimeter.
9. Study of dissociation constant of phenolphthalein by colorimeter.

III Polarography

10. Record polarogram of a solution of KCl (0.1M) in absence and presence of 0.005% gelatin in the solution. Explain the nature of polarograms. Repeat the experiment after expelling the dissolved oxygen with a stream of nitrogen gas (5-10 mm). What do you conclude from the experiment?
11. Determine the half wave potential and diffusion current of Cd^{2+} (0.001M) + Zn^{2+} (0.001M) +KCl (0.1M) + gelatine (0.005%). Estimate the concentration of the ions in separate and mixed solutions.
12. Determine the half wave potential and diffusion current of Zn (II) ion and Cd(II) ion in (a) Cd^{2+} (0.001M) in KCl (0.1M) (b) Zn^{2+} (0.001M) in KCl (0.1M).

IV Refractometry

13. Refractometric determination of the composition of solutions.
14. Determination of concentration of sugar in a solution refractometrically.

Books Suggested:

1. Practical Chemistry, A.M. James and F.E. Pricherd, Longman, 3rd Ed.,1974.
2. Practical Physical Chemistry, B.P. Levitt and Findley's, Longman, 9th Ed., 1973.
3. Practical Physical Chemistry, S.R. Palit and S.K. De, Science Book Agency, 2nd Ed., 1938.
4. Experimental Physical Chemistry, R.C. Das and B. Behra, McGraw Hill, 1983.
5. Experiments in Physical Chemistry, Shoemaker and Gailand McGraw Hill, 8th Ed., 2008.

Course outcomes:

Upon successful completion of the course, students will be able to:

CO1 Perform and interpret conductometric titrations to analyze acid-base and salt reactions, and calculate hydrolysis constants using conductivity data.

CO2 Apply spectrophotometric and colorimetric techniques to determine the composition of mixtures and study chemical equilibria.

CO3 Conduct redox and complexometric titrations using spectrophotometry to determine the strength of metal ions, and evaluate the precision and applicability of optical methods.

CO4 Record and interpret polarograms to determine half-wave potentials, diffusion currents, and ion concentrations in single and mixed metal ion systems using electroanalytical techniques.

CO5 Use refractometric methods to determine the composition of liquid mixtures and sugar solutions, and explain results based on refractive index behavior.

For Students of other Departments

3rd Semester
Open Elective Course (OEC)

Introduction to Spectroscopy

Course code: U25OEC307T
30 Hrs (2Hrs /week) **Marks for Major Test (External): 35**
Credits: 2 **Marks for Internal Exam: 15**
Time of Examination: 2 Hrs **Total Marks: 50**

Note: *The examiner is required to set five questions in all. The first question will be compulsory consisting of five short questions covering the entire syllabus consisting of 3 marks each. In addition to this, four more questions (each question may be of 2-3 parts) will be set consisting of two questions from each unit. The student/candidate is required to attempt three questions in all, selecting one from each unit consisting of 10 marks and the compulsory Question No.1.*

Objectives: This course aims to enable students to understand and apply the fundamental principles and analytical techniques of UV-Visible, IR, ^{1}HNMR, and Mass Spectrometry for the structural elucidation and characterization of organic compounds.

Unit-I **15 Hrs**

UV-Visible Spectroscopy: Brief review of electromagnetic spectrum and absorption of radiation, factors affecting the position of UV bands, Various electronic transitions, Beer-Lambert law, visible spectrum & colour, effect of solvent on electronic transitions, ultraviolet bands for carbonyl compounds, unsaturated carbonyl compounds, dienes, conjugated polyenes. Fieser-Woodward rules for conjugated dienes and carbonyl compounds.
Infrared Spectroscopy: Introduction, basic principles, Characteristic vibrational frequencies of various functional groups. factotors affecting vibrational frequencies. Detailed study of vibrational frequencies of carbonyl compounds (ketones, aldehydes, esters, amides, acids, anhydrides, lactones, lactams and conjugated carbonyl compounds).

Unit-II **15 Hrs**

Nuclear Magnetic Resonance Spectroscopy (^{1}H NMR): General introduction and definition, chemical shift, factors affecting chemical shift, solvents, spin-spin interaction, shielding and deshielding mechanism, chemical shift values and correlation for protons bonded to carbon (aliphatic, olefinic, aldehydic and aromatic) and other nuclei (alcohols, phenols, enols, carboxylic acids, amines, amides & mercapto), deuterium exchange, nuclear Overhauser effect (nOe).
Mass Spectrometry: Basic principles, ion production– EI, CI, FD and FAB, MALDI, factors affecting fragmentation, ion analysis, ion abundance, molecular ion peak, metastable peak, McLafferty rearrangement, Nitrogen rule. Mass spectral fragmentation of organic compounds containing common functional groups.

Books Suggested:

1. Spectrometric Identification of Organic Compounds, R.M. Silverstein, G.C. Bassler and T.C. Morrill, John Wiley, 8th Ed., 2014.
2. Introduction to NMR Spectroscopy, R.J. Abraham, J. Fisher and P. Loftus, Wiley, 2014.
3. Application of Spectroscopy of Organic Compounds, J.R. Dyer, Prentice Hall, 2007.
4. Spectroscopic Methods in Organic Chemistry, D.H. Williams, I. Fleming, Tata McGraw-Hill, 7th Ed., 2019.
5. Organic Chemistry, William Kemp, John Wiley, 3rd Ed., 2017.
6. Organic Spectroscopy, Jag Mohan, Narosa Publishers, New Delhi, 2nd Ed. 2009.
7. Introduction to Spectroscopy, G.M. Lampman, D.L. Pavia, G.S. Kriz and J.M. Vyvyan, Cengage Learning, 5th Ed., 2015.

Course outcomes:

Upon successful completion of the course, students will be able to:

CO1 Understand the electronic transitions in organic molecules, IR analysis, basic NMR concepts, and mass spectrometry for structure determination.

CO2 Apply Beer-Lambert Law to determine concentration and absorbance, Fieser-Woodward rules for estimation of λ_{max}, and nOe to simplify and analyze spectra.

CO3 Analyze vibrational modes and frequency shifts, mass spectra for characteristic fragmentation patterns and functional group identification.

CO4 Predict and explain UV absorption bands for carbonyl compounds, conjugated systems, ^{1}H NMR-chemical shift, spin-spin coupling, integration, MS- ionization techniques and their applications.

CO5 Correlate molecular structure with visible spectrum, chemical shift values with various proton environments in organic compounds in NMR.

For OPTION- A Only

Master of Science Chemistry
4th Semester
Instrumental Methods of Analysis

Course code: U25OEC401T

60 Hrs (4Hrs /week)	**Marks for Major Test (External): 70**
Credits: 4	**Marks for Internal Exam: 30**
Time of Examination: 3 Hrs	**Total Marks: 100**

Note: *The examiner is required to set nine questions in all. The first question will be compulsory consisting of seven short questions covering the entire syllabus consisting of 2 marks each. In addition to this, eight more questions (each question may be of 2-3 parts) will be set consisting of two questions from each unit. The student/candidate is required to attempt five questions in all, selecting one from each unit consisting of 14 marks and the compulsory Question No.1.*

Objectives: The objective of this course is to provide students hands-on understanding of modern analytical techniques used in chemical research and industry.

Unit-I **15 Hrs**

Chromatographic Methods
Classification of chromatographic methods, separation and development procedure, theoretical principles, factors influencing retention, retention and equilibrium in chromatography, separating efficiency of a column and resolution, Principle of gas chromatography, instrumentation, column and stationary phases, application and advances, Hyphenated techniques- GCMS, principle of HPLC, instrumentation and application, and LCMS.

Unit-II **15 Hrs**

Thermo-Analytical Methods
Theory, instrumental requirements and methodology for thermo gravimetric analysis (TG), differential thermal analysis (DTA) and differential scanning calorimeter (DSC), applications in organic, inorganic chemistry and polymers. Hyphenated techniques (TG-FTIR, TG-GC) and advantages.

Unit-III **15 Hrs**

Diffraction Methods
Bragg condition, Miller indices, Bragg method, Debye-Scherrer method (sodium chloride crystal), indexing reflections for a cubic system using powder method. identification of unit cells from systematic absences in diffraction pattern. Structure factor and its relation to intensity and electron density, introduction to phase problem. Description of the procedure for an X-ray structure analysis (NaCl). Introduction to electron diffraction, low energy electron diffraction and neutron diffraction.

Unit-IV **15 Hrs**

Advance Methods
Principles, instrumentation and applications of scanning probe microscopy, auger, scanning electron microscopy (SEM), Energy-dispersive *X*-ray spectroscopy (EDX), scanning tunnelling microscopy (STM), transmission electron microscopy (TEM), atomic force microscopy (AFM), X-ray fluorescence spectroscopy (XRF).

Books suggested:

1. Principles of Instrumental analysis, Skoog, Holler, Niemen, Saunders college publication, 7th Ed., 2020.
2. Fundamentals of Analytical Chemistry, D.A. Skoog, D.M. West, F.J. Holler and S.R. Crouch, Cengage Learning, 5th Ed., 1988.
3. Instrumental Methods of Analysis, H.H Willard, L.L. Merrit, J.A. Dean and F.A. Settle, CBS Publishers, 4th Ed., 1967.
4. Thermal Methods of Analysis: Principles, Application and Problems, P.J. Hains, Blackie Academic and Professional, 1st Ed., 1995.

Course outcomes:

Upon successful completion of the course, students will be able to:

CO1 Explain and apply chromatographic techniques, understanding retention mechanisms, column efficiency, and utilizing instruments for qualitative and quantitative chemical analysis.

CO2 Analyze thermal properties and decomposition patterns of materials using thermo-analytical methods, and interpret results for organic, inorganic, and polymer samples.

CO3 Interpret X-ray diffraction patterns and crystal structures, and understanding the relation between structure factor, intensity, and electron density.

CO4 Differentiate between electron, neutron, and low-energy electron diffraction techniques and describe their uses in structural determination of materials at the atomic scale.

CO5 Utilize advanced microscopic and spectroscopic techniques such as SEM, TEM, AFM, STM, EDX, and XRF for surface morphology, elemental analysis, and nanoscale characterization of materials.

For both OPTIONS- A & B
Elective: SET-A
Inorganic Chemistry (IC)

Master of Science Chemistry
4th Semester

Photo and Bioinorganic Chemistry

Course code: U25OEC411T (IC)
60 Hrs (4Hrs /week) **Marks for Major Test (External): 70**
Credits: 4 **Marks for Internal Exam: 30**
Time of Examination: 3 Hrs **Total Marks: 100**

Note: *The examiner is required to set nine questions in all. The first question will be compulsory consisting of seven short questions covering the entire syllabus consisting of 2 marks each. In addition to this, eight more questions (each question may be of 2-3 parts) will be set consisting of two questions from each unit. The student/candidate is required to attempt five questions in all, selecting one from each unit consisting of 14 marks and the compulsory Question No.1.*

Objectives: This course aims to build proficiency for photoinorganic chemistry and role of metal ions in biological systems.

Unit-I **15 Hrs**

Photoinorganic Chemistry
Absorption, excitation, photochemical laws, quantum yield, electronically excited states-life times-measurements of the times. Flash photolysis, stopped flow techniques. Energy dissipation by radiative and non-radiative processes, absorption spectra, Franck – Condon principle, photochemical stages-primary and secondary processes, Electronically excited states of metal complexes. Photosubstitution, photooxidation and photoreduction, lability and selectivity.

Unit-II **15 Hrs**

Metal Ions in Biological Systems
Essential and trace metals. Role of metals ions in biological processes, Na^+/K^+ Pump.
Bioenergetics and ATP Cycle
DNA polymerisation, glucose storage, metal complexes in transmission of energy. Model systems.
Nitrogenase
Biological nitrogen fixation, molybdenum nitrogenase, spectroscopic and other evidence, other nitrogenases model systems.

Unit-III **15 Hrs**

Transport and Storage of Dioxygen
Heme proteins and oxygen uptake, structure and function of hemoglobin, myoglobin, hemocyanins and hemerythrin, synthetic models.
Electron Transfer in Biology
Structure and function of metalloproteins in electron transport processes – cytochromes and ion-sulphur proteins, synthetic models.

Unit-IV **15 Hrs**

Mettaloenzymes

Zinc enzymes- carboxypeptidase and carbonic anhydrase. Iron enzymes- catalase, peroxidase and cytochrome P-450. Copper enzymes- superoxide dismutase. Molybednum oxatransferase enzymes- xanthine oxidase. Coenzyme vitamin B_{12}.

Metal Storage Transport and Biomineralization

Ferritin, transferrine and siderophores.

Books Suggested:

1. Principles of Bioinorganic Chemistry, S.J. Lippard and J.M. Berg, University Science Books, 1st Ed., 1994.
2. Bioinorganic Chemistry, I. Bertini, H.B. Gray, S.J. Lippard and J.S. Valentne, University Science Books, 2nd Ed., 2007.
3. Bio-inorganic Chemistry, R.W. Hay; Ellis Harwood limited, 2nd Ed., 2002.
4. Metal ions in Biochemistry, P.K. Blattachary, Narosa Publishing House, 2nd Ed., 2021.
5. Concepts of Inorganic Photochemistry, A.W. Adamson and P.D. Fieischauer, Wiley, 1st Ed., 1975.
6. Photochemistry of Coordination Compounds, V Balzari and V. Carassiti, Academic Press, 1st Ed., 1987.

Course outcomes:

Upon successful completion of the course, students will be able to:

CO1 Understand the fundamental principles of photoinorganic chemistry.
CO2 Explain concepts of bioinorganic chemistry.
CO3 Describe the biological roles of essential and trace metal ions.
CO4 Analyze the structure and function of metalloproteins.
CO5 Examine the roles of metalloproteins in electron transfer processes.
CO6 Evaluate the biological significance of metalloenzymes.

For both OPTIONS- A & B
Elective: SET-A
Inorganic Chemistry (IC)

Master of Science Chemistry
4th Semester

Chemistry of Materials

Course code: U25OEC412T (IC)

60 Hrs (4Hrs /week)	**Marks for Major Test (External): 70**
Credits: 4	**Marks for Internal Exam: 30**
Time of Examination: 3 Hrs	**Total Marks: 100**

Note: *The examiner is required to set nine questions in all. The first question will be compulsory consisting of seven short questions covering the entire syllabus consisting of 2 marks each. In addition to this, eight more questions (each question may be of 2-3 parts) will be set consisting of two questions from each unit. The student/candidate is required to attempt five questions in all, selecting one from each unit consisting of 14 marks and the compulsory Question No.1.*

Objectives: This course aims to build proficiency for Metal- π-Complexes, metal clusters, inorganic polymers and nuclear Chemistry.

Unit-I **15 Hrs**

Metal- π-Complexes
Metal carbonyls, structure and bonding, vibrational spectra of metal carbonyls for bonding and structural elucidation, important reactions of metal carbonyls; preparation, bonding, structure and important reactions of transition metal nitrosyl, dinitrogen and dioxygen complexes; tertiary phosphine as ligand.

Unit-II **15 Hrs**

Metal Clusters
Higher boranes, carboranes, metalloboranes and metallocarboranes. Metal carbonyl and halide clusters, compounds with metal-metal multiple bonds.

Unit-III **15 Hrs**

Inorganic polymers
Polyphosphazenes: Synthetic routes, ring opening mechanism, preparation of organo/organometallic substituted phosphazenes, bonding features, applications of polyphosphazenes.
Polysilanes: Preparation and characterization of polysilanes, sigma bond delocalization in polysilanes & its implications, applications of polysilanes.
Polysiloxanes: Method of synthesis by anionic and cationic polymerization properties, structural flexibility, application of polysiloxanes.

Unit-IV **15 Hrs**

Nuclear Chemistry
Fundamental particles of nucleus (nucleons), concept of nuclides, representation of nuclides, isobars and isotopes, qualitative idea of the stability of nucleus (n/p ratio), Shell and liquid drop models (qualitative idea), natural and artificial radioactivity, disintegration series, radioactive disintegration rate, half-life and average life.
Nuclear binding energy, Mass defect, Einstein mass energy relation, calculation of mass defect and binding energy, Nuclear reactions: nuclear fission, fusion and spallation, Radioactive isotopes, and Carbon dating.

Books Suggested:

1. Advance inorganic Chemistry, F.A. Cotton & G. Wilkinson, 4th Ed., 1980.
2. Inorganic Chemistry, J.E. Huheey, Pearson Education India; 4th Ed., 2006.
3. Inorganic Polymer, J.E. Mark. OUP USA, 2nd Ed., 2005.
4. Polymer Characterization, B.J. Hunt and James I. Mark. Springer; Softcover reprint of the original 1st Ed., 1993.
5. Essentials of Nuclear Chemistry, H. J. Arnikar, Wiley Eastern, New Delhi, 4th Ed., 1995.
6. Nuclear & Radiochemistry, G. Fridlander, J.W. Kennedy, E. S. Macias, and J. M. Miller, John Wiley, New York. 3rd Ed., 1981.
7. Radiochemistry and Nuclear Chemistry, G. Choppin, J. Liljenzin and J. Rydberg, Academic Press; 4th Ed., 2013.

Course outcomes:

Upon successful completion of the course, students will be able to:

CO1 Understand the basic concepts of nuclear chemistry.
CO2 Describe structure and bonding of metal π complexes and clusters.
CO3 Explain synthetic methods, reactivity and properties of inorganic polymers.
CO4 Apply the inorganic polymers in real-life world.
CO5 Evaluate the nuclear stability.

For OPTION- A only
Elective: SET-A
Inorganic Chemistry (IC)

Master of Science Chemistry
4th Semester

Inorganic Chemistry Practical-V

Course code: U25CHE413P (IC)

120 Hrs (8Hrs /week)	**Marks for Major Test (External): 70**
Credits: 4	**Marks for Internal Exam: 30**
Time of Examination: 6 Hrs	**Total Marks: 100**

Objectives: This course enables the students to systematically prepare**,** characterize**,** and visually represent a diverse set of coordination complexes through the use of ChemDraw software, enhancing understanding of coordination chemistry.

Preparation, characterization and drawing the structures of complexes using Chem Draw software

1. Vanadium(IV) oxide bis(acetylacetonate)
2. Ammonium tetrakis(isothiocyanato)diamminechromium(III)
3. Manganese(III) acetylacetonate
4. Sodium hexanitritocobaltate(III)
5. Mercury(I) tetrathiocyanato-N-cobaltate(II)
6. Copper(I) tetraiodomercurate(II)
7. Potassium trioxalatoferate(III) Trihydrate.
8. Dichlorobis(hydroxylamine) Zinc(II).
9. Pentathioureadicuprous nitrate.
10. Potassium trioxaltochromate (III).
11. Potassium trioxalatocobaltate (III).
12. Carbonato tetra-ammine cobalt (III) nitrate
13. Tetraammineaquacopper(II) sulfate monohydrate
14. Hexaammine nickel(II) chloride.

Books Suggested:

1. Vogel's Textbook of Quantitative Chemical Analysis, ELBS, London, 5th Ed., 1989.
2. Synthesis and characterization of Inorganic Compounds W.L. Jolly, Prentice Hall, 1st Ed., 1970.
3. Synthesis and Physical studies of Inorganic Compounds C.F. Bell, Pergamon Press, 1st Ed., 1972.
4. Principles and application of Organotransition Metal Chemistry, J P Collmann, L S Hegsdus, J R Norton and R.G. Finke, University Science Books, 2nd Ed., 1987.

Course outcomes:

Upon successful completion of the course, students will be able to:

CO1 Understand the concepts of coordination chemistry.
CO2 Apply different synthethic procedures for coordination compounds.
CO3 Interpret spectral and analytical data to deduce the structure.
CO4 Utilize Chem Draw software to accurately represent coordination complexes and their bonding.
CO5 Evaluate experimental findings with theoretical knowledge.

For OPTION- A only
Elective: SET-A
Inorganic Chemistry (IC)

Master of Science Chemistry
4th Semester

Inorganic Chemistry Practical-VI

Course code: U25CHE414P (IC)

120 Hrs (8Hrs /week)	**Marks for Major Test (External): 70**
Credits: 4	**Marks for Internal Exam: 30**
Time of Examination: 6 Hrs	**Total Marks: 100**

Objectives: This course enables the students to estimate various elements and compounds in given samples through quantitative analytical techniques, such as volumetric analysis**,** precipitation titrations, and complexometric methods.

Quantitative analysis

1. To estimate the available chlorine in bleaching powder
2. To determine the chlorine, bromine and iodine in a given mixture.
3. Determine the strength of Silver, Copper and Nickel in the given mixture solution.
4. Determine the strength of Silver, Copper and Zinc in the given solution.
5. To find out the strength of Copper, Zinc and Aluminium in the given mixture solution.
6. To estimate the strength of Iron, Nickel and Zinc in the given sample.
7. Determine the strength of Copper, Nickel and Magnesium in the given mixture solution.
8. Determine the strength of Copper, Nickel and Zinc in the given mixture solution.
9. Determine the strength of Silver, Nickel and Zinc in the given mixture solution.
10. Determine the strength of Silver, Nickel and Magnesium in the given mixture solution.

Books suggested:

1. Spectrometric identification of organic compounds R.M. Silverstein, G.C. Bassler and T.C. Morill John Wiley, 5th Ed., 1991.
2. Organic spectroscopy by Jag Mohan, Narosa Publication, 2nd Ed., 2022.
3. Application of Spectroscopy of organic Compounds, J R Dyer, Prentice Hall, 1st Ed., 1965.
4. Spectroscopy, G.M. Lampman, D.L. Pavia, G.S. Kriz and J.M. Vyvyan, Cengage Learning, 5th Ed., 2019.

Course outcomes:

Upon successful completion of the course, students will be able to:

CO1 Understand the concepts of gravimetric and volumetric analysis.
CO2 Perform quantitative estimation of metal ions using appropriate gravimetric and volumetric techniques.
CO3 Apply principles of selective precipitation and complexation to achieve effective separation of metal ions.
CO4 Calculate the amount of metal ions in mixtures.
CO5 Interpret data and validate results, and defend *viva-voce*.

For both OPTIONS- A & B
Elective: SET-B
Organic Chemistry (OC)

Master of Science Chemistry
4th Semester
Organic Synthesis

Course code: U25OEC411T (OC)
60 Hrs (4Hrs /week) **Marks for Major Test (External): 70**
Credits: 4 **Marks for Internal Exam: 30**
Time of Examination: 3 Hrs **Total Marks: 100**

Note: *The examiner is required to set nine questions in all. The first question will be compulsory consisting of seven short questions covering the entire syllabus consisting of 2 marks each. In addition to this, eight more questions (each question may be of 2-3 parts) will be set consisting of two questions from each unit. The student/candidate is required to attempt five questions in all, selecting one from each unit consisting of 14 marks and the compulsory Question No.1.*

Objectives: The course aims to build proficiency in reaction mechanisms**,** named reactions, and retrosynthetic (disconnection) approaches for complex molecule construction.

Unit-I **15 Hrs**

Reagents in Organic Synthesis
Principle, preparations, properties and applications of the following in organic synthesis with mechanistic details – lithium diisopropylamide (LDA) dicyclohexylcarbodimide (DCC), 1,3-Dithiane (reactivity umpoloung), trimethylisilyl iodide, tri-n-butyltin hydride, Woodward and Prevost hydroxylation, DDQ, Oxidation with Ruthenium tetraoxide, iodobenzene diacetate and thallium nitrate.

Unit-II **15 Hrs**

Reactions and Rearrangements
A detailed study of the following reaction- Favorskii, Arndt-Eistert synthesis, Baeyer-Villiger, Shapiro reaction, Chichibabin reaction. Mitsunobu reaction, Suzuki reaction, Buchwald-Hartwing reaction (cross-coupling), Sonogarshira reaction.

Unit-III **15 Hrs**

Disconnection Approach
An introduction to synthons and synthetic equivalents, disconnection approach, functional group inter-conversions, the importance of the order of events in organic synthesis, one group C-X disconnections and two-group C-X disconnections, chemoselectivity, cyclisation reactions, amine synthesis.
Protecting Groups
Principles of protection of alcohol, amine, carbonyl and carboxyl groups.

Unit-IV **15 Hrs**

One Group C-C Disconnections
Alcohols and carbonyl compounds, regioselectivity. Alkene synthesis, use of acetylenes and aliphatic nitro compounds in organic synthesis.
Two Group C-C Disconnections
Diels-Alder reaction, 1,3-difunctionalised compounds, α,β-unsaturated carbonyl compounds, 1.5-difunctionalised compounds. Michael addition and Robinson annelation.

Books Suggested:

1. Modern Synthetic Reactions, H.O. House, Benjamin Cummings Publishers, 2nd Ed., 1972.
2. Modern Methods of Organic Synthesis, I. Coldham and W. Carruthers, Cambridge University Press, 4th Ed., 2004.
3. March's Advanced Organic Chemistry: Reactions, Mechanisms and Structure, Michael B. Smith, Wiley, 8th Ed., 2019.
4. Advanced Organic Chemistry Part B: Reactions and Synthesis, F.A. Carey and R.J. Sundberg, Springer, 5th Ed., 2007.
5. Designing Organic Syntheses: A Programmed Introduction to the Synton Approach, S. Warren, Wiley, 1st Ed., 1978.
6. Organic Synthesis- Concept, Methods and Starting Materials, J. Fhrhop and G. Penzillin, Wiley-VCH, 1986.
7. New Horizons in Organic Synthesis, V. Nair, New Age International, 1997.
8. Reagents in Organic Synthesis, Fieser and Fieser, Wiley, 2008.
9. Organic Synthesis through disconnection approach, P.S. Kalsi, Medtec Science Press, 3rd Ed., 2022.
10. Comprehensive Organic Transformation, R.C. Larcock, Wiley-VCH, 3rd Ed., 2018.
11. Organic Chemistry, J.G. Smith, McGraw-Hill, 2nd Ed., 2008.
12. Organic Synthesis: The Disconnection Approach, S. Warren, Wiley, 2nd Ed., 2007.

Course outcomes:

Upon successful completion of the course, students will be able to:

CO1 Describe the role of various reagents in organic transformations.
CO2 Explain the mechanistic details of different name reactions used for effective organic synthesis.
CO3 Describe the reactions catalyzed by palladium and their applications in organic synthesis
CO4 Apply the concepts of disconnection approach for the synthesis of different target organic molecules.
CO5 Explain the importance of order of events in synthesis and protection/deprotection in synthetic organic chemistry.
CO6 Describe alkene synthesis, aliphatic nitro compounds and two group C-C disconnections in organic synthesis.

For both OPTIONS- A & B
Elective: SET-B
Organic Chemistry (OC)

Master of Science Chemistry
4th Semester
Medicinal Chemistry

Course code: U25OEC412T (OC)
60 Hrs (4Hrs /week) **Marks for Major Test (External): 70**
Credits: 4 **Marks for Internal Exam: 30**
Time of Examination: 3 Hrs **Total Marks: 100**

Note: *The examiner is required to set nine questions in all. The first question will be compulsory consisting of seven short questions covering the entire syllabus consisting of 2 marks each. In addition to this, eight more questions (each question may be of 2-3 parts) will be set consisting of two questions from each unit. The student/candidate is required to attempt five questions in all, selecting one from each unit consisting of 14 marks and the compulsory Question No.1.*

Objectives: The course equips students with the ability to provide an in-depth understanding of laying a foundation for rational drug design and discovery, chemical synthesis**,** and therapeutic applications of major classes of drugs.

Unit-I **15 Hrs**

Drug Design
Introduction, development of chemotherapeutic agents, therapeutic index, LD50 and ED50. Elementary idea about drug action: Concept of drugs receptor, elementary treatment of drug receptor interactions, ion channels and their control. Design of agonists, antagonists and partial agonists.
Drug development: concept of lead compounds. structure-activity relationships (SAR), synthetic analogues, isosteres and bioisosteres. Introductory idea of quantitative structure-activity relationships (QSAR).
Brief overview of pharmacokinetics and pharmacodynamics, concept of prodrug and synergism.

Unit-II **15 Hrs**

Analgesics, Antipyretics and Anti-inflammatory agents
Synthesis and uses of the following drugs: Morphine and related compounds (codeine and heroin), meperidine, methadone, aspirin, acetaminophen, indomethacin, phenylbutazone, mefenamic acid, ibuprofen and diclofenac.
Cardiovascular Drugs
Introduction, calcium channel blockers and β-blockers. Synthesis and uses of nitroglycerine, isosorbide dinitrate (sorbitrate), atenolol, diltiazem and verapamil.
Antifertility agents
Ovulation inhibitors and related hormonal contraceptives- norethindrone, norethynodrel, estradiol, mestranol; non-hormonal contraceptive- centchroman (synthesis of all the drugs excluded).

Unit-III **15 Hrs**

Antibiotics
Cell wall biosynthesis and protein synthesis inhibitors. Penicillins: Synthesis and uses of the penicillin G, problems of sensitivity to acids, β-lactamases and narrow spectrum of activity solved by leading to the development of oxacillin, cloxacillin, ampicillin and amoxicillin. Synthesis and uses of cephalosporin-C. Introduction to azithromycin, tetracyclines and streptomycin (structures and uses only).

Antineoplastic Agents
Introduction, role of alkylating agents and antimetabolites in treatment of cancer. Synthesis and uses of the following antineoplastic agents: mechlorethamine, cyclophosphamide, melphalan, carmustin, 5-fluorouracil and 6-mercaptopurine. Introduction to paclitaxel (synthesis of paclitaxel excluded).

Unit-IV **15 Hrs**

Antimalarials
Introduction, Synthesis and uses of the following antimalarial drugs: chloroquine, primaquine and chloroguanide.

Antimycobacterial Drugs
Synthesis and uses of the following drugs: isoniazid, ethambutol and dapsone.

Antimicrobial Drugs
Antibacterial and antifungal agents, Synthesis and uses of ciprofloxacin and fluconazole.

Anxiolytics (Tranquilizers)
Synthesis and uses of diazepam, alprazolam and buspirone.

AIDS and drugs against HIV
HIV infection to the system, structure and uses of important drugs against HIV (nucleoside reverse transcriptase inhibitors) - AZT, ddI, ddC, d4T and 3TC (synthesis only of AZT).

Books Suggested:

1. An Introduction to Medicinal Chemistry, G.L. Patrick, Oxford University Press, 5th Ed., 2013.
2. Wilson and Gisvold's Text Book of Organic Medicinal and Pharmaceutical Chemistry, J.H. Block and J.M. Baele Jr., Lippincott Williams and Wilkins, 10th Ed., 1998.
3. The Organic Chemistry of Drug Design and Drug Action, M.W. Holladay and R.B. Silverman, Academic Press Inc., 3rd Ed., 2014.
4. Synthesis of Essential Drugs, R.S. Vardanyan and V.J. Hruby, Elsevier, Amsterdam, The Netherlands, 1st Ed., 2006.
5. Textbook of Medicinal Chemistry Vol. 1 & 2, V. Algarsamy, CBS Publishers & Distributors Pvt. Ltd., 4th Ed., 2022.
6. Burger's Medicinal Chemistry and Drug Discovery Vol. 5: Therapeutic Agents, M.E. Wolff, John Wiley, 5th Ed., 1905.

Course outcomes:
At the end of the course, the students would be able to:

CO1 Understand the basic principles of design drug, action, and the terminology involved therein.
CO2 Apply the integrated concepts of drug design for development of new drugs using rational approach to drug design, concept of lead compounds. structure-activity relationships (SAR), quantitative structure-activity relationships (QSAR).
CO3 Apply the knowledge of organic reactions for synthesis of analgesics, antipyretics and anti-inflammatory agents, cardiovascular drugs, antibiotics (cell wall biosynthesis and protein synthesis inhibitors), antineoplastics, antimalarials, antimycobacterial, antimicrobial drugs, anxiolytics (tranquilizers), antifertility agents, drugs against HIV (nucleoside reverse transcriptase inhibitors).
CO4 Familiar with analysing mechanistic details of various synthetic approaches of different drug molecules as given above and their medicinal uses.
CO5 Evaluate the formation of various drug molecules on the basis of the theoretical models, equilibrium and molecular behaviour, to propose scientifically valid conclusions.

For OPTION- A only
Elective: SET-B
Organic Chemistry (OC)

Master of Science Chemistry
4th Semester
Organic Chemistry Practical-V

Paper code: U25CHE413P (OC)
120 Hrs (8Hrs /week) **Marks for Major Test (External): 70**
Credits: 4 **Marks for Internal Exam: 30**
Time of Examination: 6 Hrs **Total Marks: 100**

Objectives: This paper enables to develop practical skills in the synthesis of organic compounds of medicinal importance, along with proficiency in the estimation of biologically relevant molecules using UV/VIS spectrophotometry.

I Organic preparations:
Synthesis and characterization of organic compounds of medicinal interest:
Such as Isoniazide, Ibuprofen, Paracetamol, Benzocaine, Coumarin-3-carboxylic acid etc.

II Spectrophotometric (UV/VIS) Estimations of the following:
Glucose, amino acids, cholesterol, urea, etc.

Books Suggested:

1. Experiments and Techniques in Organic Chemistry, D. Pasto, C.R. Johnson and M.J. Miller, Prentice Hall, Pearson, 1st Ed., 1991.
2. Macroscale and Microscale Organic Experiments, K.L. Williamson, K.M. Masters, Cengage Learning, 8th Ed., 2023.
3. Systematic Qualitative Organic Analysis, H. Middleton, Adward Arnold & Co., 1948.
4. A Handbook of Organic Analysis-Qualitative and Quantitative, H. Clark, Adward Arnold, 5th Ed., 1975.
5. Vogel's Textbook of Practical Organic Chemistry, B.S. Furniss, A.J. Hannaford, P.W.G. Smith and A.R. Tatchell, Pearson India, 5th Ed., 2003.
6. Advance Practical Organic Chemistry, M, Casey, J. Leonard, B. Lygo and G. Procter, Nelson Thornes Ltd., 1989.
7. Experiments in Organic Chemistry, L.F. Fieser, D.C. Heath & Co., 1941 (Digitized 2024).
8. Elementary Practical Organic Chemistry, A.I. Vogel, Pearson India, 2nd Ed., 2010.
9. Practical Organic Chemistry, F.G. Mann and B.C. Saunders, Pearson India, 4th Ed., 2009.
10. Laboratory Manual of Organic Chemistry, R.K. Bansal, New Age International Pvt. Ltd., 5th Ed., 2008.
11. Organic Analytical Chemistry: Theory and Practice, Jag Mohan, Alpha Science International Ltd., 2003.
12. Introduction to Spectroscopy, D. L. Pavia, Cengage India Private Limited, 5th Ed., 2015.
13. Spectrometric Identification of Organic Compounds, R.M. Silverstein, F.X. Webster, D.J. Kiemle, D.L. Bryce, Wiley, 8th Ed.,2014.
14. Organic Spectroscopy, William Kamp, Bloomsbury Publishing India Pvt. Ltd., 3rd Ed., 2022.
15. Spectroscopic Methods in Organic Chemistry, D.H. William and Ian Fleming., McGraw-Hill Education, 6th Ed., 2007.

Course outcomes:
Upon successful completion of the course, students will be able to:

CO1 Demonstrate the ability to synthesize and purify selected organic compounds of medicinal importance.
CO2 Apply appropriate methods for the characterization of synthesized compounds using various techniques.
CO3 Understand the underlying reaction mechanisms and functional group transformations involved in the synthesis of organic compounds.
CO4 Perform UV/VIS spectrophotometric estimations of biologically important molecules.
CO5 Interpret spectrophotometric data and apply principles of calibration, Beer-Lambert law, and quantitative analysis.

For OPTION- A only
Elective: SET-B
Organic Chemistry (OC)

Master of Science Chemistry
4th Semester
Organic Chemistry Practical-VI

Paper code: U25CHE414P (OC)
120 Hrs (8Hrs /week) **Marks for Major Test (External): 70**
Credits: 4 **Marks for Internal Exam: 30**
Time of Examination: 6 Hrs **Total Marks: 100**

Objectives: To equip students with practical and theoretical knowledge of multistep organic synthesis, including monitoring and characterization techniques (TLC, FT-IR, NMR, MS), and the application of chemical software tools for molecular structure drawing, spectral prediction, and computational studies of small organic molecules.

1. (a) Muti-step synthesis of orgaic compounds invloving following reactions:
   Photochemical reaction
   Beckman rearrangements
   Benzilic acid rearrangements
   Synthesis of organic Compounds of medicinal and other importance, etc.
   (b) The progress of above said reactions should be monitered by Thin layer Chromatography and the final product(s) may also be characterized by utilizing different spectral techniques like FT-IR, NMR (^{1}H & ^{13}C) and MS.

2. Demonstration of different software useful in Chemistry for drawing the structure of Organic compounds as well as for the computational studies of small organic molecules.

3. Drawing of scheme for a multistep synthesis using structural drawing tool(s), getting the IUPAC name and predicted ^{1}H-NMR & ^{13}C-NMR spectrum for each compound involved in multistep preparation.

4. Introductory idea of Molecular graphics, Molecular minimization, Energy minimization and Spectral analysis.

Books Suggested:

1. Experiments and Techniques in Organic Chemistry, D. Pasto, C.R. Johnson and M.J. Miller, Prentice Hall, Pearson, 1st Ed., 1991.
2. Macroscale and Microscale Organic Experiments, K.L. Williamson, K.M. Masters, Cengage Learning, 8th Ed., 2023.
3. Systematic Qualitative Organic Analysis, H. Middleton, Adward Arnold & Co., 1948.
4. A Handbook of Organic Analysis-Qualitative and Quantitative, H. Clark, Adward Arnold, 5th Ed., 1975.
5. Vogel's Textbook of Practical Organic Chemistry, B.S. Furniss, A.J. Hannaford, P.W.G. Smith and A.R. Tatchell, Pearson India, 5th Ed., 2003.
6. Advance Practical Organic Chemistry, M, Casey, J. Leonard, B. Lygo and G. Procter, Nelson Thornes Ltd., 1989.
7. Experiments in Organic Chemistry, L.F. Fieser, D.C. Heath & Co., 1941 (Digitized 2024).
8. Elementary Practical Organic Chemistry, A.I. Vogel, Pearson India, 2nd Ed., 2010.
9. Practical Organic Chemistry, F.G. Mann and B.C. Saunders, Pearson India, 4th Ed., 2009.
10. Laboratory Manual of Organic Chemistry, R.K. Bansal, New Age International Pvt. Ltd., 5th Ed., 2008.
11. Organic Analytical Chemistry: Theory and Practice, Jag Mohan, Alpha Science International Ltd., 2003.
12. Introduction to Spectroscopy, D. L. Pavia, Cengage India Private Limited, 5th Ed., 2015.
13. Spectrometric Identification of Organic Compounds, R.M. Silverstein, F.X. Webster, D.J. Kiemle, D.L. Bryce, Wiley, 8th Ed.,2014.

14. Organic Spectroscopy, William Kamp, Bloomsbury Publishing India Pvt. Ltd., 3rd Ed., 2022.
15. Spectroscopic Methods in Organic Chemistry, D.H. William and Ian Fleming., McGraw-Hill Education, 6th Ed., 2007.

Course outcomes:

Upon successful completion of the course, students will be able to:

CO1 Perform multistep synthesis of organic compounds involving key reactions such as photochemical transformations, Beckmann and benzilic acid rearrangements.

CO2 Monitor the progress of organic reactions using TLC and analyze final products using spectroscopic techniques like FT-IR, ^{1}H-NMR, ^{13}C-NMR, and Mass Spectrometry.

CO3 Utilize chemical drawing software to construct molecular structures, multistep synthetic schemes, IUPAC naming and spectral prediction.

CO4 Apply basic computational chemistry tools to perform molecular modeling, including structure optimization, energy minimization, and visualization of molecular graphics.

CO5 Interpret and correlate spectral data with molecular structures of organic molecules.

For both OPTIONS- A & B
Elective: SET-C
Physical Chemistry (PC)

Master of Science Chemistry
4th Semester
Solid State and Biophysical Chemistry

Course code: U25CHE411T (PC)
60 Hrs (4Hrs /week) **Marks for Major Test (External): 70**
Credits: 4 **Marks for Internal Exam: 30**
Time of Examination: 3 Hrs **Total Marks: 100**

Note: *The examiner is required to set nine questions in all. The first question will be compulsory consisting of seven short questions covering the entire syllabus consisting of 2 marks each. In addition to this, eight more questions (each question may be of 2-3 parts) will be set consisting of two questions from each unit. The student/candidate is required to attempt five questions in all, selecting one from each unit consisting of 14 marks and the compulsory Question No.1.*

Objectives: The course aims to develop skills in analyzing solid materials and biological systems using theoretical concepts and experimental approaches, bridging materials science with bio-physical chemistry.

Unit-I **15 Hrs**

Solid State Reaction
General principles, experimental procedures, co-precipitation as a precursor to solid-state reactions, kinetics of solid-state reactions.
Crystal Defects and Non-Stoichiometry
Perfect and imperfect crystals, intrinsic and extrinsic defects– point defects, line and plane defects, vacancies-Schottky defects and Frenkel defects. Thermodynamics of Schottky and Frenkel defect formation, colour centres, non-stoichiometry defects.

Unit-II **15 Hrs**

Band Theory of Solids
Metals, insulators and semiconductors, electronic structure of solids-band theory, bank structure of metals, insulators and semiconductors, Intrinsic and extrinsic semiconductors, doping semiconductors, p-n junctions, super conductors.
Optical properties– Optical reflectance, photoconduction-photoelectric effects.
Magnetic Properties– Classification of materials: Quantum theory of paramagnestics-cooperative phenomena-magnetic domains, hysteresius.
Organic Solids
Electrically conducting solids, organic charge transfer complex, organic metals and new superconductors.

Unit-III **15 Hrs**

Bio-Physical Chemistry-I
Biological Cell and its Constituents: Biological cell, structure and functions of proteins, enzymes, DNA and RNA in living systems. Helix coil transition.
Bioenergetics: Standard free energy change in biochemical reactions, exergonic, endergonic. Hydrolysis of ATP, synthesis of ATP from ADP.
Statistical Mechanics in Biopolymers: Chain configuration of macromolecules, statistical distribution end-to-end dimensions, calculation of average dimensions for various chain structures. Polypeptide and protein structures, introduction to protein folding problem.

Biopolymer Interactions: Forces involved in biopolymer interactions. Electrostatic charges and molecular expansion, hydrophobic forces, dispersion force interactions. Multiple equilibrium and various types of binding processes in biological systems. Hydrogen ion titration curves.

Unit-IV **15 Hrs**

Bio-Physical Chemistry-II

Thermodynamics of Biopolymer Solutions: Thermodynamics of biopolymer solutions, osmotic pressure, membrane equilibrium, muscular contraction and energy generation in mechanochemical nerve conduction.

Cell Membrane and Transport of Ions: Structure and functions of cell membrane, ion transport through cell membrane, irreversible thermodynamics treatment of membrane transport. Nerve conduction.

Biopolymers and their Molecular Weights: Molecular weight- Sedimentation equilibrium, hydrodynamic methods, diffusion, sedimentation velocity, electrophoresis and rotational motions.

Books Suggested:

1. Biochemistry, J. M. Berg, L. Stryer, J. L. Tymoczko, G. J. Gatto, W.H. Freeman.8th Ed., 2015.
2. Biochemistry, J. David Rawn, Neil Patterson, 1989.
3. Biochemistry, D.J. Voet and J.G. Voet, John Wiley, 3rd Ed., 2004.
4. Lehninger Principles of Biochemistry, D.L. Nelson and M.M. Cox, WH Freeman and Company, 7th Ed., 2017.
5. Bioorganic Chemistry: A Chemical Approach to Enzyme Action, H. Dugas, Springer-Verlag, 3rd Ed., 1999.
6. Solid State Chemistry and its Applications, A.R. West, Wiley, 2nd Ed., 2014.
7. Principles of the Solids State, H.V. Keer, Wiley-Blackwell, 1994.
8. Solid State Chemistry, N.B. Hannay, Printice Hall, 1967.
9. Solid State Chemistry, D.K. Chakrabarty, New Age International, 2nd Ed., 2021.

Course outcomes:

Upon successful completion of the course, students will be able to:

CO1 Understand the principles, experimental procedures, and kinetics involved in solid-state reactions.

CO2. Analyze crystal defects, non-stoichiometry in solids, and apply thermodynamic concepts to explain defect formation and non-stoichiometry.

CO3 Apply band theory to electronic and magnetic properties of solids: band structure of metals, insulators, and semiconductors, intrinsic and extrinsic conductivity, doping, p-n junctions, and magnetic behavior.

CO4 Analyze electrically conducting organic materials, charge-transfer complexes, and organic superconductors with a focus on their structural and electronic properties.

CO5 Describe the structure and function of proteins, enzymes, DNA/RNA, energy transformations in biological systems, and synthesis and interpret the behavior of biopolymers using statistical mechanics.

CO6 Illustrate thermodynamic and transport phenomena in biological systems.

For both OPTIONS- A & B
Elective: SET-C
Physical Chemistry (PC)

Master of Science Chemistry
4th Semester
Physical Polymer Chemistry

Course code: U25CHE412T (PC)
60 Hrs (4Hrs /week) **Marks for Major Test (External): 70**
Credits: 4 **Marks for Internal Exam: 30**
Time of Examination: 3 Hrs **Total Marks: 100**

Note: *The examiner is required to set nine questions in all. The first question will be compulsory consisting of seven short questions covering the entire syllabus consisting of 2 marks each. In addition to this, eight more questions (each question may be of 2-3 parts) will be set consisting of two questions from each unit. The student/candidate is required to attempt five questions in all, selecting one from each unit consisting of 14 marks and the compulsory Question No.1.*

Objectives: The course aims to develop the ability to understand the kinetics of polymerization, stereochemical aspects, behavior in solutions, and the mechanical and thermal properties of polymer materials, linking theory with practical applications in polymer science and engineering.

Unit-I **15Hrs**

Kinetics of Polymerization
Introduction, Kinetics and statistics of step growth (condensation) polymerization, polyfunctional step-reaction polymerization, kinetics of radical chain (addition) polymerization, effect of temperature and pressure on chain polymerization, kinetics of ionic and coordination (addition) polymerization, kinetics of copolymerization.

Unit-II **15 Hrs**

Polymer Dimensions & Solutions
Average chain dimensions, freely jointed chain model, statistical distribution of end-to-end dimensions, chain stiffness, short range effects.
Polymer in solutions: thermodynamics of polymer solution, non-ideal solutions, Flory-Huggins theory, enthalpy change of mixing and free energy change of mixing, phase equilibria, fractionation, Flory-Krigbaum theory, theta temperature, lower and upper critical solution temperatures.

Unit-III **15 Hrs**

Polymer Stereochemistry
Introduction, orientation, configuration, geometric isomerism, conformation of stereoregular polymers, factors affecting stereo regulation, homogenous stereoselective and stereospecific cationic and anionic polymerizations.
Polymer State, Structure and Properties
Crystalline state: introduction, mechanism of crystallization, temperature and growth rate, melting, thermodynamic parameters, crystalline arrangement of polymers, morphology, kinetics of crystallization
Amorphous state: molecular motion, viscoelastic behaviour, effect of chain length, rubbry state and elastomeric state; glassy state, glass transition temperature (T_g), determination and factors affecting it, free volume theory, dependence of T_g on molar mass, relaxation process in glassy state.

Unit-IV **15 Hrs**

Mechanical Properties

Mechanical Properties: viscoelastic state, mechanical properties, mechanical models describing viscoelasticity, linear viscoelastic behavior of amorphous polymers (creep, stress-strain and temperature effect), dynamic mechanical and dielectric thermal analysis (DMTA and DETA).

Elastomeric state

Introduction, thermodynamic aspects of rubber-like elasticity

Flow Properties of Polymer Melts

Terminology; effects on temperature, pressure and molecular weight on viscous flow properties, elastic effects in polymer melts.

Books Suggested:

1 Textbook of Polymer Science, F.W. Billmeyer (Jr), Wiley., 3rd Ed., 2007.
2 Principles of Polymer Chemistry, P. J. Flory, Cornell University Press, 1953.
3 Physical Chemistry of Polymers, A. Tager, Mir Publishers, Moscow, 1978.
4 Physical Chemistry of Macromolecules, C. Tanford, John Wiley & Sons Inc, 1961.
5 Polymers: Chemistry & Physics of Modern materials, J.M.G. Cowie, Blackie Academic & Professional, 1991.
6 Plastic Materials, J.A. Brydson, Butterworth Heinemann, 7th Ed., 1991.
7 Principles of Polymerisation, G. Odian, Wiley-Interscience, 4th Ed., 2004.
8 Fundamentals of Polymer Processing, S. Middleman, McGraw-Hill Education, 1977.
9 Polymer Science, V.R. Gowariker, N.V. Viswanathan and J. Sreedhar, New Age International, 2021.
10 Functional Monomers and Polymers, K. Takemoto, R. M. Ottenbrite, M. Kamachi, CRC Press, 2nd Ed., 1997.

Course outcomes:

Upon successful completion of the course, students will be able to:

CO1 Understand the kinetics and mechanisms of various polymerization processes, and analyze the influence of various factors on polymerization rates and mechanisms.
CO2 Calculate average chain dimensions, Flory-Huggins and Flory-Krigbaum theories to describe polymer behavior in solutions, phase separation, and critical solution temperatures.
CO3 Evaluate stereochemistry and configuration in polymer synthesis, and analyze factors influencing stereoselective and stereospecific polymerizations using different polymerization techniques.
CO4 Characterize the structural states, explain thermal transitions and interpret the effects of molecular parameters on polymer morphology and relaxation behavior.
CO5 Analyze the mechanical behavior and viscoelastic properties of polymers.
CO6 Describe flow properties and elasticity in polymer melts and elastomers: thermodynamic and rheological properties of elastomers and polymer melts.

For OPTION- A only
Elective: SET-C
Physical Chemistry (PC)

Master of Science Chemistry
4th Semester
Physical Chemistry Practical-V

Paper code: U25CHE413P (PC)
120 Hrs (8Hrs /week) **Marks for Major Test (External): 70**
Credits: 4 **Marks for Internal Exam: 30**
Time of Examination: 6 Hrs **Total Marks: 100**

Objectives: This course enables the students to develop practical proficiency in modern physicochemical techniques—such as conductometry, spectrophotometry, polymer analysis, and phase equilibria.

I Conductometry

1. Titrate a moderately strong acid (salicylic acid) by (a) Salt line method and (b) Double alkali method.
2. Titrate a mixture of (H_2SO_4 + CH_3COOH) against NaOH.
3. Determine of strength of (HCl + NH_4Cl) titrating against NaOH.
4. Estimate concentration of each component of a mixture of $AgNO_3$ and HNO_3 by titrating against NaOH conductometerically.
5. Determine the strength of (acetic acid + hydrochloric acid) by titrating against NaOH.

II Spectrophotometry

6. Study of absorption of picric acid on charcoal.
7. Study of dissociation constant of phenolphthalein.

III Polymer Chemistry

8. Measurement of phase transition, glass temperature, heat transitions in polymers.
9. Determination of molecular weight of polymers by viscosity/any other methods.
10. Kinetics of polymerization/ polymer degradation.

IV Phase equilibria

11. Study (viscosity/refractive index/conductance) of eutectic solvent(s)
12. Study of phase diagram of binary organic system (naphthalene and diphenyl) and ternary phase diagram of water, benzene, and acetic acid.

Books Suggested:

1. Practical Chemistry, A.M. James and F.E. Pricherd, Longman, 3rd Ed.,1974.
2. Practical Physical Chemistry, B.P. Levitt and Findley's, Longman, 9th Ed., 1973.
3. Practical Physical Chemistry, S.R. Palit and S.K. De, Science Book Agency, 2nd Ed., 1938.
4. Experimental Physical Chemistry, R.C. Das and B. Behra, McGraw Hill, 1983.
5. Experiments in Physical Chemistry, Shoemaker and Gailand McGraw Hill, 8th Ed., 2008.
6. Thermal Methods of Analysis: Principles, Application and Problems, P.J. Hains, Blackie Academic and Professional, 1995.

Course outcomes:

Upon successful completion of the course, students will be able to:

CO1 Understand and apply conductometric techniques to analyze single and mixed acid-base systems.

CO2 Use spectrophotometric methods to study adsorption and dissociation phenomena, and calculate relevant constants with precision and accuracy.

CO3 Characterize polymers by measuring glass transition temperature, molecular weight, and analyzing polymerization or degradation kinetics using physicochemical methods.

CO4 Analyze phase equilibria in binary and ternary systems, and evaluate physical properties such as viscosity, conductance, and refractive index in eutectic solvents.

CO5 Develop experimental and analytical skills to solve complex problems in physical chemistry by integrating theoretical knowledge with laboratory techniques and data interpretation.

For OPTION- A only
Elective: SET-C
Physical Chemistry (PC)

Master of Science Chemistry
4th Semester
Physical Chemistry Practical-VI

Paper code: U25CHE414P (PC)
120 Hrs (8Hrs /week) **Marks for Major Test (External): 70**
Credits: 4 **Marks for Internal Exam: 30**
Time of Examination: 6 Hrs **Total Marks: 100**

Objectives: To equip the students with theoretical knowledge and experimental proficiency in modern electrochemical, spectroscopic, surface, and computational techniques, enabling them to analyze chemical systems, determine key physicochemical parameters, and interpret data using both classical and digital tools.

I Polarography

1. Titrate amperometrically $Pb(NO_3)_2$ (0.001M)in KNO_3 (0.1M) +gelatine(0.005%) against standard $K_2Cr_2O_7$.Repeat the experiment in reverse order too.
2. Titrate amperometrically $Pb(NO_3)_2$ (0.001M)in KNO_3 (0.1M) +gelatine(0.005%) against standard K_2SO_4.Repeat the experiment in reverse order too.

II Potentiometry

3. Determine the solubility and solubility product of an insoluble salt AgX (X=Cl, Br, I) potentiometrically.
4. Determine the mean activity coefficient of 0.01M HCl solution.
5. Find out pH values of three buffer solution using (a) indicator, (b) pH–Meter, (c) Potentiometer.

IV Spectroscopy

6. Record the UV Spectrum of a given compound (acetone) in cyclohexane:
   a) Plot transmittance vs. wavelength
   b) Plot absorbance vs. wavelength.
   c) Assign the transitions by recording spectra in solvents of different polarities (H_2O, CH_3OH, $CHCl_3$, CH_3CN and 1,4-dioxane). Calculate hydrogen bond energy.
   d) Calculate the oscillator strength/ transition probability.
7. Record the UV spectra of Benzene, pyridine and pyrimidine in methanol. Compare and discuss the various transitions observed.
8. Record the IR spectrum of few compounds and their characterization (bond strength/energy)
9. Experiment on formation and study of adsorption isotherm by UV.

V Surface Chemistry

10. Experiments on formation and study of micelles.

V Computational Techniques

11. Numerical methods and their applications in chemistry: Some typical exercises-
    (a) Decimal- binary conversion;(b) Titration curves and end point location; (c) pH of weak acid; (d) Roots of cubic equations (e.g. vander Wall's equation); (e) Least square fit including graphic; (f) Chemical kinetics
12. Use of spreadsheets and certain public domain packages in solving problems in chemistry (e.g. potentiometric titration, kinetics, regression and solving simultaneous equations).

Books Suggested:

1. Practical Chemistry, A.M. James and F.E. Pricherd, Longman, 3rd Ed.,1974.
2. Practical Physical Chemistry, B.P. Levitt and Findley's, Longman, 9th Ed., 1973.
3. Practical Physical Chemistry, S.R. Palit and S.K. De, Science Book Agency, 2nd Ed., 1938.
4. Experimental Physical Chemistry, R.C. Das and B. Behra, McGraw Hill, 1983.
5. Experiments in Physical Chemistry, Shoemaker and Gailand McGraw Hill, 8th Ed., 2008.
6. Spectroscopic Methods in Organic Chemistry, D.H. Williams, I. Fleming, Tata McGraw-Hill, 6th Ed., 2007.

Course outcomes:

Upon successful completion of the course, students will be able to:

CO1 Apply polarographic techniques to perform redox titrations and analyze the electrochemical behavior of metal ions under varying conditions.

CO2 Utilize potentiometric methods to determine solubility products, activity coefficients, and pH of buffer systems, enhancing understanding of ionic equilibria.

CO3 Interpret UV-Vis and IR spectra to characterize molecular transitions, hydrogen bonding, and vibrational modes, and calculate physical parameters like oscillator strength.

CO4 Investigate surface phenomena such as micelle formation and adsorption isotherms to understand molecular interactions at interfaces.

CO5 Apply computational and numerical methods to solve chemical problems, analyze experimental data, and model chemical systems using spreadsheets and public-domain software tools.

For OPTION-B only

Master of Science Chemistry
4th Semester
Project Work

Paper code: U25CHE401R **Report of Project/ Dissertation (External): 200**
360 Hrs (24 Hrs /week) ***Viva-Voce* Exam (External): 100**
Credits: 12 **Total Marks: 300**
Time of Examination: Presentation/ *viva-voce*

Objectives: Project Work deals with facilitation to apply the knowledge, skills and critical thinking ability to complete a specific task in a given time frame through conceptualization, exploration and analysis of research-based activities to suggest tangible solutions for a given problem related to the chosen field of learning.

Notes: *(i). A student who opts for Dissertation/Project work of 12 credits in 4th /2nd semester of 2-year/1-year PG Programme will be required to do the research work based on systematic, scientific and rigorous investigations on the chosen and approved topic utilizing relevant research methods/ techniques/ innovations.*

(ii). A student, who opts for Dissertation/Project work in 4th semester of PG Programme, shall submit a request for allotment of supervisor mentioning her/his research areas of interest in order of preference to the Chairperson/Principal/Director during 3rd semester. The Department shall allot a qualified supervisor to guide the student for doing research during Project/Dissertation work. A regular full-time teacher of that Department, who is eligible to supervise Ph.D. scholars as per ordinance of Doctor of Philosophy of the university, will be eligible to guide the students for Dissertation/Project work.

(iii). The student will submit the synopsis to the supervisor. In case of University Teaching Department (UTD), the synopsis will be approved by the Departmental Research Committee (DRC) after recommendation of the supervisor. External experts may be involved wherever sufficient qualified regular teachers are not available. The Chairperson shall constitute a committee of at least three members of the concerned subject for this purpose at the Department level. The committee will consist of at least one subject expert from Guru Jambheshwar University of Science and Technology, Hisar to be nominated by the Chairperson. The request for external expert should reach to the Dean of the Faculty before 30th November of the concerned year. The list of students, their approved topics, and names of supervisors along with their synopsis will have to be submitted by the Department to the respective Dean of the Faculty latest by 31st January of the concerned year.

(iv). The student shall be required to submit three hard copies of her/his dissertation along with soft copy as PDF file to the Department by 30th May of the concerned year. The late submission can be allowed with late fees as decided by the university from time to time.

(v). The Anti-plagiarism policy of the university is to be strictly followed by the candidate and the supervisor. Similarity report as per anti-plagiarism policy of the university is to be annexed with the dissertation/project report.

(vi). Evaluation of the dissertation shall be done by an external examiner. The panel of examiners for evaluation of dissertations/project reports will be approved by the respective PGBOS. The dissertation work will be of total 12 credits (300 marks) and evaluation will be done in two components; report of dissertation (200 marks) and open viva-voce examination (100 marks).

(vii). The schedule as specified above is to be strictly followed by the student and DCI and any relaxation will not be allowed. However, in exceptional and genuine cases, late submission may be allowed with a late fee, as decided by the University from time to time.

Books / Links Suggested:
As per the topic of "Project Work".

Course outcomes:

Upon successful completion of the Project Work, students will be able to:

CO1 Apply advanced theoretical and practical knowledge of chemistry to identify, formulate, and solve a specific research problem.

CO2 Design and conduct experiments using appropriate techniques, instrumentation, and methodologies relevant to the chosen research area.

CO3 Analyze experimental data critically and interpret results within the context of existing scientific literature.

CO4 Demonstrate the ability to work independently and manage a research project efficiently, including planning, execution, and troubleshooting.

CO5 Communicate research findings effectively through written reports, oral presentations, and scientific discussions.

CO6 Exhibit ethical research practices, data integrity, and awareness of safety, environmental, and societal impacts of chemical research.

CO7 Develop skills for lifelong learning, critical thinking, and professional development in scientific research and related careers.

For Students of other Departments

4th Semester
Skill Enhancement Course (SEC)

Water Analysis Lab

Course code: U25SEC407P
30 Hrs (2Hrs /week) **Marks for Major Test (External): 35**
Credits: 2 **Marks for Internal Exam: 15**
Time of Examination: 4 Hrs **Total Marks: 50**

Objectives: This course enables the students to develop skills for analytical techniques for assessing the physicochemical quality of water to evaluate water suitability for environmental and public health standards.

1. Determination of acidity of a water sample.
2. Determination of alkalinity of a water sample.
3. Determination of dissolved oxygen in a water sample.
4. Determination of free CO_2 in a sample of water.
5. Determination of hardness of water by EDTA.
6. Determination of total dissolved solids dried at 180°C.
7. Determination of total chlorine residuals.
8. Determination of chloride content of a water sample by Mohr's method.
9. Determination of electrical conductivity of a water sample.
10. Determination of pH of a water sample.

Books Suggested:

1. Vogel's Textbook of Quantitative Analysis, revised, J. Bassett, R. C. Denney, G.H. Jeffery and J. Mendham, ELBS, 5th Ed., 1989.
2. Vogel's Textbook of Macro and Semimicro Qualitative Inorganic Analysis, revised, G. Svehla, Longman, 5th Ed., 1979.
3. Practical Inorganic Chemistry, Marr and Rocket, 2nd Ed., 1987.
4. Applied Chemistry by O.P. Virmani and A.K. Narula, New Age International, 1st Ed., 1989.

Course outcomes:

Upon successful completion of the course, students will be able to:

CO1 Understand the principles and significance of various physicochemical parameters in water quality analysis.
CO2 Apply various methods to determine the quality of water.
CO3 Analyze the waste water samples to assess organic pollution levels.
CO4 Evaluate the various parameters of water sample.
CO5 Compile interpreted information in the form of lab record. Face /defend viva-voce examination.

For Students of other Departments

4th Semester
Vocational Course (VOC)

Extraction of Natural Products Lab

Course code: U25VOC407P
30 Hrs (4Hrs /week) **Marks for Major Test (External): 35**
Credits: 2 **Marks for Internal Exam: 15**
Time of Examination: 4 Hrs **Total Marks: 50**

Objectives: This course develops practical skills in the extraction, isolation, and purification of organic compounds from natural sources.

Extraction of organic compounds from natural sources:

1. Isolation of caffeine from tea leaves.
2. Isolation of casein from milk.
3. Isolation of lactose from milk.
4. Isolation of piperine from black pepper.
5. Isolation of β-carotene from carrots.

Any other extarction/isolation of natural products may be incorporated.

Books Suggested:

1. Experiments and Techniques in Organic Chemistry, D. Pasto, C.R. Johnson and M.J. Miller, Prentice Hall, Pearson, 1st Ed., 1991.
2. Macroscale and Microscale Organic Experiments, K.L. Williamson, K.M. Masters, Cengage Learning, 8th Ed., 2023.
3. Vogel's Textbook of Practical Organic Chemistry, B.S. Furniss, A.J. Hannaford, P.W.G. Smith and A.R. Tatchell, Pearson India, 5th Ed., 2003.
4. Advance Practical Organic Chemistry, M, Casey, J. Leonard, B. Lygo and G. Procter, Nelson Thornes Ltd., 1989.
5. Experiments in Organic Chemistry, L.F. Fieser, D.C. Heath & Co., 1941 (Digitized 2024).
6. Elementary Practical Organic Chemistry, A.I. Vogel, Pearson India, 2nd Ed., 2010.
7. Practical Organic Chemistry, F.G. Mann and B.C. Saunders, Pearson India, 4th Ed., 2009.

Course outcomes:

Upon successful completion of the course, students will be able to:

CO1 Isolate and purify naturally occurring organic compounds using standard extraction and separation techniques.
CO2 Demonstrate understanding of the chemical nature and functional groups of isolated natural products.
CO3 Apply different methods for extraction of natural products.
CO4 Develop the skill of performing experiments, analysing data and compile experimental information in the form of lab record and defend *viva-voce*.

For Students of other Departments

4th Semester
Employability and Entrepreneurship Skills Course (EEC)

General Polymer Chemistry

Course code: U25EEC407T
30 Hrs (2Hrs /week) **Marks for Major Test (External): 35**
Credits: 2 **Marks for Internal Exam: 15**
Time of Examination: 2 Hrs **Total Marks: 50**

Note: *The examiner is required to set five questions in all. The first question will be compulsory consisting of five short questions covering the entire syllabus consisting of 3 marks each. In addition to this, four more questions (each question may be of 2-3 parts) will be set consisting of two questions from each unit. The student/candidate is required to attempt three questions in all, selecting one from each unit consisting of 10 marks and the compulsory Question No.1.*

Objectives: This course aims to provide students with an understanding of the fundamentals of polymers and practical applications, and their significance in modern materials science.

Unit-I **15 Hrs**

Basics and Polymerization
Introduction, classification and nomenclature of polymers, introduction to natural polymer, polymerization: condensation, addition, radical chain-ionic, coordination-Ziegler-Natta catalytic mechanism and copolymerization. Polymerization condition and reactions: polymerization in homogenous and heterogeneous systems- bulk, solution, suspension and emulsion polymerization.

Molecular Weight and Structure
Poly dispersion-average molecular weight concept: number and weight average; practical significance of molecular weight, measurement of molecular weights by viscometry, light scattering and osmotic pressure methods. Introduction to polymer dimension (end to end distance and radius of gyration). Glass transition temperature and its importance.

Unit-II **15 Hrs**

Synthesis, Properties and Applications of Polymers
Raw material of synthetic polymers, polyethylene, polypropylene, polystyrene, polyvinylchloride, nylon-6, phenolic and amino resins, polybutadiene rubber.

Conducting Polymers
Introduction, classification, conduction mechanism, electrically and electronically conducting polymers, preparation of conducting polymer- polyacetylene, Poly(p-phenylene), factors affecting the conductivity, electrochemical polymerization, doping of conducting polymers and its significance.

Books Suggested:

1 Textbook of Polymer Science, F.W. Billmeyer (Jr), Wiley., 3rd Ed., 2007.
2 Principles of Polymer Chemistry, P. J. Flory, Cornell University Press, 1953.
3 Physical Chemistry of Polymers, A. Tager, Mir Publishers, Moscow, 1978.
4 Physical Chemistry of Macromolecules, C. Tanford, John Wiley & Sons Inc, 1961.
5 Polymers: Chemistry & Physics of Modern materials, J.M.G. Cowie, Blackie Academic & Professional,1991.
6 Plastic Materials, J.A. Brydson, Butterworth Heinemann, 7th Ed., 1991.
7 Principles of Polymerisation, G. Odian, Wiley-Interscience, 4th Ed., 2004.
8 Fundamentals of Polymer Processing, S. Middleman, McGraw-Hill Education, 1977.
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Course outcomes:

Upon successful completion of the course, students will be able to:

CO1	Understand the fundamentals and mechanisms of polymerization.
CO2	Analyze polymer structure and molecular weight
CO3	Explain polymer thermal behavior and transition phenomena.
CO4	Synthesize and characterize industrially important polymers.
CO5	Evaluate the structure, mechanism, and applications of conducting polymers.