केंद्रीयजनजातीयविश्वविद्यालयआंध्रप्रदेश

CENTRAL TRIBAL UNIVERSITY OF ANDHRA PRADESH

(A CENTRAL UNIVERSITY ESTABLISHED BY AN ACT OF PARLIAMENT)

CURRICULUM & SYLLABUS

2-Year M.Sc. Chemistry

w.e.f. 2023-24 admitted batch

DEPARTMENT OF CHEMISTRY
SCHOOL OF SCIENCES
CENTRAL TRIBAL UNIVERSITY OF ANDHRA PRADESH
VIZIANAGARAM – 535003, A.P.

DEPARTMENT OF CHEMISTRY

The Department of Chemistry at CTUAP is dedicated to providing students with a comprehensive education in Chemistry, aligned with the National Education Policy (NEP-2020). Our undergraduate and postgraduate Chemistry programs integrate fundamental principles, theories, and practical applications, covering diverse subjects such as Analytical Chemistry, Inorganic Chemistry, Organic Chemistry, Physical Chemistry, and Chemical Biology. The department focuses on addressing global challenges in Synthetic Organic Chemistry, Renewable Energy, Environmental Sustainability, Nanotechnology, and the welfare of Tribal communities through its research endeavors.

PROGRAM OBJECTIVES

- The M.Sc. Chemistry program is designed to provide students with advanced knowledge and skills in various aspects of chemistry. Through a comprehensive curriculum, students deepen their understanding of fundamental chemical principles while also specializing in areas such as organic synthesis, materials chemistry, or biochemistry.

- The program emphasizes hands-on experience in laboratory techniques and research methodologies, enabling students to conduct independent research projects and develop critical thinking and problem-solving skills.

- Effective communication, ethical conduct, and interdisciplinary perspectives are also integral components of the program, preparing students for careers in academia, industry, or government, as well as further studies at the doctoral level.

- By fostering adaptability and a commitment to lifelong learning, the program equips graduates with the expertise and mindset necessary to address current and future challenges in the field of chemistry.

M.Sc. CHEMISTRY

(W.e.f. 2023-24 admitted batch)

1. ADMISSIONS

Admissions into M.Sc. Chemistry program shall be made only through CUET(PG) conducted by National Testing Agency (NTA)

2. ELIGIBILITY CRITERIA

Bachelor's degree (3 years) with Chemistry as one of the subjects with 50% marks in aggregate or its equivalent grade from a recognized University for General, EWS and OBC categories (45% marks or its equivalent grade for SC/ST/PwD candidates).

3. CHOICE BASED CREDIT SYSTEM (CBCS) & NEP-2020

Choice based credit system (CBCS) & NEP-2020 are introduced based on UGC guidelines in order to promote:

- Student centered learning
- Cafeteria approach
- Inter-disciplinary learning.
- Industry-ready curriculum

4. STRUCTURE OF THE PROGRAMME

4.1. The program consists of:
- Core courses
- Discipline centric electives
- Practicum courses
- Project work with dissertation

4.2. Each course is assigned a certain number of credits depending upon the number of contact hours (lectures/tutorials/practical) per week.

4.3. In general, credits are assigned to the courses based on the following contact hours per week per semester.
- One credit for each lecture / tutorial hour.
- One credits for two hours of practicum
- Twelve credits for Research Project & Dissertation

4.4. The curriculum of four semesters M.Sc. Chemistry program is designed to have a total of 83 credits for the award of M.Sc. degree.

5. MEDIUM OF INSTRUCTION

The medium of instruction shall be English.

6. SWAYAM GUIDELINES:

In today's dynamic educational landscape, the integration of online learning platforms like Swayam offers tremendous opportunities for students to enrich their academic journey. With a plethora of courses available, it's imperative to provide tailored recommendations for students, especially in disciplines like Chemistry.

1. Students have the option to choose up to 12 credits of departmental/institute elective courses with SWAYAM-NPTL courses from the curated list approval by the Board of Studies in Chemistry and the Academic Council of CTUAP.
2. The catalogue of Massive Open Online Courses (MOOCs) available on the SWAYAM platform is updated every semester. To check if a previously offered MOOC is available in the current or upcoming semester, visit the SWAYAM portal at https://swayam.gov.in/explorer.
3. Students can directly register for the SWAYAM courses through CTUAP local chapter with permission of Head of the Department.
4. One of the faculty coordinators will assist the students for the registration of Swayam courses.
5. No student is permitted to register for online SWAYAM courses during the final semester of their program.
6. Upon completion of the course, credits can be transferred to the academic record of the students (Academic Bank of Credits (ABC)) for courses completed on SWAYAM.
7. If a student wishes to select a MOOC that is not listed under the Board of Studies approved SWAYAM courses for Professional Elective courses, the internal Board of Studies will make an appropriate decision. If approved, this decision will be communicated to the Dean of Academic Affairs, and a copy will be sent to the Controller of Examinations.
8. In case the student is unable to complete the MOOC for theory courses, he/she shall be allowed to select an appropriate course listed under the respective elective courses offered at the department concerned and appear for a supplementary examination in subsequent semesters.

PROGRAM STRUCTURE FOR **TWO YEARS M.Sc. CHEMISTRY PROGRAM**

	COUSE LEVEL	COURSE CODE	TITLE OF THE COURSE	LECTURES	TUTORIAL	PRACTICUM	CREDITS	Max. Marks
SEMESTER-I / SEMESTER-VII (Int. M.Sc.)	500	CHE501	Transition metal and Bioinorganic Chemistry	3	0	0	3	100
	500	CHE502	Stereochemistry and Organic Reaction Mechanisms	3	0	0	3	100
	500	CHE503	Chemical Kinetics, Thermodynamics & Electrochemistry	3	0	0	3	100
	500	CHE504	Chemistry of Materials	3	0	0	3	100
	500	CHE505	Chromatographic Separation Methods	3	0	0	3	100
	500	CHE511	Inorganic Chemistry Practicum	0	0	6	3	100
	500	CHE512	Physical Chemistry Practicum	0	0	6	3	100
						Total	**21**	
SEMESTER-II / SEMESTER-VIII (Int. M.Sc.)	500	CHE551	Main group and Organometallic Chemistry	3	0	0	3	100
	500	CHE552	Pericyclic reactions and Photochemistry	3	0	0	3	100
	500	CHE553	Surface Chemistry and Catalysis	3	0	0	3	100
	500	CHE554	Modern Analytical Techniques	3	0	0	3	100
	500	CHE571-CHE573-	Elective-I	3	0	0	3	100
	500	CHE561	Organic Chemistry Practicum	0	0	6	3	100
	500	CHE562	Analytical Chemistry Practicum	0	0	6	3	100
						Total	**21**	
SEMESTER-III / SEMESTER-IX (Int. M.Sc.)	600	CHE601	Current Trends in Organic Synthesis	3	0	0	3	100
	600	CHE602	Chemistry of Heterocyclic Compounds and Natural Products	3	0	0	3	100
	600	CHE603	Advanced Spectroscopy	3	0	0	3	100
	600	CHE604	Research Methodology	3	0	0	3	100
	600	CHE621 - CHE623	Elective-II	3	0	0	3	100
	600	CHE611	Organic Chemistry-2 Practicum	0	0	6	3	100
	600	CHE641	Research literature review	0	0	6	3	100
						Total	**21**	
SEMESTER-IV / SEMESTER-X (Int. M.Sc.)	600	CHE671 - CHE677	Elective-III	3	0	0	3	100
	600		Elective-IV	3	0	0	3	100
	600	CHE691	Pre-project Seminar	0	0	4	2	50
	600	CHE692	Research Project & Dissertation	0	0	24	12	300
						Total	**20**	
						Grand Total	**83**	

NOTE: The above courses are the minimum requirement for the degree. Students are encouraged to take additional electives online to earn extra credits.

ELECTIVE-I

[Students are encouraged to choose the appropriate course either from the following list or from **UGC- MOOCs/NPTEL** with prior permission from the Head of the Department]

COURSE CODE	TITLE OF THE COURSE
CHE 571	Symmetry and Group theory
CHE 572	Quantum and Computational Chemistry
CHE 573	Molecular Spectroscopy

ELECTIVE-II

[Students are encouraged to choose the appropriate course either from the following list or suitable course from **Swayam/NPTEL** with prior permission from the Head of the Department]

COURSE CODE	TITLE OF THE COURSE
CHE 621	Medicinal Chemistry
CHE 622	Biological Chemistry
CHE 623	Principles of Microbiology

ELECTIVES (III & IV)

[Students are encouraged to choose two appropriate courses (one under Elective-III and another under Elective-IV).

COURSE CODE	TITLE OF THE COURSE
CHE 671	Chemistry of Nanomaterials
CHE 672	Environmental Chemistry
CHE 673	Polymer Chemistry
CHE 674	Strategic Planning in Organic Synthesis
CHE 675	Nuclear and Radiochemistry
CHE 676	Industrial Safety

COURSE CODE	TITLE OF PAPER	CREDITS	SEMESTER
CHE501	**TRANSITION METAL AND BIOINORGANIC CHEMISTRY**	**3**	**I**

Course Objectives: On completion of this course, the students will be able to understand:
Theories of bonding • Spectroscopic properties of coordination compounds • Mechanisms of ligand substitution and electron transfers in coordination complexes • Role of metal ions in biological systems • Inorganic medicinal compounds.

UNIT-I

Bonding theories: Valence Bond Theory, Crystal Field Theory and their limitations; d-orbital splitting in octahedral, tetrahedral, tetragonal, square planar, square pyramidal and trigonal bipyramid geometries, Jahn-Teller-distortion, Calculation of CFSE, Ligand Field Theory and Molecular Orbital (MO) theory of selected octahedral and tetrahedral complexes.

UNIT-II

Electronic spectra of transition metal complexes: Term symbols - spin-orbit coupling, Russell - Saunders coupling, term symbols for various configurations, selection rules for electronic transitions, correlation diagrams - Orgel and Tanabe-Sugano diagrams for transition metal complexes, calculations of Dq, B and Nephelauxetic ratio (β), charge transfer spectra.

UNIT-III

Inorganic Reaction Mechanism: Substitution reactions in octahedral complexes - A, Ia, D, Id mechanisms - acid hydrolysis, anation reactions, base hydrolysis, Substitution in square planar complexes - bonding theories of trans effect, Oxidation-reduction reactions, classification of redox reactions, mechanism of one electron transfer reactions, Inner sphere redox reactions, outer sphere redox reactions, mixed inner and outer sphere reactions, two equivalent-one equivalent reactions of thallium(III)-thallium(I) and Hg(I)-Hg(II).

UNIT-IV

Bioinorganic Chemistry: Occurrence and function of transition metals in biology, Structure and oxygen binding properties of heme (haemoglobin and myoglobin) and non-heme proteins (hemocyanin & hemerythrin), Electron transfer proteins - structure and functions of Cytochromes and Ferredoxins, Metals in medicine - superoxide dismutase mimics, vanadium-based diabetic drugs and platinum-containing anticancer agents.

Recommended Books:

1. Inorganic Chemistry: Principles of Structure and Reactivity by James E. Huheey, Okhil K. Medhi Ellen A. Keiter, Richard L. Keiter, 2006.
2. Inorganic Chemistry, Gary L. Miessler and D. A. Tarr, 3rd Edition 2004, Pearson Prentice Hall.
3. Mechanisms of Inorganic Reactions in Solution by D. Benson, McGraw Hill, London, l968.
4. Mechanisms of Inorganic reactions: A study of metal complexes in solutions, F. Basalo & R. G. Pearson, Wiley-Eastern Pvt Ltd., 2ndEdn.
5. Principles of Bioinorganic Chemistry, J. Lippard and J. M. Berg, University Science Books, 1994

Course code	Title of Paper	Credits	Semester
CHE502	**STEREOCHEMISTRY AND ORGANIC REACTION MECHANISMS**	**3**	**I**

Course Objectives: On completion of this course, the students will be able to understand the intricate relationships between organic chemical structures and their reactivity. They will have gained insight into the mechanisms underlying addition, elimination, and substitution reactions. This comprehension will enable them to predict and account for the most encountered reaction mechanisms in the field of organic chemistry.

UNIT-I

Introduction to stereochemistry: Optical Isomerism: optical activity, molecular dissymmetry and chirality - elements of symmetry. Fisher's projection D, L. and R, S. configurations - relative and absolute configurations optical isomerism due to asymmetric carbon atoms - optical isomerism in biphenyls, allenes and spirans- optical isomerism of nitrogenous compounds, racemisation and resolution. Geometrical isomerism: E, Z -configurations, properties of geometrical isomers.

UNIT - II

Aliphatic Nucleophilic Substitutions: The SN2, SN1, SNi and SET mechanisms. Substitution reactions of ambident nucleophiles, anchimeric assistance, the neighbouring group mechanism: neighbouring group participation by O, N, S, halogens, aryl groups, alkyl and cycloalkyl groups in nucleophilic substitution reactions. Sigma, Pi bond participation in acylic and bicyclic systems (non-classic carbocations). Nucleophilic Substitution at allylic, trigonal and Vinylic carbons. Effect of substrate, attacking nucleophile, leaving group and reaction medium.

UNIT-III

Aliphatic Electrophilic Substitutions: Aliphatic Electrophilic Substitutions: SE1 SE2 and SEi mechanisms. Reactivity- effects of substrate, leaving group and solvent. Reactions- hydrogen exchange, migration of doublebonds, halogenation of aldehydes, ketones, carboxylic acids, acyl halides, sulphoxides and sulphones.

UNIT-IV

Addition Elimination Mechanisms: Elimination reactions -1,2; 1,3, 1,4 and pyrolytic–eliminations- E1, E1cB, E2 mechanism, stereo- selectivity in E2 reaction, Saytzeff vs. Hoffmann elimination; Wittig and its modified reactions of phosphorous ylides.

Recommended Books:

1. Advanced Organic Chemistry: Reaction Mechanisms" by Jerry March
2. "Organic Chemistry" by Jonathan Clayden, Nick Greeves, and Stuart Warren
3. "Organic Reaction Mechanisms: A Step-by-Step Approach" by Michael Edenborough
4. "Mechanism and Theory in Organic Chemistry" by Thomas H. Lowry and Kathleen Schueller Richardson
5. "Organic Chemistry: Structure, Mechanism, Synthesis" by Clayden, Greeves, Warren, and Wothers
6. "Organic Reaction Mechanisms" by V.K. Ahluwalia and Renu Agarwal
7. F. A. Carey, R. J. Sundberg, Advanced Organic Chemistry, Part A: Structure and mechanism, Kluwer Academic Publisher, (2000).

Course code	Title of Paper	Credits	Semester
CHE503	**CHEMICAL KINETICS, THERMODYNAMICS & ELECTROCHEMISTRY**	**3**	**I**

Course Objectives: On completion of this course, the students will be able to understand:
The concept of chemical kinetics and reaction rates and introduce the idea of Unimolecular reactions • The laws of thermodynamics through real-life examples and applications and generate an intuitive understanding of how thermodynamics dictates the feasibility of physical transformations and chemical reactions • The electrochemistry and applications of electrochemistry in day-to-day life such as in Batteries, Fuel cells and corrosion prevention.

UNIT-I:

Chemical Kinetics: Methods of determining rate laws, Theories of reaction rates- Collision theory, Transition state theory, Arrhenious equation and the activated complex theory, Theory of absolute reaction rates-Reaction coordinate, transition state, thermodynamic formulation of reaction rates; Unimolecular reactions- Lindemann-Hinshelwood and Rice-Ramsperger-Kassel-Marcus [RRKM] theory; Reactions in solution primary and secondary salt effects, effect of solvent on reaction rate; effect of substituents on reaction rate - Hamett and Taft equations with examples - Linear Free Energy relations.

UNIT-II:

Thermodynamics: Brief resume of the concepts of laws of thermodynamics, Free energy, chemical potential and entropy, Second law of thermodynamics-entropy change in reversible process and irreversible process-entropy of mixing; Fugacity: concept-Determination- Variation of fugacity with pressure; concept of partial molar properties- chemical potential-significance- variation with preassure and temperature- Gibbs-Duhem equation; Van't Hoff reaction isotherm, Claussius-Claperyon equation.
Third law of thermodynamics- Nernst heat theorem-determination of absolute entropy-limitations of third law of thermodynamics

UNIT-III

Electrochemistry: Electrochemical cell- galvanic and electrolytic cell. Nernst Equation-Concentration cell with and without transference. Application of EMF measurements in determining (i) free energy, enthalpy and entropy of a cell reaction, (ii) equilibrium constants, and (iii) pH values, using hydrogen, quinone-hydroquinone electrode. Interionic attraction theory and Debye-Huckel treatment, Debye-Huckel limiting law and Debye-Huckel Onsagar equation-verifications and limitation; Activity and activity coefficients- determination of mean ionic activity coefficient by EMF method. Polarization-Decomposition potential and overvoltage- Factors affecting overvoltage- Importance of over-voltage;

UNIT-IV

Electrochemistry Applications: Batteries-primary and secondary cells – lechlanche cell, lead acid storage battery, Nickel-Cadmium cell; Li-ion and Na-ion Batteries. Fuel cells-its types; Corrosion-theories of dry and wet corrosion-different forms of corrosion-prevention and control of corrosion - cathodic protection-sacrificial anodic and impressed current methods- inhibitors-anodic and cathodic inhibitors; protective coatings-galvanising and tinning.

Recommended Books:

1. Physical Chemistry by Peter Atkins and Julio de Paula, Oxford University Press.
2. Physical Chemistry by G.W. Castellon, Narosha Publishing House
3. Physical chemistry by K.L. Kapoor
4. Principles of Physical Chemistry by Puri, Sharma & Pathania

Course code	Title of Paper	Credits	Semester
CHE504	**CHEMISTRY OF MATERIALS**	**3**	**I**

Course Objectives: On completion of this course, the students will be able to understand:
Crystalline solids – synthesis and structure • Crystal structures-symmetry • Technological importance of semiconductors• Nano-structured materials- synthesis, characterization and applications.

UNIT-I

Crystalline solids, Crystal Systems, lattice, Lattice Planes and Miller Indices, Concept of close packing, packing efficiency, Pauling's electrostatic valance rules - ionic solids, Important crystal structures: NaCl, CsCl, ZnS, SiO_2, and TiO_2; perovskite, Spinel -normal and inverse. Crystal symmetry -screw axes glide planes and space group notatin. Elementary idea of crystal structure determination by X-ray diffraction.

UNIT-II

Techniques for the Growth of Single Crystals, Synthesis methods for polycrystalline powders, Crystal Imperfections: point, line and planar,
Semiconductors, types of semiconductors, compound semiconductors, band gap, thermal excitation, photoexcitation, Semiconductor devices – rectifiers, transistors and solar cells.

UNIT-III

Introduction to Zeolites, metal silicates, silicalite and related microporous materials, Mesoporous silica, metal oxides and related functionalized mesoporous materials: Covalent organic frameworks, Organic-Inorganic hybrid materials, Metal-organic frameworks: H_2/CO_2 gas storage and catalytic applications.

UNIT-IV

Overview of nano-materials (bulk *vs* nano), classification (0D 1D, 2D, and 3D materials), Synthesis of nanomaterials: "Top down' *vs* 'Bottom up' approach, Physical and chemical synthesis methods, Characterization technique: Electron microscopy(SEM and TEM), Atomic force microscopy (AFM), Applications of nanomaterials: energy, environment and catalysis.

Recommended books:

1. Solid-state chemistry and its applications by A.R. West John wiley & sons.
2. Solid-state chemistry -an introduction by Lesley Smart and Elaine Moore
3. Elements of X-Ray Diffraction by B.D. Cullity
4. Nanotechnology: Principles and Practices by by Sulabha K. Kulkarni

Course code	Title of Paper	Credits	Semester
CHE505	**CHROMATOGRAPHIC SEPARATION METHODS**	**3**	**I**

Course objectives: After completion of the course, the student shall be able to understand:
Understand chromatography principles and techniques, • Master the use of different chromatographic methods, • Become proficient with various chromatographic detectors and instruments, • Optimize chromatographic separations effectively, • Apply chromatographic techniques to practical analytical tasks.

UNIT-I

Introduction to Chromatography*:* Principles of chromatography, adsorption and partition phenomena, adsorption coefficient, retardation factor, retention time, column capacity, High Equivalent Theoretical Plate (HETP), Van Deempter equation, resolution, choice of column, length and flow velocity, qualitative and quantitative analysis.

UNIT-II

Thin layer chromatography(TLC), High Performance Thin layer chromatography (HPTLC): principle, technique, and applications.

Liquid chromatography: principles, stationary and mobile phases, types of liquid chromatography, adsorption isotherms, nature of forces between adsorbent and solutes, elution order.

UNIT-III

High performance liquid chromatography*:* Theory, instrumentation, detectors-UV detector, refractometric detector, fluorescence detector, diode array detector, applications in the separation of organic compounds.

LC-MS – Introduction – Instrumentation – liquid chromatograph – Mass spectrometer Interface – Instrumental details – Processing LC-MS data – ion chromatograms – Library searching – Sample preparation – selected ion monitoring. Application of LC-MS

UNIT-IV

Gas chromatography*:* Principle, instrumentation, different types of columns, various types of detectors: thermal conductivity detector, flame ionization detector, and electron capture detector; Programmed temperature gas chromatography and its applications.

GC-MS – Principle and advantages**,** Instrumentation, coupling GC with MS and its interface, sample preparation, ion chromatogram, library searching, selected ion monitoring – Application of GC-MS in determining the trace impurities and food analysis.

Recommended Books:

1. 1. R.P.W Scott, Techniques and practice of Chromatography, Marel Dekker Inc., New York
2. E. Helfman, Chromatography, Van Nostrand, Reinhold, New York
3. E. Lederer and M. Lederer, Chromatography, Elsevier, Amsterdam.
4. Chemical separation methods, John A Dean, Von Nostrand Reinhold, New York

Course code	Title of Paper	Credits	Semester
CHE511	**INORGANIC CHEMISTRY PRACTICUM**	**3**	**I**

Course objectives: After completion of the course, the student shall be able to understand:
The procedures for synthesis of inorganic complex compounds • Estimation of metal ions through quantitative analysis • Estimation of metal ions through gravimetric analysis • Estimation of metal ions using spectroscopic techniques.

1. **Synthesis and spectroscopic characterization (UV-Visible, FT-IR) of the following inorganic complexes:**
   a) Tetraaminecopper(II) sulphate
   b) Potassium tris (oxalato) ferrate(III) trihydrate
   c) Potassium tris (oxalato) aluminate(III)
   d) Tris (thiourea) copper(I) sulphate
   e) Hexaaminecobalt(III) chloride

2. Quantitative Analysis:

a) Volumetric:
   i) Determination of Zinc by Ferrocyanide
   ii) Determination of Ferric iron by Photochemical reduction
   iii) Complexometric determination of Magnesium
   iv) Complexometric determination of Nickel
   v) Determination of Calcium by homogenous precipitation method.

b) Gravimetric:
   i) Determination of Zinc as Zinc Pyrophosphate
   ii) Determination of Magnesium as Magnesium

3. Spectrophotometric determinations

   a) Fe^{2+} and o-phenanthroline complex by Jobs method
   b) Cu^{2+}-EDTA complex
   c) Synthesis of ammine complexes of Ni(II) and its ligand exchange reactions (e.g. bidentate ligands like acetylacetone, DMG, glycine) by substitution method.

Recommended Books:

1. Vogel's Qualitative Inorganic Analysis – 7th Edition Revised by G. Svehla, Pearson Education Ltd., 1996.

Course code	Title of Paper	Credits	Semester
CHE512	**PHYSICAL CHEMISTRY PRACTICUM**	**3**	**I**

Course Objectives: After completion of the course, the student shall be able to understand:
The practical idea about different phases, followed by the effect of electrolyte on phase equilibrium • How cell constant and equivalent conductance can be determined from conductance measurements acids and bases • The usefulness of potentiometric titrations in determining the endpoint of redox titrations • The applications of pH metric titrations.

Experiments:

1. Critical solution temperature of phenol -water system
2. Effect of electrolyte (NaCl) on miscibility temperature
3. Comparison of acid strengths through acid catalyzed methyl acetate hydrolysis
4. Determination of ionization constants of weak acids and verification of Oswald's Dilution law.
5. Verification of Onsager's limiting law.
6. Conductometric titration of a strong acid with strong base
7. Conductometric titration of a weak acid with strong base
8. Conductometric titration of a mixture of weak and strong acid with strong base
9. Distribution coefficient of I2 between two immiscible solvents.
10. Equilibrium constant of $KI + I_2 \leftrightarrow KI_3$ by distribution method.
11. Potentiometric titration of strong acid with strong base.
12. Potentiometric titration of redox system (ferrous ammonium sulfate with K2Cr2O7).
13. Determination of strength of strong acid using pH meter.
14. Determination of strength of weak acid using pH meter.
15. Determination of strength of polyprotic acid using pH meter.

Recommended Books:

1. Experimental Physical Chemistry by Das and Behera
2. Practical Physical Chemistry by B. Vishwanathan & P.S. Raghavan
3. Experimental Physical Chemistry by V.D. Athawale

Course code	Title of Paper	Credits	Semester
CHE551	**MAIN GROUP AND ORGANOMETALLIC CHEMISTRY**	**3**	**II**

Course Objectives: On completion of this course, the students will be able to understand:
Structure and bonding of cage compounds • Chemistry of metal-metal bonding in clusters • Synthesis, properties, structures and catalytical applications of organometallic compounds.

UNIT-I

Inorganic cage and ring compounds: Preparation, structure and bonding of boranes, carboranes, metallocarboranes, borazine, phosphine-boranes, Tetrasulfur tetranitride, Wade's rule (Polyhedral skeletal electron pair theory) for electron count in boranes.

UNIT-II

Metal Clusters: Evidence of metal-metal bonds - Conditions favourable for the formation of metal-metal bonds - Metal compounds with metal-metal multiple bonds - Preparation, properties and structures of $Re_2Cl_8^{2-}$, $Re_2(RCOO)_4X_2$, $Cr_2Cl_9^{3-}$, Re_3Cl_9, $Re_3Cl_{12}^{3-}$, $Mo_6Cl_8^{4+}$, $Nb_6Cl_{12}^{2+}$.

UNIT-III

Organometallic Chemistry: 18-electron rule, ligand cone angle, oxidative addition and reductive elimination, insertion and elimination reactions in organometallic compounds, Synthesis, structure and bonding of metal-carbonyls, metal-nitrosyls, dinitrogen complexes and ferrocene.

UNIT-IV

Catalysis by organometallic compounds: Homogeneous vs. heterogeneous catalysis, Hydrogenation, Hydroformylation, Monsanto acidic acid process, the Wacker process, Ziegler-Natta polymerization, Organo-lithium, beryllium and magnesium compounds.

Recommended Books:

1. Inorganic Chemistry: Principles of Structure and Reactivity by James E. Huheey, Okhil K. Medhi Ellen A. Keiter, Richard L. Keiter, 2006.
2. Inorganic Chemistry, Gary L. Miessler and D. A. Tarr, 3rd Edition 2004, Pearson Prentice Hall.
3. Basic Organometallic Chemistry: Concepts, Synthesis, and Applications, D. Gupta and A. J. Elias, 2nd Edition, Universities Press (India), 2013.

Course code	Title of Paper	Credits	Semester
CHE452	**PERICYCLIC REACTIONS AND PHOTOCHEMISTRY**	**3**	**II**

Course Objectives: Providing instruction on the principles and practical applications of diverse elements within photochemistry and pericyclic reactions. Exploring comprehension of the synthesis and mechanisms underlying a variety of reactions associated with cycloaddition and photochemistry.

UNIT-I

Principles of photochemical reactions: Excitation and excited states, Franck-Condon Principle, Jablonski diagram, energy transfer photosensitization, quenching, quantum efficiency and quantum yield. Photochemistry of carbonyl compounds (Norrish type I and type II changes, photoreaction of cyclic ketones, Paterno-Buchi reaction and Photoreducation. Photochemistry of olefins and 1, 3-Butadiene (cis-trans isomerisation, dimerisation and cycloadditions).

UNIT-II

Photo rearrangements and Significant Photoreactions:

Di-π-methane, oxa di-π- and aza di-π-methane, aromatic hydrocarbons, Wolf and Fries rearrangements. Photocycloaddition, Photochemical aromatic substitution reaction; Reactions with singlet oxygen, ene reactions (ene with oxygen, alkenes, carbonyl, alkynes, amines etc.); Photochemical methods for protection and deprotection. Barton reaction and Hoffman-Loffler-Freytag reactions, The mechanisms of reactions involving free radicals- Sandmayer, Gomberg- Bachmann, Pschorr and Hunsdiecker reactions. Photo-elimination reactions

UNIT-III

Molecular orbital symmetry and Electrocyclic reaction: Molecular orbital symmetry, frontier orbital of ethylene, 1,3-butadiene, 1,3,5 hexatriene and allyl system classification of pericyclic reactions, Woodward - Hoffmann correlation diagram. FMO & PMO approach, Electrocyclic reaction - conrotatory and disrotatory motions. 4n, 4n+2, allyl systems, Ring opening of cyclopropyl halides and tosylates, cycloadditions-antarafacial and suprafacial additions, 4n and 4n+2 systems, 2+2 addition of ketenes, 1,3-dipolar cycloadditions and cheleotropic Reactions.

UNIT-IV

Sigma-tropic rearrangement: Sigmatropic Rearrangements-suprafacial and antarafacial shifts of H, sigmatropic shifts involving carbon moieties, retention and inversion of configuration, [3,3] and [5,5] sigmatropic rearrangements, detailed treatment of Sommelet-Hauser, Claisen and Cope rearrangements introduction to ene reactions. Simple problems on Pericyclic reactions, Group transfers and eliminations.

Recommended Books:

1. Orbital interactions in chemistry, Thomas A Albright, Jeremy Burdett, Myung –Hwan Whangbo, Wiley, Second edition
2. Pericyclic reactions-A Textbook: Reactions Applications and Theory. S Sankararaman, Wiley-VCH 2015.
3. Organic Photochemistry and Peri Cyclic Reactions, S. Kalaivanai, MJP Publishers, 2011.
4. Pericyclic reactions, Sunil Kumar, Vinod Kumar, S.P. Singh, Elsevier, 2016.
5. Photochemistry and Pericyclic Reactions, **J**agdamba Singh, Jaya Singh, New Age International Pvt Ltd Publishers.

Course code	Title of Paper	Credits	Semester
CHE553	**SURFACE CHEMISTRY AND CATALYSIS**	**3**	**II**

Course Objectives: On completion of this course, the students will be able to understand:
The basic concepts of surface chemistry • The structure of the surfaces and the experimental method of surface characterization • To apply their chemical knowledge and skills to understand the adsorption and desorption processes • The principles of heterogeneous and homogeneous catalysts.

UNIT-I

Surface Chemistry: Introduction to surface chemistry, Surface tension, Capillary action, Adsorption and its types: physisorption and chemisorption, Gibbs adsorption isotherm, Freundlich's adsorption isotherm, Langmuir's adsorption isotherm and its limitations, BET adsorption isotherm and its applications-estimation of surface areas of solids from solution adsorption studies. Langmuir- Hinshelwood mechanism.

UNIT-II

Micelles and Colloids: Surface active agents- classification- critical micellar concentration (CMC)-factors affecting the CMC of surfactants- determination of cmc. Solubilisation factors influencing the solubilisation. Micellization-thermodynamics of micellization. Micro emulsions-comparison of microemulsions with conventional emulsions-applications. Reverse micelles. Introduction to Colloid Chemistry, Lyophobic, and Lyophilic sols Scattering by colloidal particles, Properties of colloidal systems.

UNIT-III

Catalysis: Historical development of catalysis, homogeneous and heterogeneous, enzymatic, phase transfer catalysis. Preparation and characterization of catalysts, influence of heat and mass transport on the rate of catalytic process. Evaluation of activity and selectivity of catalysts. Catalysts acido-basic, hydrogenation dehydrogenation, oxidation-reduction, zeolite. Mechanisms of catalyzed reactions. Modern sorption and spectral methods of characterization of
catalysts.

UNIT-IV

Catalysts Applications: Examples of catalysts applications– cracking, alkylation, hydrogenation, hydration and dehydration processes. Tolman catalytic loop, hydroformylation of alkenes (using cobalt and rhodium catalyst), enantioselective hydrofomylation, Zeigler-Natta polymerization of olefins, reduction of carbon monoxide by hydrogen (Fischer-Tropsch reaction), wacker process, mosanto acetic acid synthesis, hydrosilylation reactions, activation of C-H bond, alkene metathesis reactions, metathesis catalysts, classification of metathesis reactions, Importance of metathesis reactions.

Recommended Books:

1. Introduction to Surface Chemistry and Catalysis by Gábor A. Somorjai (John Wiley & Sons)
2. Physical Chemistry of Macromolecules by C. Tanford
3. Physical Chemistry – P. W. Atkins, Oxford University press, VII edition, 2002.
4. Text Book of Physical Chemistry Vol-1-4 by K.L. Kapoor
5. A.W. Adamson, Physical Chemistry of Surfaces, 4 th edition, Interscience, New York, 1982.

Course code	Title of Paper	Credits	Semester
CHE554	**MODERN ANALYTICAL TECHNIQUES**	**3**	**II**

Course Objectives:
On completion of this course, the students will be able to understand:
Concept of atomic spectroscopy • Understanding the electroanalytical techniques such as ion selective membranes, coulometry etc. • The gravimetric methods of analysis.

UNIT-I
Atomic Spectroscopy: Sample atomization techniques: flame atomization, electrothermal atomization; Atomic absorption spectroscopy (AAS): principle, instrumentation, interferences in AAS, and applications. Atomic emission spectrometry (AES): Glow-Discharge Sources, Inductively Coupled Plasma Source, Instrumentation, advantages and applications. Comparison between AAS and AES.

UNIT-II
Electroanalytical Techniques-I: Introduction, types of electroanalytical methods and general principles; *Potentiometry*: principle, reference electrodes, indicator electrodes, Membrane Indicator Electrodes, ion-selective electrodes, Types of Ion-Selective Membrane Electrodes, Properties of Ion-Selective Membranes, *The Glass Electrode for pH Measurements*: composition of glass, Electrical Conduction across Glass Membranes, Membrane Potentials, The Boundary Potential, The Alkaline Error, Selectivity Coefficients, The Acid Error; Potentiometric titrations, Biosensors

UNIT-III
Electroanalytical Techniques-II: *Coulometry*: Introduction constant-potential coulometry; constant-current coulometry, or coulometric titrations; and electrogravimetry. *Voltammetry*: Principle, Classification, instrumentation, Voltammograms (limiting current, half-wave potential), Hydrodynamic voltammetry, Amperometric Titrations

UNIT-IV
Thermal methods of Analysis
(a) Thermo gravimetry-theory, instrumentation, applications with special reference to
$CuSO_4 .5H_2 O$, $CaC_2O_4 .2H_2 O$, $CaCO_3$, $(COOH)_2 2H_2O$
(b) Differential thermal analysis-principle, instrumentation, difference between TG and DTA - applications with special reference to the clays and minerals, coals (fuels)
(c)Differential scanning calorimetry-principle, instrumentation, applications

Recommended Books:

1. 1.Fundamentals of Analytical Chemistry; Skoog, West. Holler and Crouch 9th edition; Mary Finch. (2014).
2. Analytical Chemistry; Gary D Christian; 6th edition; John Wiley and Sons (2010).
3. Modern Analytical Chemistry David Harvey; McGraw Hill Higher education publishers, (2000).

Course code	Title of Paper	Credits	Semester
CHE571 (Elective-I)	**SYMMETRY AND GROUP THEORY**	**3**	**II**

Course Objectives:
On completion of this course, the students will be able to understand:
Introduction to symmetry element and symmetry operations • Concept of Group and Group Theory • Understanding the Point group. Making groups of elements based on symmetry • To introduce spectroscopic analysis IR and RAMAN based on point group and symmetry.

UNIT-I
Molecular Symmetry: Symmetry elements and Symmetry Operations. Definition of group and characteristics, subgroups, similarity transformation.

UNIT-II
Symmetry element to groups: Products to symmetry operations, relations between symmetry elements, point group classifications.

UNIT-III
Optical activity and dipole moment: Representation of groups, reducible and irreducible representations. The Great Orthogonality theorem. Selection rules, character tables.

UNIT-IV
IR and Raman Spectroscopy: Problem solving to get the IR and Raman spectra from character tables. Hybridisation, MO using group theory.

Recommended Books:

1. Chemical Applications of Group Theory: F. A. Cotton.
2. Symmetry in chemical bonding, Hagfield and Parker.
3. Group theory ad Chemistry, D.M. Bishop

Course code	Title of Paper	Credits	Semester
CHE572 (Elective-I)	**QUANTUM AND COMPUTATIONAL CHEMISTRY**	**3**	**II**

Course Objectives:

To understand the difference between classical and quantum mechanics, introduce wave-particle duality, and introduction to quantum chemistry, operators • Introducing Schrodinger equation for 1D, 3D box. Eigen Functions, Rigid rotor, Simple harmonic oscillator. Introduction to Hydrogen atom • To introduce approximation method (Perturbation and Variational theorem), Hartree Fock Theory, Born Oppenheimer approximation. LCAO MO and VB treatments of hydrogen molecule. Huckel pi-electron theory and its applications • Introduction to Computational Chemistry. Force Fields, potential energy surfaces, solvation models, optimization methods, basis functions and basis sets. Introduction to quantum chemical software.

UNIT-I

Quantum Chemistry Introduction: Introduction to Classical Mechanics. Black Body Radiation. Wave Particle Duality, Wave equation-interpretation of wave function, Normalization and Orthogonalisation, Operators, Commutators. Postulates of quantum mechanics.

UNIT-II

Schrodinger Equation: Hermitian Operator, Particle in one dimensional box, Particle in a three dimensional box, rigid rotor, simple harmonic oscillator, hydrogen atom.

UNIT-III

Approximation: Approximation methods, Perturbation theory (First order) and Variation principle, Ground and excited state of Helium atom, Many electron theory, Hartree Fock Theory, Self Consistent method, Born-Oppenheimer approximation, LCAO MO and VB treatments, Huckel pi-electron theory and its applications.

UNIT-IV

Computational methods: Introduction to Molecular Modelling: Theoretical concepts and calculations of different reactions; potential surfaces, optimization methods, introduction to computational quantum mechanics with concepts of semi-empirical methods, Basis function and Basis sets, Density functional theory, ab initio calculations, Empirical Force field models and Energy minimizations, Challenges in Molecular Modelling.

Recommended Books:

1. Physical Chemistry by Peter Atkins and Julio de Paula, Oxford University Press.
2. Quantum Chemistry by Ira N. Levine
3. Quantum Chemistry by D. A. Macquire
4. Computational Chemistry: Introduction to the Theory and Applications of Molecular and Quantum Mechanics" by Errol G Lewars
5. Computational Chemistry: A Practical Guide for Applying Techniques to Real World Problems" by David Young

Course code	Title of Paper	Credits	Semester
CHE573 (Elective-I)	**MOLECULAR SPECTROSCOPY**	**3**	**II**

Course Objectives:
To provide insights into Electromagnetic radiation- the interaction of electromagnetic radiation with matter • To explain Rotational spectra of diatomic molecules-rigid rotor-selection rules-calculation of bond length • To provide insights into the concept of Raman Effect and Electronic Spectroscopy • To demonstrate nuclear spin, nuclear resonance, saturation, shielding of magnetic nuclei, chemical shift and its measurements.

UNIT-I

Introduction: Electromagnetic radiation- interaction of electromagnetic radiation with matter- absorption, emission, transmission, reflection, refraction, dispersion and scattering. transition probability and selection rules, line widths and line shapes. Polarization: polarization of light; plane of vibration, plane of polarization, optical activity, factors affecting the angle of rotation, specific rotation, optical rotator dispersion and circular dichroism, cotton effect, Fourier Transforms in spectroscopy.

UNIT-II

Vibrational and rotational Spectroscopy: Rotational spectra of diatomic molecules- rigid rotor - selection rules- calculation of bond length- isotopic effect - second order stark effect and its applications, infrared spectra of diatomic molecules-harmonic and anharmonic oscillators, Selection rules- overtones-combination bands-calculation of force constant-anharmonicity constant and Zero point energy. Fermi resonance, simultaneous vibration-rotation spectra of diatomic molecules

UNIT-III

Raman Spectroscopy: Raman effect - classical and quantum mechanical explanations - pure rotational, vibrational and vibrational-rotational Raman spectra-selection rules, mutual exclusion principle.

UNIT-IV

Electronic Spectroscopy: Electronic spectra of diatomic molecules- vibrational course structure-intensity of spectral lines- Franck-Condon principle – applications- rotational fine structure – band head and band shading- charge transfer spectra.

Recommended Books:

1. C.N. Banwell and E.M. Mc Cash, Fundamentals of Molecular Spectroscopy, 4 th edition, Tata McGraw Hill, New Delhi, 1994
2. Introduction to Molecular Spectroscopy, G.M. Barrow, McGraw Hill, 1962
3. Instrumental Methods of Chemical Analysis, Willard, Meritt, Dean & Settle (Wiley Eastern), 7th Ed., 1988
4. Spectroscopy Vol. I & II by Walker & Straw.
5. Fundamentals of Molecular Spectroscopy, P S Sindhu, New Age International Publishers

Course code	Title of Paper	Credits	Semester
CHE561	**ORGANIC CHEMISTRY PRACTICUM**	**3**	**II**

Preparation of organic compounds: Single stage preparations (Any four out of the following)

1. Benzophenone → Benzophenoneoxime
2. Benzaldehyde → Dibenzilidene acetone (Chalcone)
3. Benzaldehyde → Benzalacetophenone
4. Aniline → Benzanilide
5. Aniline → Acetanilide
6. Salicylic acid → Acetyl salicylic acid (Aspirin)

For all preparation

- TLC to be done and Rf values of each compound to be reported
- Melting point of pure compounds to be found
- A small portion should be recrystallized from suitable sovent
- Purified products to be displayed
- Mechanisms for each preparation should be suggested

Textbooks:

1. P.W.G. Smith, A.J. Hannaford, B.S. Furnis and A.R. Tatchell, "Vogel's Textbood Practical Organic Chemistry", ELBS/Longmann, 1989.
2. Ralph L. Shriner, Christine K.T. Hermann, Terence O. Morrill, David Y. Curt, Reynold C. Fuson, 'Systematic Identification of Organic Compounds', John Wiley sons, 2003.
3. Mann and Saunders, 'Practical Organic Chemistry', Pearson edition, 2009.

Course code	Title of Paper	Credits	Semester
CHE562	**ANALYTICAL CHEMISTRY PRACTICUM**	**3**	**II**

1. Water analysis

(i) Determination of alkalinity (CO_3^{2-}, HCO_3^-) of water samples.

(ii) Determination of chemical oxygen demand (COD) of drinking water and sewage water

(ii) Determination of biological oxygen demand (BOD)of drinking water and sewage water

2. Thin layer chromatography

(i) Separatation and identification of the given mixture of colourless compounds (Diphenylamine, Benzophenone and Naphthalene)

(ii) Separatation and identification of the given mixture of coloured compounds (azobenzene, hydroxyazobenzene, p-aminoazobenzene).

3. Gas chromatography:

(i) Identification of Unknown Volatile Organic Compounds (VOCs) in a Mixture Using Gas Chromatography with Flame Ionization Detector (GC-FID)

(ii) Quantitative Analysis of Hydrocarbons in Gasoline Using Gas Chromatography with Flame Ionization Detector (GC-FID)

4. High performance liquid chromatography(HPLC)

(i) Identification of Unknown Compounds in a Mixture Using High Performance Liquid Chromatography with UV-Visible Detection

(ii) Separation of Food Dyes in Commercial Products Using High Performance Liquid Chromatography

Recommended Books:

1. A Text Book of Quantitative Inorganic Analysis (3rd Edition) – A. I. Vogel

COURSE CODE	TITLE OF PAPER	CREDITS	SEMESTER
CHE601	**CURRENT TRENDS IN ORGANIC SYNTHESIS**	**3**	**III**

Course Objectives: The objective of this course is to give the student a broad understanding about diverse modern synthetic methods, multicomponent reactions, oxidation, reduction, and green chemistry-related reactions. Understanding the intricacies of these techniques. Applying this comprehension to novel situations. Developing a genuine interest in the field of modern synthetic methods, multicomponent reactions, oxidation, reduction, and green chemistry-related reactions.

UNIT- I

Modern Synthetic Methods: Baylis-Hillman reaction, Henry reaction, Nef reaction, Kulinkovich reaction, Ritter reaction, Sakurai reaction, Tishchenko reaction and Ugi reaction. Brook rearrangement; Tebbe olefination. Metal mediated C-C and C-X coupling reactions: Heck, Stille, Suzuki, Negishi and Sonogashira, Nozaki-Hiyama, Buchwald-Hartwig, Ullmann coupling reaction.

UNIT-II

Oxidation: Metal based and non-metal-based oxidations of (a) alcohols to carbonyls (Chromium, Manganese, aluminium, DMSO, hypervalent iodine-based reagents). (b) phenols (Fremy's salt, silver carbonate) (c) alkenes to epoxides (peroxides/per acids based), Sharpless asymmetric epoxidation, Jacobsen epoxidation. (d) alkenes to diols (Manganese, Osmium based), Sharpless asymmetric dihydroxylation. (e) alkenes to carbonyls with bond cleavage (Manganese, Osmium, Ruthenium and lead based, ozonolysis) (f) alkenes to alcohols/carbonyls without bond cleavage (hydroboration-oxidation, Wacker oxidation, selenium, chromium based allylic oxidation) (g) ketones to ester/lactones (Baeyer-Villiger).

UNIT-III

Reduction: (a) Catalytic hydrogenation (Heterogeneous: Palladium/ Platinum. (b) Metal based reductions using Li/Na/Ca in liquid ammonia, Sodium, Magnesium, Zinc, Titanium and Samarium (Birch, Pinacol formation, McMurry, Acyloin formation, dehalgenation and deoxygenations) (c) Hydride transfer reagents- $NaBH_4$, LiAlH4, DIBAL-H, and Red-Al.

UNIT-IV

Newer methods in organic synthesis: Green Chemistry: Introduction, principles, atom economy and scope (illustrate with two examples) **Microwave induced reactions:** Principal conditions, advantages over conventional heating methods-applications **Ionic liquids:** Introduction and applications in organic synthesis (illustrate with two examples). **Phase-transfer catalysis:** solid-solid, solid- liquid systems-mechanism of catalytic action, type of catalysts, application in few important reactions.

Recommended Books:

1. Some Modern Methods of Organic Synthesis W. Carothers, Third Edition, Cambridge University Press, Cambridge, 1988.
2. F. A. Cary and R. I. Sundberg, Advanced Organic Chemistry, Part A and B, 5th Edition, Springer, 2009.
3. M. B. Smith, Organic Synthesis, 2nd Edition, 2005
4. J. Tsuji, Palladium Reagents and Catalysts, New Perspectives for the 21st Century, John Wiley & Sons, 2003.
5. I. Ojima, Catalytic Asymmetric Synthesis, 2nd edition, Wiley–VCH, New York, 2000.

COURSE CODE	TITLE OF PAPER	CREDITS	SEMESTER
CHE602	**CHEMISTRY OF HETEROCYCLIC COMPOUNDS AND NATURAL PRODUCTS**	**3**	**III**

Course Objectives: The objective of this course is to give the student a broad understanding of the major classes of heterocyclic compounds. Specifically, the student will learn nomenclature, structure, properties, syntheses, and reactions of the simple 5 and 6-membered ring heterocycles, the benzene ring fused ring heterocycles, the pyridine group, and the quinoline and isoquinoline groups.

UNIT-I

Chemistry of Heterocyclic Compounds: Structure, reactivity and synthesis of three membered Heterocycles: (a) Oxirane: Sharpless method, Shi epoxidation, Jacobsen epoxidation, etc, (b) Aziridine;
Four membered Heterocycles: (a) Oxetane (b) Azetine; Five membered Heterocycles: (a) Pyrrole: Paal Knorr, Hantzsch Methods, etc, (b) Thiophene: Paal Knorr, Hinsberg method, etc. (c) Furan: Paal Knorr, Fiest-Benary, Industrial Method, etc.; (d) Pyrazole, (e) Imidazole, (f) Oxazole, (g) Thiazole;

UNIT-II

Six membered Heterocycles: (a) Pyridine, (b)Pyridazine, (c) pyrimidine and (d) Pyrazine; Aromatic heterocyclics: a) Indole: Fischer indole synthesis, Bischler synthesis, and Madelung synthesis (b) Quinoline and Isoquinoline, (c) Coumarins and Chromones**.**

UNIT-III

Chemistry of Natural Products: A) Terpenoids: - Occurrence, Isolation, isoprene rule, structure elucidation and synthesis of α- Terpineol and α- pinene; B) Steroids:- Nomenclature of steroids, structure elucidation, synthesis and stereochemistry of cholesterol and progesterone; C) Lipids:- Classification, properties and function-free fatty acids, triglycerides, phospholipids, glycolipids & waxes conjugated lipids-lipoproteins

Unit-IV

Planning Organic Synthesis: An introduction to retero synthesis -synthon- synthetic equivalent-target molecule, functional group interconversion. Disconnection approach, one group disconnection of alcohols, olefins and ketones. Logical and illogical disconnections. Two group disconnection 1,2; 1,3 ; 1,4; 1,5 and 1,6 dioxygenated skeletons and dicarbonyls; umpolung, antithesis, chiron. C-C bond forming reactions (alkylation as well as enamine alkylation). Retro Diels-Alder reactions- pericyclic reactions- retrosynthesis of heterocycles containing two nitrogens. Designing synthesis: disconnection approach in camphor and reserpine.

Recommended Books:

1. “Heterocyclic Chemistry" by J. A. Joule and K. Mills
2. "Comprehensive Heterocyclic Chemistry" edited by Alan R. Katritzky
3. "O rganic Chemistry" by Jonathan Clayden, Nick Greeves, and Stuart Warren
4. "Heterocyclic Chemistry" by Thomas L. Gilchrist
5. "Advanced Organic Chemistry: Reactions, Mechanisms, and Structure" by Jerry March
6. "Natural Products: Chemistry and Biochemistry" by Richard J. Sundberg
7. "Organic Chemistry of Natural Products" by O. P. Agarwal
8. "Introduction to Natural Products Chemistry" by Lin-Guo Wang and Jianbo Wang
9. "Advanced Organic Chemistry: Part B: Reaction and Synthesis" by Francis A. Carey and Richard J. Sundberg
10. "Organic Synthesis: Strategy and Control" by Paul Wyatt and Stuart Warren

COURSE CODE	TITLE OF PAPER	CREDITS	SEMESTER
CHE603	**ADVANCED SPECTROSCOPY**	**3**	**III**

Course Objective:
Develop expertise in UV, infrared, NMR, and mass spectrometric techniques to elucidate the structures of organic compounds. Grasp the principles and practical applications of these methods. Utilize acquired skills to analyze data effectively for structural determination.

UNIT-I

Nuclear Magnetic Resonance Spectroscopy (1H NMR): Nuclear spin, resonance, satuaration, shielding of magnetic nuclei, chemical shifts and its measurements, factors affecting chemical shift, chemical and magnetic equivalence of spins, spin-spin coupling, integration, the coupling constant, types of spin-spin couplings, factors influencing coupling constants, first-order and non-first order spectra, spin system notations (ABX, AMX, ABC, A2B2 etc.). Simplification of non-first order spectra- use of higher magnetic fields, nuclear magnetic double resonance and contact shift reagents. Deuterium exchange, Nuclear Overhauser Effect difference spectra, Study of dynamic processes by Variable temperature (VT) NMR, restricted rotation DMF, cyclohexane ring inversion.

UNIT-II

Nuclear Magnetic Resonance Spectroscopy (13C NMR): Introduction, 13C-chemical shifts, factors affecting the chemical shifts, chemical shifts of organic compounds. Calculation of chemical shifts of alkanes, alkenes and aromatic compounds. Types of 13C NMR spectra: Proton-coupled, proton-decoupled and OFF- resonance decoupled (ORD) spectra, DEPT.

UNIT-III

UV SPECTROSCOPY: UV spectra of aromatic and heterocyclic compounds, α-diketones , β-diketones, enediones and quinines. Applications of UV Specroscopy-study of isomerism, determination of strength of hydrogen bonding and conformations of α-substituted cyclohexanones. Steric effect in biphenyls.
Infrared Spectroscopy: Characteristic vibrational frequencies of alkanes, alkenes, alkynes, aromatic compounds, alcohols, ethers, phenols, amines, carbonyl compounds, esters, amides, carboxylic acids, anhydrides, lactones, lactums, nitriles and conjugated carbonyl compounds. Effect of hydrogen bonding and solvent on vibrational frequencies.

UNIT-IV

Mass spectroscopy: Basic Principles, instrumentation, isotope abundance, the molecular ion, metastable ions, base peak, fragment ions, even-electron rule and nitrogen rule. McLafferty rearrangement, ortho effect. *retro*-Diels- Alder reaction, Fragmentation processes- fragmentation associated with various functional groups (alkanes, cycloalkanes, alkenes, alkynes, aromatic hydrocarbons, alcohols, phenols, ethers, aldehydes , ketones, esters , carboxylic acids, amides, amines, alkyl chlorides and alkyl bromides.
Application of UV, IR, NMR and MASS Structural elucidation of Organic compounds by a combined application of the UV, IR, NMR and MASS spectral data.

Recommended Books:

1. Spectroscopic identification of organic compounds by RM Silverstein, G C Bassler and T B Morrill
2. Organic Spectroscopy by William Kemp
3. Spectroscopic methods in Organic chemistry by DH Williams and I Fleming
4. Modern NMR techniques for chemistry research by Andrew B Derome
5. NMR in chemistry - A multinuclear introduction by William Kemp

COURSE CODE	TITLE OF PAPER	CREDITS	SEMESTER
CHE604	**RESEARCH METHODOLOGY**	**3**	**III**

Course Objectives: On completion of this course, the students will be able to understand:
Concepts of research and different types of research • Develop competence on data collection and process of scientific documentation • Analyse the ethical aspects of research • Evaluate the different methods of scientific writing and reporting.

UNIT-I

Basic Concepts of Research: Research definition and types of research (Descriptive vs analytical; applied vs fundamental; quantitative vs. qualitative; conceptual vs empirical). Research methods vs methodology. Literature review and its consolidation; Library research; field research; laboratory research.

UNIT-II

Data Collection and Documentation of Observations: Maintaining a laboratory record; Tabulation and generation of graphs. Imaging of tissue specimens and application of scale bars. The art of field photography.

UNIT-III

Ethics and Good Practical's and Art of Scientific Writing: Authors, acknowledgements, reproducibility, plagiarism, Numbers, units, abbreviations and nomenclature used in scientific writing. Writing references. Power-point presentation. Poster presentation. Scientific Writing and ethics, Introduction to copyright-academic misconduct/plagiarism.

UNIT-IV

Overview of Application to Chemistry related problems: Key chemistry research areas.

1. Experiments based on chemical calculations.
2. Poster presentation on defined topics.
3. Technical writing on topics assigned.
4. Identification of different types of research in day-by-day life
5. Demonstration for checking for plagiarism using recommended software
6. Technical writing on topics assigned.

Recommended books:

1. Dawson, C. (2002), Practical research methods. UBS Publishers, New Delhi.
2. Uday Kumar (2012), Research Methodology and Techniques in Chemistry by, Anmol Publishers.
3. C.R. Kothari (2019) Research Methodology, New Age International Publishers.

COURSE CODE	TITLE OF PAPER	CREDITS	SEMESTER
CHE621 (Elective-II)	**MEDICINAL CHEMISTRY**	**3**	**III**

Course Objectives: On completion of this course, the students will be able to understand:
The basics of medicinal chemistry, biophysical properties • Biological activity parameters • Drug metabolism • Concept of rational drug design

UNIT-I

Bio-physicochemical properties: Acidity/Basicity, Solubility, Ionization, Hydrophobic properties, Hydrophilic properties, Lipinski Rule, Drug-like properties, Understanding of the biological activity parameters such as Ki, Kd, LD50, EC50, IC50, CC50, ADMET properties.

UNIT-II

Structural properties: Isosterism, Bioisosterism, Nonclassical isosteres, Understanding of the 3D-structure along with bond length, bond angle and dihydral angle, Concept of Configuration and Conformation with examples, Concept of stereochemistry in terms of biological response with examples, Stereoselective receptors or enzymes such as muscarinic receptor, Stereo-chemically pure drug and racemates, Examples such as catecholamines, etc.

UNIT-III

Drug target understanding: Metabolism, Drug metabolism, Anti-metabolite, Enzyme inhibitor, Agonist, Antagonist, Examples.
Concept of rational drug design: Structure-activity relationship, Drug-receptor understanding, Molecular modelling, Structure-based drug design. QSAR.

UNIT-IV

Medicinal Chemistry of Therapeutic Agent

Structure, Chemistry, Mode of action and adverse effect of the representative therapeutic agents such as Anti-infective agents, Antimalarials, Antibacterial, Antiviral, Anticancer, CNS acting drugs, Adrenergic Agents, Cholinergic Drugs, Diuretics, Cardiovascular, local anaesthetic agents, Analgesic Agents, Histamine and Antihistamine agents.

Recommended books/References:

1. Foye's Principles of Medicinal Chemistry by David A. Williams, Thomas L. Lemke, William O. Foye (2008), Kluwer publication.
2. Burgers Medicinal Chemistry and Drug Discovery by Abraham D. J., Lewis F. L., Burger, A., vol.5, 6th Edn., 2003, Hoboken N.J.Wiley,
3. The Organic Chemistry of Drug Design and Drug Action by Silverman R. B., 2nd Edn., Academic Press. 2012.
4. Patrick, G. Medicinal Chemistry, Oxford University Press (2000)

COURSE CODE	TITLE OF PAPER	CREDITS	SEMESTER
CHE622 (Elective-II)	**BIOLOGICAL CHEMISTRY**	**3**	**III**

Course Objectives: On completion of this course, the students will be able to understand:
The structure of amino acids, proteins & its structural organization and conformation • The structure & physiological role of vitamins • Mechanism and kinetics of enzymes • The structures of DNA and RNA, sequence determination • High energy compounds from biological oxidations • The carbohydrate metabolism • The concept of fatty acids and lipids, their biological and chemical roles.

UNIT-I

Proteins & Vitamins: Structure and properties of amino acids, essential and nonessential amino acids, peptide bond, naturally occurring peptides, structure of proteins (Primary, Secondary, Tertiary and Quaternary), Denaturation of proteins.
Classification, structure and properties of vitamins, biochemical action of vitamins, role of vitamins in the metabolism.

UNIT-I

Enzymes & Nucleic acids: Classification of enzymes, coenzymes, mechanism of enzyme activity, allosteric effect, enzyme kinetics and the Michaelis-Menten equation, various types of enzyme inhibition.
Ribonucleotides and deoxyribonucleotides, RNA and DNA, base pairing, double helical structure of DNA, nucleic acid characterization, separation and sequencing.

UNIT-III

Carbohydrates: Monosaccharides, oligosaccharides and polysaccharides, glycolipids and glycoproteins, Major pathways of carbohydrate metabolism - Glycolysis, Citric acid cycle, gluconeogenesis, glycogen metabolism. High energy compounds, biological oxidation, Electron transport chain, Mechanism and Inhibitors of oxidative phosphorylation.

UNIT-IV

Lipids and Membranes: Structure and functions of fatty acids, phospholipids and cholesterol. Classification and functions of lipids, formation of micelles and reverse micelles, Lipid polymorphism, Properties and applications of liposomes, fluid mosaic model of membrane structure, transport across membranes.

Recommended books:

1. Biochemistry by U. Satyanarayana and U. Chakrapani, Elsevier RELX India Pvt. Ltd., 6 Edition (2021).
2. Biochemistry by D. Voet & J. G. Voet, Published by John Wiley (New York), 4th Edition (2010).
3. Lehninger's Principles of Biochemistry by D. L Nelson & M. M. Cox, Published by W. H. Freeman, New York and CBS Publishers, New Delhi, 5th Edition (2008)

COURSE CODE	TITLE OF PAPER	CREDITS	SEMESTER
CHE623 (Elective-II)	**PRINCIPLES OF MICROBIOLOGY**	**3**	**III**

Course Objectives: On completion of this course, the students will be able to understand:
The history of microbiology • the characteristics of different types of microorganisms • Staining techniques • Useful and harmful activities of the microorganisms.

UNIT-I

History of microbiology and introduction to the microbial world. Germ theory of disease, Development of various microbiological techniques and golden era of microbiology. Contributions of Antony von Leeuwenhoek, Louis Pasteur, Robert Koch, Joseph Lister, Alexander Fleming, Martinus W. Beijerinck, Sergei N. Winogradsky, Selman A. Waksman, Paul Ehrlich, Elie Metchnikoff and Edward Jenner.

UNIT-II

Physiochemical and biological characteristics of microorganisms (including viruses); Baltimore classification. Binomial Nomenclature. General characteristics of Cellular microorganisms, wall-less forms - MLO (mycoplasma and spheroplasts) with emphasis on distribution and occurrence, morphology, mode of reproduction and economic importance.

UNIT-III

General concept of phytoplanktons and zooplanktons. General characteristics, structure, mode of reproduction and economic importance of actinomycetes with special reference to its application in medicine and industry.

UNIT-IV

Methods of studying microorganisms; Staining techniques: simple staining, Gram staining, negative staining and acid-fast staining. Sterilization techniques (physical & chemical sterilization). Culture media & conditions for microbial growth. Pure culture isolation: Streaking, serial dilution and plating methods; cultivation, maintenance and preservation of pure cultures.

Beneficial and harmful microbes and their role in daily life.

Recommended Books:

1. Prescot, M.J., Harley, J.P. and Klein, D.A. Microbiology. 5th Edition WCB Mc Graw Hill, New York, (2002).
2. Tortora, G.J., Funke, B.R. and Case, C.L. Microbiology: An Introduction. Pearson Education, Singapore, (2004).
3. Alcomo, I.E. Fundamentals of Microbiology. VI Edition, Jones and Bartlett Publishers. Sudbury. Massachusetts, (2001).
4. Black J.G. Microbiology-Principles and Explorations. John Wiley & Sons Inc. New York, (2002).
5. Pelczar, MJ Chan ECS and Krieg NR, Microbiology McGraw-Hill.
6. Madigan, Martinko, Bender, Buckley, Stahl. Brock Biology of Microorganisms. Pearson
7. Tom Besty, D.C Jim Koegh. Microbiology Demystified McGraw-Hill.

COURSE CODE	TITLE OF PAPER	CREDITS	SEMESTER
CHE611	**ORGANIC CHEMISTRY-2 PRACTICUM**	**3**	**III**

Preparations of Organic Compounds: Multistage preparations (any Four out of the following)

1. Benzoin → Benzil → Benzilic acid → Quinoxaline
2. Acetophenone → Oxime → Acetanilide
3. Phthalic anhydride → o-benzoyl benzoic acid → Anthraquinone
4. Acetophenone → Benzalacetophenone → Epoxide
5. Hydroquinone → Quinone → 1,2,4 triacetoxybenzene
6. p-Nitro tolune → p-nitro Benzene → Ethyl -p- nitrobenzoate → p-aminobenzene
7. Pthalic acid → pthalic anhydride → phthalimide → Anthranilic acid

For all preparations:

- TLC to be done and Rf values of each compound to be reported.
- Melting point of pure compounds to be found.
- A small portion should be recrystallised from suitable solvent.
- Purified products to be displayed.
- Mechanisms for each preparation should be suggested.

Recommended Books:

1. Vogel,A. I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J., Smith, P.W.G., Textbook Of Practical Organic chemistry ,Prentice-Hall, 5ht edn, 1996.
2. Mann, F. G., Saunders, B.C. Practical Organic chemistry, 4th edn, Pearson Education India, 2009
3. Khosla, B.D. Garg, V.C & Gulati, A. Senior Practical Physical chemistry, R. Chand & Co. : New Delhi, 2011.
4. Qualitative Organic Analysis, Pearson Education, 2011.
5. Leonard, J., Lygo, B., Procter. G., Advanced Practical Organic Chemistry, 3rd edn, CRC Press, 2013.
6. Cranwell, P. B., Harwood, L. M., Moody, C.J., Experimental Organic chemistry, 3rd edn, wiley-Blackwell,2017.
7. Ahluwalia, V.K., Aggrawal, R. Comprehensive practical organic chemistry, University Pres, 2004

COURSE CODE	TITLE OF PAPER	CREDITS	SEMESTER
CHE641	**RESEARCH LITERATURE REVIEW**	**3**	**III**

Students will cultivate research skills, mastering the art of literature review, citation analysis, and observation generation. Emphasizing documentation throughout the process, students are advised to engage in comprehensive research literature reviews.

At the commencement of the third semester, the allocation of guides for MSc projects/dissertations will be done by the Head of the department, taking into account students' performance in the previous two semesters. Students will choose a topic in consultation with the guide and will write detailed review (in a publishable format) and submit it to the respective guide for the evaluation.

COURSE CODE	TITLE OF PAPER	CREDITS	SEMESTER
CHE671 (Elective-III / IV)	**CHEMISTRY OF NANOMATERIALS**	**3**	**IV**

Course Objectives: On completion of this course, the students will be able to understand:
Basic aspects of Nanoscience and Nanotechnology • Synthesis and properties of nanomaterials • Characterization of nanomaterials • Nanomaterials for energy and biomedical applications.

UNIT-I

Introduction: Concept of Size and Shape, the difference between bulk and Nanomaterials; Definition of Nanomaterial; Classification of nanomaterials - Quantum dots, Nanowires, Nanotubes, 2D and 3D films; Carbon nanomaterials (SWCNTs, MWCNTs, Graphene); Mechanical, optical, and magnetic properties of nanomaterials.

UNIT-II

Synthesis and Characterization: Bottom-up and Top-Down Approaches, Sol-Gel chemical synthesis, Ultrasonication, Mechanical Milling, Chemical Vapour deposition (CVD) technique, biological synthesis; Characterization of nanomaterials using UV-visible spectroscopy, Fluorescence Spectroscopy, Powder XRD, Particle size analysis by Dynamic Light Scattering (DLS), SEM, TEM, AFM techniques.

UNIT-III

Energy applications: The energy challenges - Optical luminescence and fluorescence from direct, bandgap semiconductor nanoparticles - White LEDs - High-Efficiency Materials for OLEDs; Nano solar cells, making hydrogen fuel cells, hydrogen production and storage; Lithium-ion batteries.

UNIT-IV

Nanomaterials in Medicine: Materials for use in diagnostic and therapeutic applications - Nanocarriers and their interaction with bloodstream, Gold nanoparticles, Silver nanoparticles, Quantum dots, Magnetic nanoparticles; Diagnostic applications of immune-targeted nanoparticles; Targeted drug delivery.

Recommended Books:

1. Nanotechnology, Richard Booker, Earl Boysen, Wiley Publications, 2005
2. Nano: The Essentials, T. Pradeep, McGraw-Hill Education, 2010.
3. Textbook of Nanosciene and Nanotechnology, B.S. Murty, Universities Press, 2011
4. Nanochemistry: A chemical approach to Nanomaterials, Ozin Geoffrey A. and Andre C. Arsenault, Royal Society of Chemistry Publication, 2005.

COURSE CODE	TITLE OF PAPER	CREDITS	SEMESTER
CHE672 (Elective-III/ IV)	**ENVIRONMENTAL CHEMISTRY**	**3**	**IV**

Course Objectives: On completion of this course, the students will be able to understand:
The components of environment and effects of air pollutants on environment • Types of water pollutants • The domestic and industrial water treatment methodologies • Biochemical effects of toxic metals and gases • Various sources of energy.

UNIT-I

Air Pollution: Composition of atmosphere. Air quality standards, types of air pollutants, effect of air pollutants on man & environment. Chemical and photochemical reactions in atmosphere, environmental effects of ozone, greenhouse effect and global warming, major sources of air pollution, pollution by SO_2, CO_2, CO, NOx, H_2S and Particulate matter. Methods of estimation of CO, NOx, SOx and control procedures.

UNIT-II

Water Pollution: Hydrological cycle, water resources, Water and quality standards, Sources and nature of water pollutants. Analysis of drinking water for Hardness, Alkalinity, DO, BOD, COD, Chlorides, ammonia, nitrate, nitrite, sulphate; phosphate etc. Techniques for measuring water pollution, primary, secondary and tertiary water treatment methods, purification water by reverse osmosis, electro dialysis, ion exchange methods. Industrial effluents and their treatment from electroplating, tannery, dairy etc industries.

UNIT-III

Chemical Toxicology: Biochemical effects of the following, Calcium, Lead, Mercury, Arsenic, Cyanide, Pesticides, Carbon monoxide, Nitrogen oxide and Sulphur dioxide.

UNIT-IV

Energy & Environment: Sources of energy: Coal, petrol and natural gas. Nuclear Fusion / Fission, Solar energy, Hydrogen, Geothermal, Tidal and Hydel, etc. Disposal of nuclear waste, nuclear disaster and its management.

Recommended Books:

1. Environmental Chemistry by S.K. Banerjee.
2. Environmental Chemistry by O.P. Tyagi
3. Environmental pollution control engineering by S.P. Mahajan.
4. A Text book of Environmental chemistry and pollution control by S.S. Dara.
5. Principles of Instrumental analysis by Skoog, West and Nieman.
6. *Environmental Chemistry*: New Age International Pvt., Ltd, New Delhi by A. K. De.

COURSE CODE	TITLE OF PAPER	CREDITS	SEMESTER
CHE673 (Elective-III / IV)	**POLYMER CHEMISTRY**	**3**	**IV**

Course Objectives: On completion of this course, the students will be able to understand:
The mechanism of polymer material formation • Molecular weight and structure-property relationship • Polymerization procedure and Zigler-Natta catalysis • Characterization of polymers.

UNIT-I

Introduction: Polymer, monomer, examples of polymers, biopolymers, classification, polymerization process, degree of polymerization, condensation, addition polymers, kinetics of addition polymerization process.

UNIT-II

Polymeric Structure and Property Relationship: Structure of polymers - Linear, branched, cross linked, and network polymers, molecular weight (number average, weight average, viscosity average) and distribution of molecular weight, polydispersity index, crystallinity in polymer, melting temperature and glass transition temperature, Volumetric properties - molar volume, density, Van der Waals volume – Coefficient of linear thermal expansion and volumetric thermal expansion - Pressure volume temperature (PVT) relationship.

UNIT-III

Polymerization Chemistry: Industrial methods of polymerization such as bulk, solution, emulsion, suspension. Stereochemistry of polymers and stereo-specific polymerization, Catalysts-their utility in polymers and stereo-specific polymerizations, Catalysts their utility in polymer manufacture, Zieglar-Natta, Metallocene and others.

UNIT-IV

Characterization of Polymers: Molecular Weight Determination by Light Scattering, Osmometry, End-Group Analysis, Viscosity, Gel Permeation Chromatography; Application, of FTIR, UV-visible, NMR, and Mass Spectroscopy for Identification of polymers.

Recommended books/References:

1. D.W. Van Krevelen and P.J. Hoftyzen, "Properties of Polymer, 3rd Edition Elsevier Scientific, Publishing Company Amsterdam - Oxford – New York. 1990.
2. J.E. Mark Ed.AIP, Physical Properties of Polymers Handbook, Williston, Vt, 1996.
3. Reaction Engineering of Step Growth Polymerization, S K Gupta and Anil Kumar, Plenum Press, 1987
4. Odian; George, Principles of Polymerization, McGraw-Hill Book Co., New York (1970).
5. W. Billmeyer, Textbook of polymer science, 3rd Edn., 2007, Wiley.
6. J.R. Fried, Polymer Science and Technology, (2005), PHI publication.
7. Billmeyer Jr.; Fred W., Textbook of Polymer Science, Wiley- Interscience Publishers, New York (1962).

COURSE CODE	TITLE OF PAPER	CREDITS	SEMESTER
CHE674 (Elective-III / IV)	**STRATEGIC PLANNING IN ORGANIC SYNTHESIS**	**3**	**IV**

Course Objectives: This course covers a wide range of organic synthesis principles, including the disconnection approach, one/two group disconnections, and the utilization of organoboranes and organosilanes. Emphasizing practical application, the curriculum sharpens interpretation, comparison, and analysis skills. The course is designed to aid in applying these principles effectively in real-world scenarios, ensuring a comprehensive understanding of organic synthesis.

UNIT-I

Disconnection Approach – Principles Introduction, Terminology: Retrosynthesis, Target Molecule (TM), synthon, synthetic equivalent,functional group interconversion (FGI). Linear and convergent synthesis. Criteria for selection oftarget . Order of events in retrosynthesis with reference to Salbutamol, Proparcaine and Dopamine. Chemoselectivity, Regioselectivity, reversal of polarity and cyclizations. Protecting groups- Principles of protection of alcohols, amine, carbonyl and carboxyl groups

UNIT-II

Synthetic Strategies - One group Disconnections. Introduction to one group disconnections: C-C disconnection-alcohols and carbonyl compounds; C-X disconnections- alcohols and carbonyl compounds and sulphides two group C-C and C-X Disconnections; Two group Disconnections Introduction to Two group C-C disconnections; Diels-Alder reaction, 1,5- difunctionalised compounds, Michael addition and Robinson annulation. Two group C-X disconnections; 1, 1- difunctionalised, 1, 2-difunctionalised and 1, 3-difunctionalised compounds. Control in carbonyl condensations, explanation with examples oxanamide and mevalonic acid.

UNIT –III

Organoboranes : Hydroboration- Preparation of Organoboranes. Reagents – dicylohexyl borane, disiamyl borane, thexyl borane, 9-BBN and mono-, di-isopinocamphenyl borane. Functional group transformations of Organo boranes-Oxidation, protonolysis and rearrangements. Formation of carbon-carbon-bonds viz organo boranes- carbonylation, cyanoboration.

UNIT –IV

Organosilanes : Preparation and synthetic applications of trimethylsilyl chloride, dimethyl-t-butylsilyl chloride, trimethylsilylcyanide, trimethylsilyliodide and trimethylsilyltriflate. Protection of functional groups - Trimethylsilylethers, Silylenolethers. Synthetic applications of α-silyl carbanions, β-silyl carbonium ions. Peterson's olefination.

Recommended Books:

1. Organic syntheses via boranes / Herbert C. Brown; with techniques by Gary W. Kramer,
2. Some Modern Methods of Organic Synthesis W. Carothers, Third Edition, Cambridge University Press, Cambridge, 1988.
3. Organic Synthesis: The disconnection approach, S. Warrant John Wiley & sons, New York, 1984.
4. Modern Synthetic Reactions, Herbert O. House, Second Edition, W.A. Benzamine Inc. Menio Park, California, 1972.
5. Principle of Organic Synthesis- R.O.C. Norman and J. M. Coxon.(ELBS)
6. Organic Synthesis: Special techniques. V.K.Ahulwalia and Renu Aggarwal.
7. Organic Synthesis by C Willis and M Willis
8. Problems on organic synthesis by Stuart Warren

COURSE CODE	TITLE OF PAPER	CREDITS	SEMESTER
CHE675 (Elective-III / IV)	**NUCLEAR AND RADIOCHEMISTRY**	**3**	**IV**

Course Objectives: On completion of this course, the students will be able to understand:
the nuclear and chemical properties of elements and the characteristic radiations emitted by their radioisotopes. The scope of applications of radioisotopes in various fields such as, chemistry, industry, healthcare, agriculture, water, environment, etc.

UNIT-I

Radioactivity and Nuclear decay: Nucleus and its classification, nuclear forces, nuclear stability, binding energy, nuclear models. Radioactive decay (Radioactive elements, general characteristics of radioactive decay, decay kinetics - decay constant, half life, mean life period), units of radioactivity, Transient and secular equilibria, Carbon dating and its usefulness.

UNIT-II

Nuclear reactions: Bethe notation, types of nuclear reactions (n, p, α, d and γ), conservation of quantities (mass-energy and linear momentum) in nuclear reactions, reaction cross-section, compound nucleus theory and nuclear reactions. Type of nuclear reactions - Nuclear fission, Nuclear fusion. Nuclear fission: the process, fragments, mass distribution, and fission energy. Nuclear fusion and stellar energy**.**

UNIT-III

Radiation measurements and Reactors: Interaction of radiation with matter, Radiolysis of water, Radiation dosimetry Measurement of radioactivity, idea about accelerator and detectors, Van de Graaaf and linear**,** acceletors, synchrontrons, Geiger-Muller detector, Scintillaton detectors, Nuclear reactor: classification of reactors, the natural uranium reactor, breeder reactor.

UNIT-IV

Nuclear pollution and applications. Nuclear disaster and its management (nuclear accidents and holocaust – discussion about case studies), disposal of nuclear waste; Radioactive isotopes, radiochemical principle in the use of tracers, applications of tracers in chemical investigations, physiochemical methods, analytical applications, age determinations, medical applications, agricultural applications.

Recommended Books:

1. Friendlander G, Kennedy G and Miller J. M. Nuclear and Radiochemistry, Wiley Interscience
2. Harvey, B. G. Introduction to Nuclear Physics & Chemistry, Prentice – Hall,
3. Overman R. T, Basic concept of Nuclear Chemistry, Chapman & Hall.
4. A. N. Nesmeyanov, Radiochemistry, MIR Publication, Moscow.
5. Spinks J. W. T. and Woods R. J. An Introduction to Radiation Chemistry, Wiley
6. Arnikar H. J., Essentials of Nuclear Chemistry, Wiley Eastern, Second Edition.

COURSE CODE	TITLE OF PAPER	CREDITS	SEMESTER
CHE676 (Elective-III / IV)	**INDUSTRIAL SAFETY**	**3**	**IV**

Course Objectives: On completion of this course, the students will be able to understand:
The safety engineering fundamentals and safety management practices.

UNIT-I

Introduction to modern safety concepts – Fire prevention – Mechanical hazards – safety of Boilers, Pressure vessels, Electrical Exposure, Chemical exposure – Toxic metals and materials – Ionizing and Non-ionizing Radiations

UNIT-II

Safety & Hygiene: Transport, handling & storage of inflammable liquids & gases & toxic materials, Process equipment including piping (fire, static electricity, pressure, temperature etc.)

UNIT-III

Environmental Control: Industrial Health Hazards – Environmental Control – Industrial Noise - Noise measuring instruments, Solid Hazardous Waste Management, HAZOP analysis and Risk Assessment Personal Protection.

UNIT-IV

Safety Regulations: Explosions – Disaster management – catastrophe control, hazard control, Safety education and training - Factories Act, Safety regulations Product safety – case studies.

Recommended Books:

1. John V. Grimaldi, “Safety Management”, AITB S Publishers, 2003.
2. Safety Manual, “EDEL Engineering Consultancy”, 2000.
3. David L.Goetsch, “Occupational Safety and Health for Technologists”, 5th Edition, Engineers and Managers, Pearson Education Ltd., 2005

COURSE CODE	TITLE OF PAPER	CREDITS	SEMESTER
CHE691	**PRE-PROJECT SEMINAR**	**2**	**IV**

Engaging in seminar presentations provides students with a valuable opportunity to enhance their knowledge and refine skills within specific subject areas. It is advisable for students to demonstrate their research interests through a pre-project seminar at the beginning of the semester, in collaboration with their research guide. The selected topic should directly correlate with the dissertation work the student intends to undertake. Evaluation of the seminar will be divided, with the guide's assessment accounting for 50% and other 50 % by the DRC.

COURSE CODE	TITLE OF PAPER	CREDITS	SEMESTER
CHE692	**RESEARCH PROJECT & DISSERTATION**	**12**	**IV**

The aim of this research project is to identify the independent research skills developed by students during their project involvements. It is strongly recommended that all students pursue a research project aligned with their interests and subsequently present their findings in a dissertation upon its conclusion. Furthermore, students are encouraged to disseminate their project outcomes by publishing them in esteemed international journals.

The following evaluation pattern will be followed

Examination	**Items**	**Marks**
Midterm presentation	M.Sc. dissertation three-member committee will be formed by HOD in consultation with guide (Guide + one member within the department + one member outside the department)	**100**
End semester evaluation	Presentation: 50 marks Viva-versa: 50 marks Dissertation: 100 marks (Guide will have 50% weightage and DRC members 50%)	**200**

Student should submit 2 hard copies along with soft copy of the final research project dissertation along with plagiarism report in proper recommended format to HOD with all declarations and signatures. The students should follow research ethics and guidelines of the University.