MANONMANIAM SUNDARANAR UNIVERSITY

TIRUNELVELI

M.Sc., ORGANIC CHEMISTRY

SYLLABUS

FROM THE ACADEMIC YEAR 2023-2024

Vision and mission of the department Vision

To develop a Centre of Excellence for teaching as well a research at par with national and international standards. Reach a position of distinction by offering first-class education and serving the community in relevant areas of interest to the rural areas.

Mission

- Provide an educational environment where students can realize their full potential in chemistry and attain quality education to face the challenges of the future.
- Provide a dynamic, challenging, and ethical environment for pursuing high-quality teaching, learning, research and service.

TANSCHE REGULATION ON LEARNING OUTCOMES-BASED CURRICULUM FRAMEWORK FOR POSTGRADUATE EDUCATION	
Programme	**M.Sc. ORGANIC CHEMISTRY**
Programme Code	
Duration	**PG – 2 YEARS**
Programme Outcomes (Pos)	**PO1: Problem Solving Skill** Apply knowledge of Management theories and Human Resource practices to solve business problems through research in Global context. **PO2: Decision Making Skill** Foster analytical and critical thinking abilities for data-based decision-making. **PO3: Ethical Value** Ability to incorporate quality, ethical and legal value-based perspectives to all organizational activities. **PO4: Communication Skill** Ability to develop communication, managerial and interpersonal skills. **PO5: Individual and Team Leadership Skill** Capability to lead themselves and the team to achieve organizational goals. **PO6: Employability Skill** Inculcate contemporary business practices to enhance employability skills in the competitive environment. **PO7: Entrepreneurial Skill** Equip with skills and competencies to become an entrepreneur. **PO8: Contribution to Society** Succeed in career endeavors and contribute significantly to society. **PO 9 Multicultural competence** Possess knowledge of the values and beliefs of multiple cultures and a global perspective. **PO 10: Moral and ethical awareness/reasoning** Ability to embrace moral/ethical values in conducting one's life.

Programme Specific Outcomes (PSOs)	**PSO1 – Placement** To prepare the students who will demonstrate respectful engagement with others' ideas, behaviors, beliefs and apply diverse frames of reference to decisions and actions. **PSO 2 - Entrepreneur** To create effective entrepreneurs by enhancing their critical thinking, problem solving, decision making and leadership skill that will facilitate startups and high potential organizations.
	PSO3 – Research and Development Design and implement HR systems and practices grounded in research that comply with employment laws, leading the organization towards growth and development. **PSO4 – Contribution to Business World** To produce employable, ethical and innovative professionals to sustain in the dynamic business world. **PSO 5 – Contribution to the Society** To contribute to the development of the society by collaborating with stakeholders for mutual benefit.

Component wise Credit Distribution for M.Sc. Organic chemistry

Credits	Sem. I	Sem. II	Sem. III	Sem. IV	Total
Part A core	**18**	**18**	**10**	**14**	**60**
Part B **(i) Elective (Discipline – Centric / Generic Skill) and MOOC NPTEL online**	**3**	**6**	**9**	**6**	**24**
(ii) Soft Skill	**2**	**2**	**2**	**2**	**8**
(iii) Skill enhancement course / Value added courses	**-**	**2**	**2**	**-**	**4**
Part C **(iii) Summer Internship / Industrial Training**	**-**	**-**	**2**	**-**	**2**
Total	**23**	**28**	**25**	**22**	**98**

List of Courses:

Semester	Course Code	Title of the Course	Core/Elective/ Soft Skill	Credits
I	CHE C001	Fundamentals of Analytical Chemistry	CORE	3
I	CHE C101	Coordination and Nuclear Chemistry	CORE	3
I	CHE C201	Stereochemistry and Organic Reaction Mechanism	CORE	3
I	CHE C301	Thermodynamics, Electrochemistry and Chemical Kinetics	CORE	3
I	CHE C202	Organic Chemistry Practical-I	CORE	3
I	CHE C302	Physical Chemistry Practical-I	CORE	3
I	UOM S115	Lab Safety and First Aid	SOFT SKILL	2
I		Elective (One subject from the following)	ELECTIVE	3
I	CHE E001	Electronics and Computers for Chemists	ELECTIVE	
I	CHE E101	Inorganic Reaction Mechanism	ELECTIVE	
I	CHE E201	Name Reactions in Organic Chemistry	ELECTIVE	
I	CHE E301	Essentials of Statistical Thermodynamics	ELECTIVE	
II	CHE C002	Analytical Instrumentation	CORE	3
II	CHE C102	Main Group Elements and Inorganic Polymers	CORE	3
II	CHE C203	Organic Reaction Mechanism	CORE	3
II	CHE C303	Quantum Chemistry and Group Theory	CORE	3
II	CHE C003	Analytical Chemistry Practical-I	CORE	3
II	CHE C103	Inorganic Chemistry Practical-I	CORE	3
II	UOM S118	Spectroscopy Instrumentation	SOFT SKILL	2
II		Advanced methods of chemical analysis	Value added course	2
		Elective (One subject from the following)	ELECTIVE	3
II	CHE E002	Analysis of Complex materials	ELECTIVE	
II	CHE E102	Nuclear Chemistry	ELECTIVE	
II	CHE E202	Functional Group Transformation	ELECTIVE	
II	CHE E302	Macromolecular Chemistry	ELECTIVE	
II		MOOC-NPTEL	Online	3
III	CHE C601	Physical Methods in Chemistry	CORE	4
III	CHE C204	Organic Chemistry Practical-II	CORE	3
III	CHE C205	Organic Chemistry Practical-III	CORE	3
III	CHE E601	Biological Chemistry	ELECTIVE	3
III	CHE E604	Chemistry of Heterocycles, Organolithium and Asymmetric Synthesis	ELECTIVE	3
III		MOOC-NPTEL	Online	3
III	UOM S147	Software packages for Chemists	SOFT SKILL	2
III		Advanced methods in Materials characterization	Value added course	2
III	UOM I001	Short time exposure to Research Institution/Industrial training (Summer)	Internship	2

IV	CHE C206	Orbital Symmetry, Photochemistry and Non-conventional techniques in Organic Synthesis	CORE	4
IV	CHE C207	Chemistry of Natural Products	CORE	4
IV	CHE E204	Modern Synthetic Methodology and Spectrometric Identification of Organic Compounds	ELECTIVE	3
IV	CHE E603	Novel Reagents in Organic Synthesis	ELECTIVE	3
IV	UOM S117	Chemistry Databases	SOFT SKILL	2
IV	CHE C208	Project/Dissertation	CORE	6
		TOTAL CREDITS		**98**

METHOD OF EVALUATION:

Theory

Continuous Internal Assessment	External Examination	Total
25	**75**	**100**

Practical

Internal (Continuous Assessment)	End Semester Examination	Total
60	40	100

Methods of assessment:

Recall (K1) – Simple definitions, MCQ, Recall steps, Concept definitions

Understand/ Comprehend (K2) – MCQ, True/False, Short essays, Concept explanations, Short summary or overview

Application (K3) – Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain

Analyse (K4) – Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge

Evaluate (K5) – Longer essay/ Evaluation essay, Critique or justify with pros and cons **Create (K6)**

– Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations

SEMESTER I

Course code	CHE C001	FUNDAMENTLS OF ANALYTICAL CHEMISTRY
Core/Elective/Supportive		Core Credit - 3
Pre-requisite		Student must have an idea about chemical analysis

Course Objectives:

The main objectives of this course are to:

- To interpret and analyze data acquired during testing of samples
- To differentiate the nature of samples and choose the correct sampling technique
- To understand the nature of chemical reactions
- To compare and contrast the various titration methods with sound theoretical knowledge for estimation of ions.

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1.	The students will be able to understand and apply the correct method to analyze analytical data	K1-K4
2.	They will be able to employ the correct technique to collect samples of any nature for analysis	K2-K4
3.	Can evaluate the accuracy and summaries the methods adapted for certain practical activities.	K3-K4
4.	Can explain and summarize the various titrimetric techniques used for analysis	K2
5.	To understand the chemical equilibria to predict the solution chemistry	K5
6.	Compare and contrast the various methods of titration based on the nature of samples	K5 & K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1	TREATMENT OF ANALYTICAL DATA AND SAMPLING	15 hours

Nature of quantitative measurements and treatment of data. Basic statistical concepts – Errors- random and systematic, mean, median, precision and accuracy, significant figures, Gaussian distribution curves, Null Hypothesis, Confidence interval of mean, Rejection of data (Q test), Student's t, F tests. Reliability of results, Regression and correlation. Quality control and control chart.

Analytical Chemical standards, types and traceability, Evaluation of Analytical process, Analytical Method Calibration. Chemical Measurement Process (CMP) – concept and steps.

Principles of sampling methods for solid, liquids and gases. Gross sampling, Sampler's responsibility and pitfalls, hazards of sampling.

Unit:2	CHEMICAL EQUILIBRIA AND NEUTRALIZATION REACTIONS	15 hours

Chemical Equilibria - Activity concept, equilibrium constant and applications, ionisation constants of acids and bases. Concept of pH, hydrolysis of salts, hydrolysis constant and degree of hydrolysis, Buffers – types, range and capacity, dissociation of polyprotic acids, common ion effect, salt effect.

Neutralization reactions – Theory of acid-base titrations, theory and choice of indicators, mono and polyprotic systems, titration curves and feasibility of reactions, calculation of pH during titrations

Unit:3	REDOX TITRATION, PRECIPITATION TITRATIONS AND COMPLEXOMETRIC TITRATIONS	15 hours

Redox titration – Redox potentials, theory and feasibility of redox titration, calculation of potentials at different stages of titrations, redox indicators, their choice and applications.

Precipitation titrations – Theory and types, Mohr, Volhard and Fajan's methods. Adsorption indicators – theory, choice and applications.

Complexometric titrations – Theory, Stepwise and overall formation constants, Titrations involving chelates (EDTA). Metallochromic indicators – Theory and Choice. Masking and demasking and extractive methods. Direct, indirect (including substitution) titration and applications.

	Contemporary Learning	15 hours

Expert lectures, YouTubes Videos, Animations, NPTEL, MOOC videos, online seminars – webinars for strengthening the subject matters. Assignment and class room seminar

	Total Lecture hours	45 hours

Text Book(s)

1.	Fundamentals of Analytical Chemistry - Skoog, West and Holler, Saunders College Publishing, VI Edition, 1991, and VII Edition, 1996.
2.	Text Book of Quantitative Inorganic Analysis – A.I. Vogel, ELBS, III Edition, 1976, and IV Edition, 1985
3.	Vogel's Text Book of Quantitative Chemical Analysis – A.I. Vogel, Pearson Education Ltd, VI Edition, 2001
4.	Analytical Chemistry – Gary D. Christian, John Wiley & Sons, INC, V Edition, 2001
5.	Statistics for Analytical Chemistry – J.C. Miller and J.N. Miller, Ellis Harwood, Chichester, 1984.

Reference Books

1	Instrumental Analysis – Gary D. Christian & James, E. O'Reilly, Allyn & Bacon Inc, II Edition, 1986
2	Analytical Chemistry – J.G. Dick, McGraw Hill Publishers, 1975
3	Analytical Chemistry- An Introduction – Skoog, West & Holler, Saunders College Publishing VI Edition,1994.
4	Instrumental Methods of Chemical Analysis – G.W. Ewing, McGraw Hill Publishers, 1975.
5	Statistics for Analytical Chemists – R. Caulcutt and R. Boddy, Chapmann and Hall Publications, London, 1982

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1.	https://youtu.be/dlDnzswhTsU-Data Analysis and decision making
2.	https://youtu.be/ozEWJAk4JCc-Acid Base Reactions
3.	https://www.youtube.com/watch?v=n9wUdgxCLMQ-Neutralizations Reactions
4	https://www.youtube.com/watch?v=flCQz0QjPmA-Redox Reactions
5.	https://youtu.be/dtTx5f9zdm0- Quantitative Methods in Chemistry

Mapping with Programme Outcomes*										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	M	S	L	S	S	S	L	S	L
CO2	S	S	S	S	M	M	S	S	S	S
CO3	M	S	S	M	L	M	S	L	S	S
CO4	S	S	S	S	L	S	S	L	M	L
CO5	S	S	S	S	M	S	S	M	L	M

*S-Strong; M-Medium; L-Low

Semester - I	CHE C101	COORDINATION AND NUCLEARCHEMISTRY
Core/Elective /Supportive	Core Credit-3	
Pre-requisite	Students must know about the fundamental terms of coordination chemistry, Werner's theory, Valence Bond Theory, basics of nucleus, nuclear particles and nuclear forces.	

Course Objectives:

The main objectives of this course are to:

- Know about the structure, properties and bonding nature of coordination compounds
- Illustrate the basic concept of theories of coordination complexes
- To impart the basic knowledge on Atomic states, microstates and term symbol
- Understand orgel and Tanabe Sugano diagrams for prediction of absorption band
- Illustrate different types of nuclear models and their features
- Describe nuclear reactions and their energies
- Study the applications of nuclear chemistry in various fields

Expected Course Outcomes (CO):

On the successful completion of the course, student will be able to:

	Understand and compare different theories involve in thecoordination complexes	K1-K2
	Interpret the electronic and magnetic properties of coordination compounds based on CFT	K2-K4
	Knowledge on the modern M. O theory and its application in conscious understanding of bonding of metal complexes	K2-K5
	Calculate nuclear spin, I value of elements	K3-K4
	Differentiate different nuclear reactions and to determine activity by various techniques	K5-K6

K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 – Create

UNIT:1	STRUCTURAL ASPECTS AND CRYSTAL FIELD THEORY	15 hours

Crystal field theory - crystal field splitting patterns in octahedral, tetrahedral, tetragonal, square planar, geometries – CFSE, Factors affecting CFSE– Interpretation of electronic spectra and magnetic properties – Spectrochemical series – Jahn-Teller effect; Effect of chelation and stability of complexes – Thermodynamic aspects of complex formation –Determination of stability constants by spectrophotometric, polarographic and potentiometric methods – Hard and soft acids and bases

UNIT:2	MOLECULAR ORBITAL THEORY	15 hours

Theoretical failure of the Crystal Field Theory - Nephelauxetic effect - Evidences for the metal-ligand orbital overlap; the ligand field theory; Molecular Orbital - application of group theory to tetra coordinate and hexa coordinate systems - M.O. theory as applied to non-bonding and anti-bonding complexes – Calculation of Dq, B and β parameters. Colour of transition metal complexes, types of electronic spectra - d-d transition, Charge transfer spectra, selection rule and its relaxation, Term states for dn ions, energy diagram, - Orgel and Tanabe- Sugano diagrams – Spin-Orbit coupling

UNIT:3	NUCLEAR CHEMISTRY	15 hours

Models of nucleus – Modes of radioactive decay: orbital electron capture: nuclear isomerism, internal conversion, Nuclear reaction: Types, reactions, cross section, Q- value, threshold energy, compound nucleus theory, High nuclear reactions, nuclear fission and fusion reactions as energy sources; direction reactions, photonuclear and thermo nuclear reactions, detection and determination of activity by cloud chamber, nuclear emulsion, bubble chamber, G.M counter – Scintillation and Cherenkov counters. Application of radioactivity in the chemistry- medical field, age determination and in agriculture, Neutron activation analysis, isotopic dilution analysis, radiometric titrations, Nuclear reactors, the breeder reactor, nuclear reactors in India

Contemporary Learning **15 hours**

Expert lectures, YouTubes Videos, Animations, NPTEL, MOOC videos, online seminars – webinars for strengthening the subject matters. Assignment and class room seminar

	Total Lecture hours	45 hours

Text Book(s)

1.	F.A. Cotton & G. Wilkinson - Advanced Inorganic Chemistry, 3rd and 4th Ed., John Wiley
2.	Huheey, J.W. - Inorganic Chemistry, 4th Edition - Harper and Row
3.	J. D. Lee, Concise Inorganic Chemistry, 5th edition, John Wiley
4.	A. K. Das Vol. 1 & 2, Fundamentals of Inorganic Chemistry
5.	Gregory R Choppin; Jan-Olov Liljenzin; Jan Ryd berg, Radiochemistry and Nuclear Chemistry, 3rd Edition, 2002, Butterworth-Heinemann

Reference Books

1.	K.F. Purcell & J.C. Kotz - Inorganic Chemistry, Saunder Company
2.	S.F.A. Kettle - Coordination Compounds
3.	B.N. Figgis - Introduction to Ligand Fields
4.	A.B.P. Lever - Inorganic Electronic Spectroscopy, Elsevier
5.	C.J. Balehausen - Introduction to Ligand Field Theory, McGraw Hill, 1962.
6.	G. Friedlander, G. Herrmann (auth.), Attila Vértes, Sándor Nagy, Zoltán Klencsár, Rezső G. Lovas, Frank Rösch (eds.), Hand Book of Nuclear Chemistry, 2011, springers

	Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]
1.	Coordination complexes : http://www.infocobuild.com/education/audio-video-courses/chemistry/CoordinationChemistry-IIT-Kharagpur/lecture- 18.html
2.	Nuclear shell model: YouTube Videos: https://nptel.ac.in/courses/115/104/115104043/
3.	GM counters lecture Notes: https://qa.ff.up.pt/rq2020/Bibliografia/etc/geiger1.pdf

Mapping with Programme Outcomes*										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	M	S	M	S	M	S	L	M	L	L
CO2	S	S	S	S	S	M	L	M	L	L
CO3	M	M	S	S	M	M	L	S	M	L
CO4	S	S	S	S	S	S	M	S	L	L
CO5	S	S	L	M	M	L	S	L	M	L

*S-Strong; M-Medium; L-Low

Course Code	**CHE C201**
Title of the Course	**STEREOCHEMISTRY AND ORGANIC REACTION MECHANISM**
Course	**Core Credit- 3**
Pre-requisites, if any	Students should know about the fundamental aspects on stereochemistry, electrophilic and nucleophilic substitution reactions.
Course Objectives	• Realize the significance and relevance of stereochemistry • Role of electrophilic as well as nucleophilic substitution reaction in organic synthesis • Realize the concept of selectivity in organic transformations • Understand the concept of reaction mechanism • To visualize the concept of substitution Vs reactivity
Course Outcomes	On the successful completion of the course, student will be able to:
CO 1	Learn about different aspects involved in stereochemistry and the relevance of the topic in all branches including biology (K1-K5)
CO 2	Understand the basic concept and origin of asymmetric synthesis (K2-K4)
CO 3	Learn about the significance of reaction intermediates and the rate of the reaction (K3-K5)
CO 4	Selectivity and synthetic utility of substitution reactions (K2-K6)
CO 5	Understand the relevance of conformation and reactivity in organic synthesis (K5 & K6)
K1-Remember; **K2**-Understand; **K3**-Apply; **K4**-Analyze; **K5**-Evaluate; **K6**-Create	

Unit I	**STEREOCHEMISTRY**	**15 hours**

Chirality, Symmetry elements, Asymmetric and Dissymmetric chiral molecules. Calculation of number of optical isomers. Stereochemistry of mono and di-substituted cyclopropane, cyclobutane, cyclopentane and cyclohexane. Stereochemistry of tri-substituted cyclopentane, tri-substituted pentane and tetra-substituted hexane. Description of various types of optically active compounds including allenes, cumulenes, spiranes, biphenyls, *trans*-cyclooctene, Ansa compounds cyclophanes and helicenes.

Compounds containing two asymmetric centers-Erythro and threo isomers. Conversion of Fischer projection into perspective forms. Erythro and Threo-Inter conversion of Fischer to Sawhorse and Newman projections. Zig-Zag representation of glucose. Interpretation of homotopic, enantiotopic and diastereotopic atoms and faces. Origin of *Re*- and *Si*-faces. Prochiral chiral carbon. R & S nomenclature of simple compounds, allenes, spiranes, biphenyls, Ansa compounds and cyclophane systems. Optical rotation and enantiomeric excess (ee). Stereospecific and Stereoselective reactions.

Asymmetric Synthesis-Crams rule and Felkin Anh Model. Conformational analysis of cyclohexane and di-substituted cyclohexanes.

Unit II	ALIPHATIC NUCLEOPHILIC SUSBTITUTION	15 hours
Mechanism of nucleophlic substitution reaction: SN^1, SN^2 and SN^i mechanisms. Substrate, Nucleophiles, Solvent and leaving group effects and neighboring group participation (NGP). Substitution at carbonyl, vinylic and bridgehead system. Substitution with ambident nucleophiles: "O" Vs "C" alkylation. Role of LDA, crown ethers and phase transfer catalysts (PTC) in nucleophilic substitution reactions. Generation of enolates, enolate selectivity (Kinetic Vs Thermodynamic), alkylation of enolates and stereochemistry of enolate alkylation. Mechanism of ester hydrolysis		
Unit III	**AROMATIC ELECTROPHILIC & NUCLEOPHILIC SUSBTITUTION REACTIONS**	**15 hours**
Aromatic electrophilic substitution: mechanism of nitration, sulfonation, Friedel-Crafts alkylation and acylation reactions. Synthesis of di- and tri- substituted benzenes from benzene or mono-substituted benzenes. Haworth reaction (for naphthalene), Scholl reaction, Vilsmeier-Haack formylation, Gattermann reaction, Reimer-Tiemann and Bischler-Napieralski reactions. Aromatic nucleophilic substitution in aryl halides by Meisenheimer complex mechanism and benzyne mechanism. Various methods of benzyne generation and reactions of benzynes (inter and intramolecular). Reactions of aryldiazonium salts. Zeigler alkylation, Vicarious Nucleophilic Substitution (VNS), Chichibabin and Schiemann reactions. Hammett and Hammett-Taft equation-Significance of reaction constant (ρ) and substituent constant (σ). Methods of determining reaction mechanism.		
Contemporary Learning		**15 hours**
Expert lectures, YouTubes Videos, Animations, NPTEL, MOOC videos, online seminars – webinars for strengthening the subject matters. Assignment and class room seminar		
	Total lecture hours	**45 hours**
Recommended Text/Reference Books	• Carey, F. A & Giuliano, R. M. (2012); Organic Chemistry 8th Edition, McGraw Hill (I) Pvt Ltd • Bruice, P. Y. (2014); Organic Chemistry, 7th Edition, Dorling Kindersley (I) Pvt Ltd • Wade, Jr, L. G. & Singh, M. S. (2008); Organic Chemistry 6th Edition, Dorling Kindersley (I) Pvt Ltd • Finar, I. L. Vol 2 (2018); Organic Chemistry: Stereochemistry and the Chemistry of Natural product, IIIrd Edition, Pearson • Smith, M. B & March, J. (2006); March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure, 6th Edition, John Wiley & Sons, Inc. • Kalsi, P. S & Oza, R. S. (2018); Organic Reactions: Stereochemistry and Mechanism, New Age International • Clayden, J, Greeves, N. Warren, S. (2017); Organic Chemistry, 2nd Edition, Oxford University Press. • Graham Solomons, T. W, Fryhle, C. B. (2014); Organic Chemistry, 10th Edition, Wiley.	

Methods of assessment:

Recall (K1) – Simple definitions, MCQ, Recall steps, Concept definitions **Understand/ Comprehend (K2) –** MCQ, True/False, Short essays, Concept explanations, Shortsummary or overview

Application (K3) – Suggest idea/concept with examples, Suggest formulae, Solve problems,Observe, Explain

Analyse (K4) – Problem-solving questions, Finish a procedure in many steps, Differentiatebetween various ideas, Map knowledge

Evaluate (K5) – Longer essay/ Evaluation essay, Critique or justify with pros and cons **Create (K6) –** Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations

Mapping with Programme Outcomes*

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	L	M	M	S	S	M	M	M	L	M
CO2	M	M	M	S	S	M	M	M	L	L
CO3	L	L	M	S	S	M	S	L	L	M
CO4	L	M	L	S	M	M	L	M	L	L
CO5	L	L	M	S	M	M	M	L	L	L

***S-Strong M-Medium L-Low**

Core/ Elective/ Supportive	Course Code	Title of the Course	Credits
Core	**CHE C301**	**THERMODYNAMICS, ELECTROCHEMISTRY AND CHEMICAL KINETICS**	**3**

Course Objectives:

The main objectives of this course are,

- To provide basics and knowledge related to thermodynamics in terms of system, chemical potential and phase equilibria.
- To understand theories and principles of electrochemistry in terms of electrolytic conductance, electrode equilibrium and electromotive force.
- To learn kinetic theories and factors affecting reaction rates, complex reactions, fast reactions and adsorption reactions.
- To correlate and apply the fundamental knowledge in thermodynamics, electrochemistry and chemical kinetics to different areas of chemistry and emerging problems in basic science.
- To demonstrate the ability to do some independent research and use some experimental resources at the end of the course.

Pre-requisites, if any:

Students should know the UG level fundamental aspects on thermodynamics, electrochemistryand chemical kinetics along with problems solving.

Course Outcomes:

After completion of this course successfully, the students will be able to..

- **CO1:** Recall basics of thermodynamics, electrochemistry and chemical kinetics. (**K1**)
- **CO2:** Understand the relationships of thermodynamics, electrochemistry and chemical kinetics in chemical reaction dynamics. (**K2**)
- **CO3:** Apply the knowledge of thermodynamics, electrochemistry and chemical kinetics to different areas of chemistry. (**K3**)
- **CO4:** Analyze and Evaluate research problems in thermodynamics, electrochemistry and chemical kinetics. (**K4** and **K5**).
- **CO5:** Create new concepts to give contribution to dimensional growth for thermodynamics, electrochemistry and chemical kinetics. (**K6**)

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6**– Create

UNITS

UNIT - I: Kinetic Theory and Thermodynamics (9 Hours)

Thermodynamic description of various types of process, Laws, state and path function Second law of thermodynamics, Maxwell's relations and thermodynamic equations of state, (CP- CV) in terms of coefficient of expansion and coefficient of compressibility.

Closed and open systems, partial molal quantities and experimental determination, chemical potential, Gibbs-Duhem and Gibbs-margules equation, variation of chemical potential with temperature and pressure.

Real systems, fugacity and activity, activity coefficients and their electrochemical and graphical determination, standard states for gases, liquids, solids and solutions, Lewis – Randall rule and its applications.

(1)

UNIT - II: Electrochemistry-I (10 Hours)

Nernst Equation, Redox System, Electrolytic conductance of Kohlrausch's law and it is Applications. Theory of electrolytic dissociation – ionic activity and activity coefficients, Debye

-Huckel-Onsagar theory of interionic attraction and its refinements. Influence of ionic atmosphere on the conductivity of electrolytes, equation for the equivalent conductivity of electrolytes – Experimental verification of the equation. Electrode equilibrium - Thermodynamics, electrodes and electrode potentials, electrochemical cells, electromotive force.

UNIT - III: ELECTROCHEMISTRY-II (8 Hours)

Polarization and overpotential – concentration polarization – Polarography. Electrochemical polarization – Butler – Volmer equation for one electron transfer reaction and Tafel equations. Ionic equilibria – conductometric and potentiometric titrations.

UNIT - IV: Chemical Kinetics (10 Hours)

Mechanisms of complex reactions – equilibrium and steady state approximation; Theories of reaction rates - collision theory, transition state theory and its thermodynamic aspects - enthalpy, entropy and free energy of activations; Kinetics of complex reactions - opposing, parallel and consecutive reactions; Unimolecular reactions; Kinetic isotopic effects; Salt effects; Potential energy surfaces and reaction coordinates. Factors determining reaction rates in solution - solvent, dielectric constant and ionic strength; Fast reactions - T-jump, flow methods, pump-pulse, relaxation methods.

UNIT – V: Adsorption and Colloids (8 Hours)

Langmuir, Freundlich, BET and Gibbs adsorption isotherms; Surface films; Homogeneous and Heterogeneous catalysis; Reactions on surfaces - Simple decomposition, Bimolecular reactions by Langmuir-Hinshelwood and Eley-Rideal mechanisms.

Surface tension, viscosity. Self-assembly. Physical chemistry of colloids and micelles.

Contemporary Learning 15 hours

Expert lectures, YouTube Videos, Animations, NPTEL, MOOC videos, online seminars – webinars for strengthening the subject matters. Assignment and class room seminar

Total Lecture hours 45 hours

Reference Books:

1. Thermodynamics for chemists, S. Glasstone, Affiliated East West
2. Chemical Thermodynamics, I. M. Klotz and R. M. Rosenberg, Benjamin, Menlo Park, 1972.
3. Thermodynamics, J. C. Kuriakose, J. Rajaram.
4. An Introduction to Electrochemistry, S. Glasstone, An East West Edition.
5. Modern Electrochemistry Vol. I J. O' M Bockris and A. K. N. Reddy, Plenum, New York, 1970.
6. Theoretical Electrochemistry, LI. Antropov, Mir. Publication.

7. Chemical Kinetics, K. J. Laidler, 2nd Ed, McGraw Hill.
8. Kinetics and mechanism, John. W. Moore, Ralph. G. Pearson, 3rd Ed, Wiley, 1981

Text Books:

1. Physical Chemistry, G. M. Barrow, 4 th Ed., McGraw Hill.
2. Physical Chemistry, P. W. Atkins, 4 th Ed., Oxord.

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]

1. https://www.youtube.com/watch?v=S73srEM_4QA&list=PL9m2Lkh6odgK6pbaO7Yddu_jPzYlK8OM5
2. https://www.youtube.com/watch?v=yrnQTAc_S8o
3. https://www.youtube.com/watch?v=PH1DR0c-jqw
4. https://www.youtube.com/watch?v=dNkDAgg9MUY
5. https://www.youtube.com/watch?v=pm3HpBfooMA

https://www.youtube.com/watch?v=XaId7WR0mGo

Mapping with Programme Outcomes: (S-Strong, M-Medium, L-Low)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	S	S	M	L	M	M	S	S	S	M
CO 2	M	S	S	M	S	L	M	L	S	M
CO 3	M	M	L	S	S	M	M	S	S	S
CO 4	M	S	L	S	M	M	L	S	L	M
CO 5	S	M	M	S	M	L	L	M	S	S

Course Code	**CHE C202**
Title of the Course	**ORGANIC CHEMISTRY PRACTICAL - I**
Course	**Core Credit- 3** **60 hours**
Pre-requisites, if any	Students should know the basic techniques used in the organic laboratory for preparation, purification and identification of organic compounds.
Course Objectives	• To understand the basic techniques used in organic laboratory for preparation and purification of organic compounds • To compare theory with experiment by performing preparation of organic compounds • To understand the reaction mechanism and intermediates involved in organic reaction. • Able to visualize the organic transformations in the reaction flask.
Course Outcomes	On the successful completion of the course, students will acquire knowledge of:
CO 1	Good laboratory practices in handling laboratory glasswares and chemicals (K1-K6)
CO 2	To gain experience in the maintenance laboratory notebook (K2-K4)
CO 3	Well versed with common laboratory techniques such as reflux, recrystallization, vacuum filtration, aqueous extraction and melting point determination (K2-K5)
CO 4	To understand the difficulties involved in the preparation of organic compounds (K1-K5)
CO 5	Understand the differences in theory and practical concept (K4-K6)

K1-Remember; **K2**-Understand; **K3**-Apply; **K4**-Analyze; **K5**-Evaluate; **K6**-Create

Unit I

Single Stage Preparations

1. Preparation of *p*-benzoquinone
2. Preparation of 2,5-ditertiarybutylhydroquinone
3. Preparation of 4,6-dimethylcoumarin
4. Preparation of dibenzyllidene acetone
5. Preparation of 2,4-dinitrotoluene
6. Preparation of benzhydrol
7. Preparation of picric acid

Unit II

Double Stage Preparations

1. Preparation of *p*-bromoaniline from acetanilide
2. Preparation of *p*-nitroaniline from acetanilide
3. Preparation of *m*-nitrobenzoic acid from methylbenzoate
4. Preparation of symmetric tribromo benzene and 2,4,6-tribromo iodo benzene from aniline

Reading List (Print and Online)	• https://www.youtube.com/watch?v=1oO-fQvMrkE • https://www.youtube.com/watch?v=oROSQnzSdZE
Recommended Text/Reference Books	• Vogel, A.I.; Tatchell, A. R.; Furnis, B. S.; Hannaford, A. J.; Smith, P.W.G. (2003); Vogel's Textbook of Practical Organic Chemistry, 5th Edition, Pearson Education

Method of Evaluation:

Internal (Continuous Assessment)	End Semester Examination	Total	Grade
60	40	100	A, A+, B, D, D+, O

Methods of assessment:

Recall (K1) – Simple definitions, MCQ, Recall steps, Concept definitions **Understand/ Comprehend (K2) –** MCQ, True/False, Short essays, Concept explanations, Short summary or overview

Application (K3) – Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain

Analyse (K4) – Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge

Evaluate (K5) – Longer essay/ Evaluation essay, Critique or justify with pros and cons **Create (K6) –** Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations

Mapping with Programme Outcomes*

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	L	M	M	M	M	M	M	M	M	S
CO2	M	L	M	M	M	M	M	M	L	L
CO3	M	M	M	L	S	M	L	L	M	M
CO4	L	M	L	M	M	L	M	M	L	L
CO5	M	M	M	M	M	L	M	L	L	L

***S-Strong M-Medium L-Low**

Core/ Elective/ Supportive	Course Code	Title of the Course	Credits
Core	**CHE C302**	**PHYSICAL CHEMISTRY PRACTICAL – I**	**3**

Course Objectives:

The main objectives of this course are,

- To provide experimental knowledge on adsorption isotherm and heat of neutralization.
- To understand the applications of conductivity experiments to determine solubility product, neutralization point, weak and strong electrolyte behavior.
- To recognize the applications of EMF measurements to determine pH of a solution and solubility product.
- To demonstrate the reaction kinetics of ester hydrolysis, simple eutectic system and equilibrium in solutions.
- To develop the ability to do some independent experiments and learn recent developments in the related experiments at the end of the course.

Pre-requisites, if any:

Students should know the UG level fundamentals of physical chemistry practicals like solution preparation, normality, molarity, solution dilution, etc.

Course Outcomes:

After completion of this course successfully, the students will be able to..

- **CO1:** Recall the basics and practices of physical chemistry practicals. **(K1)**
- **CO2:** Understand the experimental aspects of different areas of physical chemistry. (**K2**)
- **CO3:** Apply the knowledge of experimental physical chemistry to existing and emerging problems in basic sciences. (**K3**)
- **CO4:** Analyze and Evaluate the research problems in different areas of physical chemistry. (**K4** and **K5**).
- **CO5:** Create new concepts to expand the dimensions of the experimental physical chemistry. (**K6**)

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Experiments (60 Hours)

1. Adsorption- verification of Freundlich adsorption isotherm
2. Thermo chemistry – heat of neutralization of a strong acid
3. Conductivity
   (a) Cell constant determination
   (b) Solubility product of a sparingly soluble salt
   (c) Acid – base titration (strong acid vs strong base; strong base vs weak acid) ,precipitation titration (barium chloride vs magnesium sulphate)
   (d) Dissociation constant of a weak acid- verification of Ostwald's dilution law
   (e) Verification of Onsager equation- strong electrolyte
4. EMF
   a) Determination of buffer and pH-quinhydrone electrode- Henderson's relation
   b) Determination of solubility product of sparingly soluble AgX type salts.

5. Reaction kinetics

   Hydrolysis of ester- comparison of strength of acids, determination of hydrolysis constant.

6. Phase rule and thermodynamics Simple eutectic

7. Equilibrium in solutions

   a) Association factor of benzoic acid in benzene and water

   b) KI + I2 = KI3. Equilibrium constant in aqueous media

Text Books:

1. D.P. Shoemaker and C.W.Garland, Experiments in Physical Chemistry, McGraw Hill, 1962.
2. Findlay's Practical Physical Chemistry, Longman, 1954
3. An Introduction to Electrochemistry, S. Glasstone, an East West Edition.

Mapping with Programme Outcomes: (S-Strong, M-Medium, L-Low)

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
CO 1	S	M	S	M	M	S	S	L	M	S
CO 2	M	M	M	M	S	M	M	S	M	L
CO 3	S	S	S	L	M	L	S	S	L	M
CO 4	M	S	S	S	M	S	L	M	S	M
CO 5	M	S	M	S	M	L	M	S	M	S

Course code	UOMS115	SOFT SKILL	Credit - 2
Core/Elective/Supportive		Laboratory Safety Skills	
Pre-requisite		Students should have an idea about science laboratories	

Course Objectives:

The main objectives of this course are to:

- To train the student how to work safely in the lab and protect others
- To outline the organization of a chemistry laboratory
- To state the role of MSDS and universal precautions for disposal and handling of hazardous chemicals

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1.	To work in a lab safely and prevent human accidents	K1-K4
2.	To practice best lab practices	K2-K4
3.	Student should know how to design a safe chemistry lab	K3-K4
4.	Knowledge of Material Safety Data Sheet (MSDS) and handling of harmful chemicals	K2-K5
5.	Setting up and handling clean room facilities	K5& K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1	Lab safety	10 hours

Chemistry lab layout and safety procedures practiced in the Chemical laboratory that pertain to general laboratory safety and awareness including eye shower to fume hoods.

Safety kits, devices, uses and storage. SOP for personal safety.

Unit:2	Universal precautions	10 hours

Material Safety Data Sheet (MSDS), chemical, radiation, fire, electrical and gas safety; Clean room facility Universal Precautions and its importance in the handling of hazardous chemicals in the lab; handling radioactive materials and biohazardous materials

	Contemporary Learning	10 hours

Expert lectures, You Tubes Videos, Animations, NPTEL, MOOC videos, online seminars – webinars for strengthening the subject matters.

	Total Lecture hours	30 hours

Text Book(s)

1	Laboratory Safety Theory and Practice 1st Edition Anthony Fuscaldo December 1980
2	The Foundations of Laboratory Safety Stephen R. Rayburn 1990 Springer-Verlag New York

Reference Books

1	Prudent practices in the laboratory: handling and management of chemical hazards, updated version. National Academies Press, 25-Mar-2011 - Science - 360 pages

2	Guidelines for Chemical Laboratory Safety in Academic Institutions American Chemical Society Washington, DC 2016.
3	Guidelines for Laboratory Design: Health, Safety, and Environmental Considerations, Fourth Edition Louis 15 March 2013 John Wiley & Sons, Inc.

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1.	https://youtu.be/qrUja_ILrOI - Material safety Data Sheet
2.	https://youtu.be/FD2hXZjgcEM- Problems related to safety and loss statistics
3.	https://youtu.be/8queMM7VVfw- Chemical Hazards / Lab Safety
3.	https://youtu.be/GjAD83B4JaY-PPE and Lab Safety
4.	https://youtu.be/ICz1GUQoiAQ-Fire Extinguishers
Course Designed By: Dr. Deepa P Nambiar and Dr. K. Venkatachalam	

Mapping with Programme Outcomes*

COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	L	M	S	S	S	M	S	S
CO2	S	S	S	S	S	S	S	S	S	S
CO3	S	S	S	S	M	S	S	M	S	S
CO4	S	S	S	S	M	S	S	S	S	S
CO5	M	S	M	S	L	M	S	M	S	S

*S-Strong; M-Medium; L-Low

Course code	CHE E001	ELECTRONICS, COMPUTERS AND COMPUTER PROGRAMING FOR CHEMISTS
Core/Elective/Supportive		Elective Credit-3
Pre-requisite		Student must have an awareness about computers and electronics

Course Objectives:

The main objectives of this course are to:

- To understand the working of electronic components used in instruments
- To outline the organization and working of a computer
- To state the development and requirements of programing languages
- To introduce modern concepts in computer science
- To critically access the application of computer programming languages in chemistry applications.

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1.	Student can operate the computer and install hardware and software without any assistance.	K1-K4
2.	They will be able to identify the electronic parts and accordingly maintain them	K2-K4
3.	Possess working knowledge of how to develop computer programs	
4.	They will be able to choose the required programming language to write a program for their chemistry application.	K2-K5
5.	They will be able to develop new programs for their chemistry requirements.	K3-K4
6.	Can evaluate new software developed for chemistry applications	K5 & K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1	BASIC ELECTRONICS AND COMPUTERS IN CHEMISTRY	15 hours

Basic electronics – Resistors, capacitors, transistors, operational amplifiers, integrated circuits, integrators, differentiators, rectifiers and battery eliminators, signal to noise ratio, optimization and limit of detection.

Computers in chemistry - Basic structure of a computer – input / output devices, memory and storage systems, central processing unit, peripherals, computer codes and arithmetic, binary number systems – floating point representation, floating point arithmetic, computational errors.

Unit:2	COMPUTER PROGRAMING	15 hours

Computer Programing: Principles and techniques of programming, High and low level languages, operating systems, algorithms essentials of BASIC. C, C++, Java, Visual Basic, Fortran, Pascal, SQL

Unit:3	PROGRAMS FOR CHEMIST	15 hours

Concepts of Python, Cloud computing, Artificial Intelligence

Programs for chemist – pH calculations – monobasic and polybasic acid systems, buffers, XRD – peak interpretation, conductometry, potentiometry, equilibrium constants, solubility products, standard deviation, F and t tests, regression analysis, half-wave potential calculations.

	Contemporary Issues	15 hours

Expert lectures, YouTubes Videos, Animations, NPTEL, MOOC videos, online seminars – webinars for strengthening the subject matters.

	Total Lecture hours	45 hours

Text Book(s)	
1	Principles of Instrumental Analysis – Skoog and Leary, IV Edition, Saunders College Publishing, 1992.
2	Text book of Quantitative Inorganic Analysis – A.I. Vogel, ELBS, III Edition, 1976, and IV Edition, 1985
3	Electronic Principle – A.P. Malvino, PMH Publishers, III Edition, 1984.
4.	BASIC Programming for Chemists – Peter C. Jurs, T.L. Isenhour and C.L. Wilkins, John Wiley and Sons, 1987
5.	Vogel's Text Book of Quantitative Chemical Analysis – A.I. Vogel, Pearson Education Ltd, VI Edition, 2001.
Reference Books	
1	Instrumental Methods of Analysis – Willard, Merit, Dean and Settle, CBS Publ.& Distributors, VI Edition, 1986
2	BASIC Programming – B.J. Holmes, Galgotia Book source Pub., 1983.
3	Programming for BASIC – M. Subramanian, A.H. Wheeler and Co. Pvt, Ltd., II Edition, 1987.
4	Programming and Computing with Fortran IV - K. P. Sharma, Affiliated East-West Press, Pvt. Ltd., 1976
5	Principles of Instrumental Analysis – Skoog, Holler & Nieman, Saunders College Publishing, V Edition, 2000
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1.	An Introduction to Programming through C++ https://youtu.be/efXI8anQwXo
2.	An Introduction to Artificial intelligence https://youtu.be/GHpchgLoDvI
3.	https://youtu.be/woVJ4N5nl_s-Phyton Basics
3.	https://youtu.be/JMUxmLyrhSk-Artificial Intelligence
Course Designed By: Dr. T.M. Sridhar	

Mapping with Programme Outcomes*

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	L	M	L	S	L	M	S	S	L	L
CO2	M	M	M	L	L	L	M	M	L	M
CO3	S	S	S	M	M	S	S	S	M	M
CO4	M	M	S	S	S	S	L	M	M	S
CO5	S	L	S	S	S	L	S	S	S	S

*S-Strong; M-Medium; L-Low

Semester-I	CHE E101	INORGANIC REACTION MECHANISM
Core/Elective /Supportive	**Elective**	**Credit-3**
Pre-requisite	Students should aware about basic knowledge of formation of metal ligand complexes, bonding and geometries and stabilities. Student should also know the basics of chemical bonding including metal carbon bond formation.	

Course Objectives:

The main objectives of this course are to:

- Describe the efforts of inorganic and organometallic chemists to apply old principles and develop new ones in an incredible set of contexts
- Illustrates how ligands influence the stability, structural and reactivity properties of central metal atoms
- Describe various reaction pathways for mechanism of formation of various geometrics of metal ligand complexes
- Give knowledge on the theory of electron transfer process from simple molecules to complex molecules
- Understand various theory on the stability of organometallic compounds and their reactivity with nucleophile and electrophilic compounds

Expected Course Outcomes (CO):

On the successful completion of the course, student will be able to:

1	Know most common and important futures of oxidation of metals complexes and its lability and inertness in the aspect of kinetics and thermodynamic of the coordination complexes	K1-K2
2	Understand the formation of metal complexes bonding and to able to study the various reaction mechanism involved in inorganic complex along with trans influence of ligands	K2-K5
3	Gain more knowledge on the electron transfer/redox reactions in various metal complexes and understand the Marcus-Hush theory, to become familiar with some applications of photochemical reaction of coordination compounds	K3-K5
4	Comprehend the potential new ligands and predict the binding affinity to its target	K2-K4
5	Able to elucidate the different types of application in metal complexes and its reaction mechanism of different metal complex concerned reactions in organometallic chemistry	K3-K6
	K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 – Create	

UNIT:1	INERT AND LABILE METAL CHEMISTRY	15 hours
Reactivity of metal complexes – Inert and labile complexes – Explanation of lability on the basis of valence bond and crystal field theories – Metal ion catalysed reactions and reaction mechanism, induced reactions and their characteristics, applications – kinetics and mechanism of induced reaction in metal complexes, – Stabilization of unusual oxidation states in solution – Survey of oxidation states with various electronic configuration of transition metals and inner-transition metals		
UNIT:2	**SUBSTITUTION REACTIONS IN COORDINATION COMPLEXES**	**15 hours**
Reaction pathways – mechanisms of substitutions in octahedral complexes – Dissociative (D), Associative (A), and Interchange (I) mechanisms – Aquation (acid hydrolysis) – Acid catalyzed aquation reactions, Anation reactions. Base hydrolysis, CB mechanism in octahedral complexes – Substitution reactions in square planar complexes, trans effect, theories and applications – Isomerisation and racemisation reactions of coordination complexes; Electron transfer reactions or redox reactions– two electron transfer reactions, Inner sphere and outer sphere processes, electron exchange reactions, complementary reactions and non complementary reactions, Marcus-Hush theory and photochemical reactions		
UNIT:3	**BASIC CONCEPTS OF ORGANOMETALLIC COMPOUNDS AND REACTION MECHANISM**	**15 hours**
Definition of Electron counting–Types of ligands and their classifications in organometallic compounds, Hapto-nomenclature –16 and 18 electron rule and its limitations – Metal carbonyls – Metal π-cyclic compounds; Oxidative addition, reductive elimination, insertion migration and rearrangement –salient features and evidences, ligand protonation, electrophilic and nucleophilic attack on ligands – C-H activation -ortho metalation and cyclometalation, Fluxional behaviour of metal complexes		
	Contemporary Learning	**15 hours**
Expert lectures, YouTubes Videos, Animations, NPTEL, MOOC videos, online seminars – webinars for strengthening the subject matters. Assignment and class room seminar		
Total Lecture hours		**45 hours**

Text Book(s)

1.	Huheey, J.E. - Inorganic Chemistry, 4th Edition, Harper and Row
2.	Basolo, F. and Pearson, R.G. - Mechanism of Eastern Inorganic Reactions, Wiley
3.	Purcell, K.F. and Kotz, J.C. - Inorganic Chemistry, Saunders
4.	D.F. Shriver and P.W. Atkins, Inorganic Chemistry, Oxford University Press, 5th Edition, 2010
5.	J. D. Lee, Concise Inorganic Chemistry, Oxford University Press, 5th Edition, 2014
6.	F.A. Cotton and G. Wilkinson Advanced inorganic Chemistry, John Wiley & Sons, 6th Edition, 1999

	Reference Books
1.	Nyholm, R.S. and Tobe M.L., - The stabilisation of oxidation state of the Transition metals, Advances in Inorganic and Radiation Chemistry, Volume 5 (1963)
2.	(a) J. Hartwig, Organotransition Metal Chemistry: From Bonding to Catalysis, University: Science Books, Sausalito, CA, 2010
3.	G. L. Miessler, P. J. Fischer, D. A. Tarr, Inorganic Chemistry, 5th edn, Pearson, Upper Saddle River, NJ, 2014
4.	R. H. Crabtree, The Organometallic Chemistry of the Transition Metals, Vol. 4, John Wiley & Sons, Inc., Hoboken, NJ, 2005
	Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]
1.	https://www.youtube.com/watch?v=ez40OIQrP60
2.	https://www.dalalinstitute.com/wp-content/uploads/Books/A-Textbook-of-Inorganic-Chemistry-Volume-1/ATOICV1-3-1-Inert-and-Labile-Complexes.pdf
3.	https://link.springer.com/chapter/10.1007%2F978-1-4419-9276-5_6
4.	https://www.schoollearningresources.com/PDF/_Lectures%208-10(1).pdf

Mapping with Programme Outcomes*										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	M	S	M	S	M	S	L	M	L	M
CO2	S	S	L	S	S	M	L	M	L	L
CO3	S	M	S	M	L	M	L	S	M	L
CO4	S	S	L	S	S	S	M	S	L	S
CO5	S	S	S	M	M	L	S	L	L	L

*S-Strong; M-Medium; L-Low

Course	**Elective (I)**
Course Code	**CHE E201**
Title of the Course	**NAME REACTIONS IN ORGANIC CHEMISTRY**
Credits	**3**
Pre-requisites, if any	Students must have known about the basic organic name reactions.
Course Objectives	• To understand new carbon-carbon formation by name reactions • To understand the heterocycle synthesis through name reactions • To study the significances of name reaction in organic synthesis • Importance of substitution reaction and their synthetic utilities
Course Outcomes	On the successful completion of the course, students will acquire knowledge of:
CO 1	Design and syntheses of organic molecules based on name reaction (K2- K5)
CO 2	Understand the mechanism involved in organic name reactions (K1-K4)
CO 3	Understand key intermediates involved in organic name reactions (K1- K4)
CO 4	Understand functional group transformations and reactivity in organic name reactions (K2-K4)
CO 5	Explore synthetic utility of name reactions in organic synthesis (K3-K5)

K1-Remember; **K2**-Understand; **K3**-Apply; **K4**-Analyze; **K5**-Evaluate; **K6**-Create

Unit I	**15 hours**
Carbon-Carbon bond formation reactions-Perkin, Knovenagel, Wittig, Wittig-Horner, Vilsmeier Haack, McMurray, Glacer, Mannich, Pschorr, Simmons-Smith and Thorpe reactions**.**	
Unit II	**15 hours**
Heterocycle forming reactions-Paal-Knorr synthesis of pyrroles; Hantsch synthesis of pyridines, Madelung, Reissert and Bischler synthesis of indole**;** Skraup, Friedländer , Doebner-Miller and Konard-Limpatch synthesis of quinoline. Pomerantz-Fritsch synthesis of isoquinoline. **.**	
Unit III	**15 hours**
Name reactions on substitution and substituents-Chichibabin reaction, Eschweiler Clark reaction, Polonowski reaction, Reissert reaction, Sommlett reactions, Mitsunobu reaction, Leukart reaction, Bucherer reaction, Willegerodt reaction and Willegerodt-Kindler reaction.	
Contemporary Learning	**15 hours**
Expert lectures, YouTubes Videos, Animations, NPTEL, MOOC videos, online seminars – webinars for strengthening the subject matters. Assignment and class room seminar	
Total Lecture hours	**45 hours**

Reading List (Print and Online)	• https://nptel.ac.in/courses/104/103/104103110/ • https://nptel.ac.in/courses/104/105/104105034/ • https://nptel.ac.in/courses/104/101/104101115/
Recommended Text/Reference Books	• March, J. (2007); Advanced Organic Chemistry, 6th Edition, Wiley • Carey, F. Sundberg R. J. Advanced Organic Chemistry-Part A and B- 5th Edition, Springer • Clayden, J, Greeves, N, Warren, S. (2012); Organic Chemistry, 2nd Edition, Oxford

Mapping with Programme Outcomes*

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	L	M	M	S	M	M	M	M	L	L
CO2	L	L	M	S	M	M	M	M	M	L
CO3	M	M	M	S	M	M	S	L	L	M
CO4	L	M	L	M	M	L	M	M	L	L
CO5	M	M	M	M	M	L	M	L	L	L

***S-Strong M-Medium L-Low**

Core/ Elective/ Supportive	Course Code	Title of the Course	Credits
Elective	**CHE E301**	**ESSENTIALS OF STATISTICAL THERMODYNAMICS**	**3**

Course Objectives:

The main objectives of this course are,

- To provide basics of statistical thermodynamics in terms of concept of distribution, probability, ensemble and microstates.
- To learn the concepts of partition functions and its applications to calculate thermodynamic properties.
- To study different concepts of statistics and apply to electrons in metal to helium.
- To correlate the fundamental knowledge in statistical thermodynamics with different areas of chemistry and emerging problems in basic sciences.
- To develop the ability to do some independent research problems and use some experimental resources at the end of the course.

Pre-requisites, if any:

Students should know the UG level fundamental aspects on thermodynamics and statistical thermodynamics along with problems solving.

After completion of this course successfully, the students will be able to,

- **CO1:** Recall basics and principles of statistical thermodynamics. (**K1**)
- **CO2:** Understand the importance of statistical thermodynamics in chemical reaction dynamics. (**K2**)
- **CO3:** Apply the knowledge of statistical thermodynamics to different areas of chemistry. (**K3**)
- **CO4:** Analyze and Evaluate research problems in statistical thermodynamics. (**K4** and **K5**).
- **CO5:** Create new concepts to expand the dimensions of in statistical thermodynamics. (**K6**)

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6**- Create

UNITS

UNIT - I: Basics of Statistical Thermodynamics **(9 Hours)**

A Review of Thermodynamics and Kinetic theory of gases. Phase space. Ensemble. Liouville theorem. Equal a priori probability. Microcanonical ensemble. Quantization of phase space. Classical limit. Various distributions using Microcanonical ensemble.

UNIT - II: Probability Factor **(9 Hours)**

Concept of distribution, thermodynamic probability and most probable distribution.

Ensembles, Canonical, grand canonical, micro canonical ensembles.

UNIT - III: Partition Functions **(9 Hours)**

Partition functions - translational, rotational, vibrational and electronic: calculation of thermodynamic properties ΔS, ΔS, ΔG, ΔU, ΔH, Cv, in terms of partition functions.

UNIT - IV: Types of Statistics **(9 Hours)**

Equilibrium constants and rare constants in terms of partition functions: Fermi-Dirac (FD), Maxwell, Boltzmann. Bose-Einstein (BE) statistics: Application to electrons in metals (FD), and to helium (BE).

UNIT - V: Fluctuations **(9 Hours)**

Mean square deviation and fluctuation in ensembles. Concentration fluctuation in quantum statistics. Non-equilibrium States-Boltzmann transport equation. Particle diffusion. Electrical conductivity

Contemporary Learning 15 hours

Expert lectures, YouTubes Videos, Animations, NPTEL, MOOC videos, online seminars – webinars for strengthening the subject matters. Assignment and class room seminar

Total Lecture hours 45 hours

Reference books:

1. Thermodynamics - J. Rajaraman, SC Kuriakose, SLN Chand, 1986.
2. Physical chemistry - PW Atkins, Oxford, 5th ed., 1995.
3. B.K. Agarwal and M. Eisner, Statistical Mechanics, (1988) Wiley Eastern, New Delhi.
4. D.A. McQuarrie, Statistical mechanics, (1976) Harper and Row Publishers, New York.

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]

1. https://www.youtube.com/watch?v=4RX_lpoGRBg&list=PLUl4u3cNGP60gl3fdUTKRrt5t_GPx2sRg
2. https://www.youtube.com/watch?v=w_I0AkvbWFc&list=PLUl4u3cNGP60gl3fdUTKRrt5t_GPx2sRg&index=5
3. https://www.youtube.com/watch?v=BwIUE1C6Iwk
4. https://www.youtube.com/watch?v=XIXQ38JnF0k
5. https://www.youtube.com/watch?v=LIbjB2Tef8A
6. https://www.youtube.com/watch?v=KBe1d8BdjqQ

Mapping with Programme Outcomes: (S-Strong, M-Medium, L-Low)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	M	S	S	S	M	S	M	M	M	S
CO 2	S	M	S	M	S	M	M	M	L	M
CO 3	M	S	L	L	M	S	L	S	M	M
CO 4	M	S	M	S	S	M	S	M	S	M
CO 5	S	M	L	M	M	S	M	L	M	S

SEMESTER II

Course code	CHE C002	ANALYTICAL INSTRUMENTATION	Credits – 3
Core/Elective/Supportive		Core	
Pre-requisite		Student is required to have acquaintance with spectroscopic and chromatographic analysis	

Course Objectives:

The main objectives of this course are to:

- To introduce the students to basic electronics in instrumentation
- Introduce EMR and study the principle of Electronic and Molecular absorption in molecules
- Estimation of molecular species using spectrophotometers
- To understand the principle of absorption and emission using flame
- Selection of the chromatographic technique to separate and identify molecules and ions
- Demonstrate the role of modern instrumentation in chromatography
- To evaluate and critically assess the organization and functioning of spectroscopic instruments
- To conceive different ideas and conceptualize different hypotheses for qualitative and quantitative analysis of chemical compounds using m odern instrumentation.

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1.	The student can interpret the electromagnetic spectra	K1-K4
2.	Understand the electronics and block diagram of spectroscopic instruments.	K2-K4
3.	Principle of absorption / emission and their molecular interaction with light and flame.	
4.	Separation and identification of molecules and ions using chromatography.	K2-K5
5.	Construction and operation of modern chromatographic equipment's	K3-K4
6.	Collection and interpretation of data from spectroscopic and chromatographic Instruments	K5 & K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Unit:1	Molecular Spectroscopy	15 hours

Basic Electronics - Resistors, capacitors, transistors, operational amplifiers, integrated circuits, semiconductor devices.

Beer-Lambert's law, Filter photometry, Types of electronic excitation. Chromophore and Auxochrome-Bathochromic and Hypsochromic shift, UV-visible Spectrophotometry – Photometric titrations, Reaction rates, Complex studies.

Fluorimetry – Principles of fluorescence, Instrumentation and Applications. Turbidimetry and Nephelometry – Theory, Instrumentation and Applications

Unit:2	Emission Techniques	15 hours

Flame Photometry – Theory, Instrumentation and a few important applications.

Emission Techniques – Theory, techniques of excitation, electrodes and their shapes, flame and plasma emission spectrometry – instrumentation and application.

Atomic Absorption Spectrometry – Theory, instrumentation (flame and flameless atomization) and applications.

Types of interfaces, background correction and applications

Unit:3	Chromatography	15 hours

Classical forms of chromatography – Introduction, principle and applications of column, thin layer chromatography and paper chromatography.

Modern chromatographic techniques – Principle and applications of flash vacuum column chromatography, Gas chromatography and High performance liquid chromatography.

Contemporary learning (15 hours)

Expert lectures, YouTube Videos, Animations, NPTEL, MOOC videos, online seminars – webinars for strengthening the subject matters.

	Total Lecture hours	45 hours

Text Book(s)

1	Principles of Instrumental Analysis – Douglas A. Skoog, Saunders College Publ. III Edition, 1985.
2	Text Book of Quantitative Inorganic Analysis – A.I. Vogel, ELBS, III Edition, 1976, and IV Edition, 1985.
3	Vogel's Text Book of Quantitative Chemical Analysis – A.I. Vogel, Pearson Education Ltd, VI Edition, 2001
4.	Principles of Instrumental Analysis – Skoog and Leary, Saunders College Publ. IV Edition, 1992.
5.	Analytical Chemistry – Gary D. Christian, Wiley, New York, V Edition, 2001.
6	Handbook of Instrumental Techniques for Analytical chemistry – F. Settle, Prentice Hall inc, 1997

Reference Books

1	Instrumental Methods of Analysis – Willard, Merit, Dean and Settle, CBS Publ. & Distributors, VI Edition, 1986.
2	Instrumental Analysis – Gary D. Christian & James, E. O'Reilly, Allyn & Bacon Inc, II Edition, 1986.
3	Analytical Chemistry – J.G. Dick, McGraw Hill Publishers, 1975
4	Instrumental Methods of Chemical Analysis – G.W. Ewing, McGraw Hill Publishers, 1975.
5	Quantitative Chemical Analysis – D.C. Harris, W.H. Freeman Publication, IV Edition, 1995.

Related Online Contents MOOC, SWAYAM, NPTEL, Websites etc.

1.	https://youtu.be/9KkcioAoO-Y- Gas chromatography
2.	https://youtu.be/DAwXk77DXUM- Introduction to Industrial Instrumentation

3.	https://youtu.be/5wR9H1FryLs-Fluoroscence Spectroscopy
4.	https://youtu.be/Yzan11nP6Ls-Atomic Absorption Spectroscopy
5.	https://youtu.be/SnbXQTTHGs4-Chromatographic Techniques
6.	https://youtu.be/1F6CxVF5I9g-Flame Photometer
Course Designed By: Dr. K. Ravichandran, Dr. Deepa P Nambiar and Dr. K. Venkatachalam	

Mapping with Programme Outcomes*										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	M	S	S	S	S	M	S	S
CO2	S	S	S	S	M	S	M	M	M	L
CO3	S	S	S	S	L	S	S	S	S	S
CO4	S	M	S	S	L	S	S	L	S	M
CO5	S	S	S	M	S	S	S	S	S	M

*S-Strong; M-Medium; L-Low

Semester -II	CHE C102	MAIN GROUP ELEMENTS AND INORGANIC POLYMERS	Credits – 3
Core/Elective /Supportive	Core		
Pre-requisite	Students should have basic knowledge about unit cell, lattice points, radius ratio, basic solid structures and polymers		

Course Objectives:

The main objectives of this course are to:

- Provide introduction and overview of fundamental properties of solids
- Illustrate the importance of having defects in solids
- To interpret electrical, optical and magnetic properties of ionic solids
- Describe band theory and free electron theories
- Explain semiconductors, superconductor and magnetic properties of various compounds
- Explain different types, synthesis, structural features and applications of silicates, silicones, isopoly and heteropoly acids of transition metals
- Make students to acquire the methods of preparation, nature of bonding, properties, applications of sulphur nitrogen and phospohorus nitrogen compounds
- Explain preparation, properties, reactivity and application of various borane compounds

Expected Course Outcomes (CO):

On the successful completion of the course, student will be able to:

1	Learn different equations related to lattice energy calculation and analyze the structures adopted by different ionic crystals. Students are expected to explain the unique properties of solids due to various types of defects	K1-K4
2	Analyze physical properties such as electrical, magnetic and optical aspects of solids and properties of superconductors and semiconductors	K4-K6
3	Compare the trends in the synthesis and properties of main group elements and discuss the chemistry of Si, S, N and P based inorganic polymers	K2-K5
4	Understand the chemistry and applications of boranes, carboranes and metalloboranes	K2-K3
5	Elucidate various methods of synthesis, properties applications of polymetallate anions, isopoly and heteropoly acids of transition metal ions K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 –Create	K3-K6

UNIT:1	STRUCTURE OF SOLIDS	15 hours

Basics of structure of ionic solids – Dissolution of Ionic Solids – Derivation of Born-Lande and Born-Mayer equations-Kapustinski's modification - entropy of solution and its significance, lattice energy – Structure of rutile, fluorite antifluorite, zinc blende, wurttzite, cadmium iodide and nickel arsenide, spinels and inverse spinels - defects in solids, non-stoichiometric compounds.

Electrical, magnetic and optical properties of solids – free electrons and band theory – semiconductors – superconductors – Ionic conductivity in solids - Solid electrolytes - types of magnetic behaviour, dia, para, ferro, antiferro and ferrimagnetism; Hysterisis – solid state lasers – inorganic phosphors – ferrites – garnets

UNIT:2	Si, S, N AND P BASED INORGANIC POLYMERS	15 hours

Chemistry of silicon – classification and structure of silicates and silicones – Synthesis, structure, reactivity and application of polysilanes – Preparation, structure, properties, reactivity and applications of sulphur nitrogen compounds- Phosphorus nitrogen compounds

UNIT:3	HIGHER BORANES AND POLYOXOMETALATES	15 hours

Chemistry of boron and its isotopes, neutron Capture Therapy – Preparation and structure of borane and higher boranes – STYX numbers – Wade's and Wade's - Mingo's rule – Preparation, structure, properties and reactivity of carboranes, metalloborane and metallocarboranes – Isopoly acids of Vanadium, Chromium, Molybdenum and Tungsten – Heteropoly acids

Contemporary Learning 15 hours

Expert lectures, YouTubes Videos, Animations, NPTEL, MOOC videos, online seminars – webinars for strengthening the subject matters. Assignment and class room seminar

	Total Lecture hours	45 hours

Text Book(s)

1.	Cotton, F.A. and Wilkinson, L - Advanced Inorganic Chemistry 3rd and 4thEdition, John Wiley
2.	Earnshaw and Greenwood - Chemistry of Elements
3.	Huheey, J.E., - Inorganic Chemistry, 2nd Edition, Harper and Row, 1976
4.	Concise Inorganic Chemistry, J.D.Lee
5.	Solid State Chemistry and applications- A.R. West (John Wiley and Sons)
6.	Principles of the Solid State- H.V. Keer (Wiley Eastern Limited)

Reference Books

1.	Hanney, N.D. - Solid State Chemistry, Prentice Hall, 1967
2.	Greenwood, N.N. - Ionic Crystals, Lattice Defects and Non- Stoichiometry, Butterworths, 1968
3.	A.F. Wells - Structural Inorganic Chemistry

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]

1.	https://nptel.ac.in/courses/104/104/104104101/
2.	https://nptel.ac.in/noc/courses/noc19/SEM1/noc19-cy16/

3.	https://www.britannica.com/science/fluorocarbon-polymer
4.	http://homes.nano.aau.dk/fp/uke/pdf/chapter12.pdf
5.	https://www.dalalinstitute.com/books/a-textbook-of-inorganic- chemistry-volume-1/isopoly-and-heteropoly-acids-and-salts-of-mo-and-w-structures-of-isopoly-and-heteropoly-anions/
6.	https://www.britannica.com/science/coordination-compound/Isopoly- and- heteropoly-anions

Mapping with Programme Outcomes*										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	M	L	M	S	M	M	M	M
CO2	S	S	S	S	M	M	S	M	L	L
CO3	M	M	S	M	S	M	L	L	M	S
CO4	S	S	S	S	S	S	M	S	L	L
CO5	M	S	L	L	M	L	S	L	M	M

*S-Strong; M-Medium; L-Low

Course	**Core**
Course Code	**CHE C203**
Title of the Course	**ORGANIC REACTION MECHANISM**
Credits	**3**
Pre-requisites, if any	Students should know about the fundaments of concept of chemical reaction and their mechanism.
Course Objectives	• To study the basic concepts addition and elimination reactions and their mechanism. • To predict the selectivity and stereo-chemical outcome of addition reactions, elimination reactions, oxidation and reduction reactions • To understand the basic concepts of group or atom migration during molecular rearrangements along with mechanistic details • Realize importance of oxidation and reduction reagents in organic synthesis
Course Outcomes	On the successful completion of the course, student will be able to:
CO 1	Understand different aspects of addition reactions and elimination reactions (K2-K5)
CO 2	Familiar with various types of molecular rearrangements and their mechanisms (K1-K6)
CO 3	Understand the concept of atom or group migration involved in molecular rearrangements (K2, K3, K4 and K5)
CO 4	Understand the significance and mechanism of various types oxidation and reduction reactions (K2, K4 and K5)
CO 5	Understand the selectivity and synthetic utility of addition, elimination, oxidation and reduction reactions (K1-K5)

K1-Remember; **K2**-Understand; **K3**-Apply; **K4**-Analyze; **K5**-Evaluate; **K6**-Create

Unit - I	**ADDITION AND ELIMINATION REACTIONS**	**15 hrs**

Electrophilic addition to carbon–carbon double and triple bonds. Nucleophilic addition to carbon–carbon multiple bonds. Generation and addition of carbenes-Michael addition and Robinson annulation.

Nucleophilic addition to –C=O bond- A study of Mannich, benzoin, Darzen's glycidic ester, Stobbe and Knovenegal condensation reactions- Wittig, Wittig-Horner olefination reaction- Julia & Peterson alkene synthesis. Elimination reactions: E1, E2, E1cb and Ei-elimination. Conformation of mechanism; solvent, substrate, leaving group effects-Saytzeff's *Vs* Hoffman elimination; Chugaev and Cope elimination.

Unit - II	**MOLECULAR REARRANGEMENTS AND NAME REACTIONS**	**15 hrs**

A study of mechanism of the following rearrangements: Beckmann, Curtius, Hoffmann, Schmidt, Lossen, Wolff, Pinacol, Wagner Meerwin, Demyanov, Dienone-Phenol, Favorski, Benzidine, Claisen, Cope, Sommlet- Hauser, Pummerer and Von-Richter rearrangements.

Unit - III	OXIDATION AND REDUCTION REACTIONS	15 hrs

Oxidation with Cr and Mn reagents; Oxidation with LTD, DDQ and SeO2; Oxidation using DMSO either with DCC or Ac2O Hydroxylation of olefinic double bonds (OsO4, KMnO4); Woodward and Prevost oxidation. Epoxidation using peracids including Sharpless epoxidation, Ozonolysis. Reduction with NaBH4, LiAlH4 , Birch reduction. Hydrogenation (homogenous and heterogeneous), hydration of carbon- carbon double and triple bonds. Asymmetric reduction of carbonyl functions (Corey's procedure).

Contemporary Learning 15 hours

Expert lectures, YouTube Videos, Animations, NPTEL, MOOC videos, online seminars – webinars for strengthening the subject matters.

Assignment and class room seminar

Total Lecture hours	**45 hours**

Reading List (Print and Online)	• Organic Chemistry Portal: https://www.organic-chemistry.org/ • Organic Synthesis Portal: http://www.orgsyn.org/ • Organic Chemistry notes: https://nptel.ac.in/courses/104/101/104101005/ https://nptel.ac.in/courses/104/101/104101127/ • YouTube: https://onlinecourses.swayam2.ac.in/ugc19_ch01/preview • YouTube: https://onlinecourses.swayam2.ac.in/cec21_cy02/preview
Recommended Text/Reference Books	• Norman, R. O. C & Coxon, J. M (1993); Principles of Organic Synthesis, 3rd Edition, *CRC Press*. • Ahluwalia, V. K. (2012); Oxidation in Organic Synthesis, Ane Books Pvt. Ltd. • Smith, M. B. (2015); March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure, 7th Edition, John Wiley & Sons, Inc. • Carruthers, W. & Coldham, I. (2015); Modern Methods of Organic Synthesis, 4th Edition, Cambridge University press, UK. • Stuart Warren, (2007); Organic Synthesis: The Disconnection Approach, 2nd Edition, Wiley. • March, J (2006); Advanced Organic Chemistry, 4th Edition, Wiley. • Carey, F. A. & Sundberg, R. J. (2008); Advanced Organic Chemistry- Part A and B. 5th Edition, Springer. • Clayden, J, Greeves, N, Warren, S & Wothers, P (2000); Organic Chemistry, Oxford University Press. • House, H. O. (1998); Modern Organic Synthesis, 2nd Edition. W. A. Benjamin, New York.

Mapping with Programme Outcomes*

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	L	L	S	L	S	S	M	L	M	L
CO2	M	M	M	L	S	S	M	M	L	L
CO3	M	M	M	M	S	M	M	L	L	L
CO4	M	M	M	M	S	S	M	M	L	L
CO5	M	M	S	M	S	M	L	M	L	L

***S-Strong M-Medium L-Low**

Core/ Elective/ Supportive	Course Code	Title of the Course	Credits
Core	**CHE C303**	**QUANTUM CHEMISTRY AND GROUP THEORY**	**3**

Course Objectives:

The main objectives of this course are,

- To provide the fundamentals of quantum chemistry in terms of Schrodinger equation, simple harmonic oscillator, rigid rotator, bonding in molecules.
- To understand group theory in terms point group of a molecule and its applications to spectral transitions.
- To learn the principles of microwave, IR and Raman spectroscopy with application to different molecules.
- To correlate and apply the fundamental knowledge of quantum chemistry, group theory and spectroscopy to the different areas of chemistry.
- To develop the ability to do some independent calculations and use some theoretical concepts at the end of the course.

Pre-requisites, if any:

Students should know the UG level fundamental aspects on quantum chemistry, group theoryand spectroscopy along with problems solving.

Course Outcomes:

After completion of this course successfully, the students will be able to,

- **CO1:** Recall basics of quantum chemistry, group theory and spectroscopy. (**K1**)
- **CO2:** Understand the relationships of quantum chemistry, group theory and spectroscopy. (**K2**)
- **CO3:** Apply the knowledge of quantum chemistry, group theory and spectroscopy to different problems in chemistry. (**K3**)
- **CO4:** Analyze and Evaluate problems of quantum chemistry, group theory and spectroscopy. (**K4** and **K5**).
- **CO5:** Create new concepts to expand the dimensions of quantum chemistry, group theory and spectroscopy. (**K6**)

K1 - Remember; **K2 -** Understand; **K3 -** Apply; **K4 -** Analyze; **K5 -** Evaluate; **K6** – Create

UNITS

UNIT - I: Quantum Chemistry-I **(10 Hours)**

Blackbody radiation, Photoelectric effect, Bohr's quantum theory, Wave Particle duality uncertainty principle. Operator Algebra – linear and Hermitionan operators, Quantum mechanical postulates, Schrodinger equation and its solutions to the problem of a particle in one and three dimensional boxes, Quantum mechanical results for a simple harmonic oscillator and rigidrotator. Schrodinger equation for the hydrogen atom and its solution, the origin of electronic quantum numbers and their physical significance.

UNIT - II: Quantum Chemistry-II **(8 Hours)**

Variation theorem MO and VB treatment of bonding in molecules – MO theory of homo – and hetero atomic molecules. VSEPR theory – shapes and bonding in molecules of AB1, AB2, AB6, etc. type systems.

UNIT - III: Group Theory-I **(9 Hours)**

Symmetry elements and symmetry operations, point groups, Reducible and irreducible representations, character tables, orthogonality theorem and its consequences, symmetry selection rules for IR Raman and electronic spectral transitions, Systematic procedure for determining symmetries of normal modes of vibration, symmetry applied to MO theory and orbital hybridization.

UNIT - IV: Group Theory-II **(8 Hours)**

Direct product, Direct product representations, Importance of direct product, symmetry selection rules, Projection operators, LCAO approximation, Huckel theory, Symmetry factoring of secular equations, Simplification of Huckel's molecular orbitals, Group theory and Hybridization, HMO calculations.

UNIT - V: Rotational and Vibrational Spectroscopy **(10 Hours)**

Rotational Spectroscopy: Rotational Spectra of diatomic and polyatomic molecules.

Vibrational Spectroscopy: Simple harmonic oscillator and an hormonic oscillator, calculation of force constants from spectra of diatomic molecules Vibration Rotation spectra- PQR branches, interaction of vibration and rotation. Polyatomic molecules, normal modes and normal coordinates. Symmetries of normal modes of vibration and bond assignment for H2O,

CO2, NH3, BCl3, CCl4, XeF4, CO stretching frequencies in metal carbonyls. Fundamentals, Overtones, combinations Fermi resonance, polarized Raman Spectra, Laser Raman spectra. Raman selection rule basic principles of Magnetic resonance.

Group frequencies – identification of functional groups, Applications in organic and inorganic chemistry.

Contemporary Learning 15 hours

Expert lectures, YouTube Videos, Animations, NPTEL, MOOC videos, online seminars – webinars for strengthening the subject matters. Assignment and class room seminar

Total Lecture hours 45 hours

Reference Books:

1. Chemical Application of Group Theory, F.A.Cotton, Wiley, 1971.
2. Group Theory – Application to Chemistry, K.V.Raman, TMH,1990.
3. Group Theory ,V.Ramakrishnan, Vishal.
4. Quantum chemistry, Eyrimg,Walter and Kimball.
5. Mathematics for physics and chemistry margenau and Murphy.
6. Introduction to ligand field theory, C.J.Balhauson and H.B.Gray.
7. Introduction to ligand field theory- B.N.Figgis.

Text Books:

1. Physical Chemistry, G. M. Barrow, 4 th Ed., McGraw Hill.
2. Physical Chemistry, P. W. Atkins, 4 th Ed., Oxord.
3. Molecular quantum mechanics, P.W.Atkins, Oxford university press 1983.
4. Quantum mechanics in chemistry, M.W.Haung, W.A.Benjaamen.

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]

1. https://www.youtube.com/watch?v=IHypiMpMy50
2. https://www.youtube.com/watch?v=hnWu3ey7ifk
3. https://www.youtube.com/watch?v=7jOSbtR8mTs&list=PLyqSpQzTE6M8eGML9tjCEgZjci 5USazoW

Mapping with Programme Outcomes: (S-Strong, M-Medium, L-Low)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	S	S	M	S	M	L	S	S	S	S
CO 2	M	M	S	S	M	S	M	L	L	M
CO 3	S	S	M	M	L	M	L	M	S	M
CO 4	S	M	S	M	S	S	L	S	S	L
CO 5	M	M	M	S	S	M	S	L	L	M

Course code	CHE C003	ANALYTICAL CHEMISTRY- PRACTICAL-I	Credits – 3
Core /Elective /Supportive		**Core**	
Pre-requisite		Students should know about analytical chemistry	

Course Objectives:

The main objectives of this course are to:

- To learn the practical knowledge about the conductivity and potentiometric titrations, nephelometry and fluorometry using lab scale experimental methods.
- To motivate the students to understand the basic principles of spectrophotometry and carry out quantitative analysis.
- To train them in analytical instrumental analysis
- To learn proper maintenance of records, observations and data interpretation

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1.	To prepare for each experiment by studying lab handouts and links therein	K1-K4
2.	To appreciate the modern problems and scientific controversies in analytical chemistry	K2-K4
3.	To design and perform experiments to estimate the amount of species using instrumentation techniques.	
4.	To verify Beer-Lambert's law and determine the unknown concentration	K2-K5
5.	To validate the theory of electrochemistry and the measurement of electrical conductance through the practical seasons.	K3-K4
6.	To understand the basic concepts of conductometric and potentiometric titrations and the quantitative analysis of unknown solutions using the corresponding instruments.	K5 & K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

List of Experiments

Spectrophotometry:

1. Determination of Iron /Cobalt.
2. Determination of dissociation constant of an indicator.
3. Determination of Binary mixtures.
4. Determination of Mn in steel.

Gas Chromatography:

1. Determination of efficiency of a column.
2. Determination of Rt values for various organic compounds.
3. Resolution of mixtures - Hydrocarbons, alcohols

Potentiometry/ pHmetry:

1. Determination of pKa of an acid.
2. Determination of zinc with ferrocyanide.
3. Determination of ferrous ion with dichromate.
4. Determination of carbonate/bicarbonate and mixtures.

Conductomentry : Conductormetric titrations Nephelometry:
Determination of sulphate.
Fluorimeter: Determination of Quinine.
Flash Point – analysis CV, FTIR, AAS, HPLC – demonstration

Contemporary Issues YouTubes Videos, Animations, NPTEL, MOOC videos,	
Total Practical hours	**60 hours**
Text Book(s)	
Reference Books	
1	Instrumental Methods of Analysis – Willard, Merit, Dean and Settle, CBS Publ. & Distributors, VI Edition, 1986.
2	Text Book of Quantitative Inorganic Analysis – A. I. Vogel, ELBS, III and IV Edition
3	Instrumental Analysis – Gary D. Christian & James, E. O'Reilly, Allyn & Bacon Inc, II Edition, 1986
4	Principles of Instrumental Analysis D. A. Skoog, Saunders College Pub. Co., III Edition, 1985
5	Instrumental Methods of Chemical Analysis – G.W. Ewing, McGraw Hill Publishers, 1975.
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	https://youtu.be/xHQM4BbR040-Spectrophotomettry
2	https://youtu.be/anlIEj4xWhU-Potentiometry
3	https://youtu.be/u9t4vBF0h9k-Conductometry
Course Designed By: Dr. K. Venkatachalam	

Mapping with Programme Outcomes*										
Cos	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	M	L	S	M	S	L	S	M	L	S
CO2	S	S	S	S	M	S	S	M	M	S
CO3	S	S	S	L	L	S	S	S	S	S
CO4	S	S	S	S	S	M	S	L	M	S
CO5	S	S	S	S	M	L	S	M	S	S

*S-Strong; M-Medium; L-Low

Semester -II	CHE C103	INORGANIC CHEMISTRY PRACTICAL – I	Credits – 3
Core/Elective /Supportive	Core		
Pre-requisite	Basic knowledge on inorganic salts and metal chelated complexes		

Course Objectives:

The main objectives of this practical course is able to:

- Identify individual two common and rare cations, respectively, present in the given mixture of inorganic salts and reactions behind it through semi micro qualitative analysis
- Develop the skill for systematic qualitative analysis with strong theoretical backround
- To develop the skill for the estimation of various metal cations from the mixtures through complexometric titrations

Expected Course Outcomes (CO):

On the successful completion of the course, student will be able to:

1	The students will develop the key technical skill related to the quantitative determination of various metal ions through complexometric titrations	K3-K4
2	Learn the lab discipline and maintain high standards of professional and scientific ethics in the laboratory	K1-K3
3	Learn quick identification of nature of any unknown metal ions	K1-K4
4	Develop the skill to prepare various unknown solutions and reagents for their respective experiments	K2-K6

K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 – Create

(A) QUANTITATIVE ANALYSIS	**30 hours**

Complexometric titrations using EDTA - Estimation of zn, Ca, Ni, Mg and Hardness and softness of water

	(B) QUALITATIVE ANALYSIS	**30 hours**

Semimicro qualitative analysis of mixtures containing two common and rare cations.
The following are the rare cations are included:
Tl, Mo, W, Se, Te, Ce, Th, Ti, Zr, V, Be, U and Li.

Note: Examination to be conducted for six hours and to consist of Part-I Semi- micro qualitative analysis of one mixture containing three rare cations along with one common cations.

	Total practical hours	**60 hours**

Text Book(s)

1. Vogel's Textbook of Macro and Semimicro Qualitative Inorganic Analysis,Arthur Israel Vogel, Arthur Israel Vogel, G. Svehla, 1979.
2. V.V. Ramanugam, Inorganic semimicro qualitative analysis, 3rd edition, National Publishing company, 1974.
3. A Text Book of Quantitative Inorganic Analysis- A.I. Vogel 6thedition Longman
4. Concise Inorganic Chemistry, J.D.Lee
5. Inorganic Synthesis- R.A. Rowe and M.M. Jones (1957)5, 113 – 116.

Mapping with Programme Outcomes*										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	L	S	M	L	L	L	M	L	L
CO2	L	L	L	M	L	L	M	S	S	S
CO3	M	M	S	M	S	M	L	L	M	S
CO4	S	M	S	L	L	L	S	L	M	L

*S-Strong; M-Medium; L-Low

Course Code	**UOMS-118**
Title of the Course	**SPECTROSCOPY INSTRUMENTATION**
Course	**Soft skill** **Credit - 2**
Pre-requisites, if any	Basic knowledge on UV, IR, NMR and Mass Spectroscopy will be advantageous.
Course Objectives	The main objectives of this course are to: • To study the basic principles of molecular spectroscopy • To study the instrumentation aspects of molecular spectroscopy • To provide hands on training on various instruments such as UV, IR, NMR and Mass Spectroscopy Instrumentation.
Course Outcomes	On the successful completion of the course, students will acquire knowledge of:
CO 1	To carry out experiments individually and gain knowledge about principles and techniques involved in Spectroscopy (UV, IR, NMR and Mass) Instrumentations (K1-K3).
CO 2	Acquire skills in sampling techniques for spectral analysis (K2-K5)
CO 3	Acquire experimental skills and handling instruments (K2-K5)

K1-Remember; **K2**-Understand; **K3**-Apply; **K4**-Analyze; **K5**-Evaluate; **K6**-Create

Unit- I **(10 hrs)**

UV SPECTROSCOPY INSTRUMENTATION

Principles – Instrumentation – hands on training-sample handling techniques - Application of UV-Visible spectroscopy.

IR SPECTROSCOPY INSTRUMENTATION:

Principles – Instrumentation – hands on training-sample handling techniques - Application of IR spectroscopy

Unit – II **(10 hrs)**

NMR INSTRUMENTATION

Principles – Instrumentation – advantages of NMR techniques – Application of NMR

Unit – III **(10 hrs)**

MASS SPECTROMETRY

Basic Principles – Instrumentation – advantages of mass techniques – Application of mass spectrometry

Reading List (Print and Online)	• https://nptel.ac.in/content/storage2/courses/102103044/pdf/mod2.pdf • https://www2.chemistry.msu.edu/courses/cem351/FS16_HUANG/ Lecture_Presentation/ Ch_10_Lecture_Presentation.pdf • https://www.slideshare.net/siraj174/sir-aj-nmr-spectroscopy-lecture • http://web.iyte.edu.tr/~serifeyalcin/lectures/chem305/cn_1.pdf • https://www.youtube.com/watch?v=qtpVfccYEHE&t=98s

Recommended Text/Reference Books	• Silverstein, R. M, Webster, F. X, Kiemble, D. J, Bryce, D. L (2015); Spectrometric Identification of Organic Compounds, 8th Ed, Wiley • Kalsi, P. S (2016); Spectroscopy of Organic Compounds, 7th Ed, New Age International • Pavia, L, Lapman, G. M, Kriz, S, Vyvyan, J.-R (2015); Introduction to Spectroscopy, Cengage Learning, ISBN 13: 978-81-315-2916-4 • Jag Mohan (2016); Organic Spectroscopy Principles & Applications, 3rd Ed, Narosa Publishing House.

Mapping with Programme Outcomes*

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	L	M	M	M	M	M	M	M	M	L
CO2	M	L	S	M	M	L	L	M	S	S
CO3	M	M	M	M	M	M	M	L	M	S

***S-Strong M-Medium L-Low**

Course code		ADVANCED METHODS IN CHEMICAL ANALYSIS	Credits – 2
Skill enhancement course / Value added courses		Value added course	
Pre-requisite		Students should know about chemical analysis to identify the molecules	

Course Objectives:

The main objectives of this course are to:

- Ability to analyze organic molecules
- Knowledge of procedures to be used for different types of molecules
- Analysis and Interpretation of spectrum
- Identification of molecules and ions present in organic compounds.

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1.	Basic knowledge of methods used in analysis of organic molecules	K1-K2
2.	To learn the procedure of Spectroscopic methods to analyze the chemical nature of organic molecules	K2-K4
3.	To summaries the data and find out the structure of organic molecules	K3-K4
4.	To understand the principle and assimilate the various steps involved in chemical analysis	K3-K5
5.	To estimate and critically assess properties of organic molecules	K4-K5
6.	To device a protocol to analyze the organic molecules	K5 - K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Valued added course	Advanced methods in chemical analysis	30 hours

1. Gas Chromatography
2. Gas Chromatography-Mass Spectrum
3. High Performance liquid chromatography
4. High Performance liquid chromatography-Mass spectrum
5. Nuclear Magnetic resonance spectroscopy
6. FT-IR Spectroscopy
7. UV-Vis spectroscopy

Course code	CHE E002	ANALYSIS OF COMPLEX MATERIALS	Credits – 3
Core/Elective/Supportive		ELECTIVE	
Pre-requisite		Students should know about chemical analysis	

Course Objectives:

The main objectives of this course are to:

- Ability to analyze ores and alloys
- Knowledge of procedures to be used for different types of ores and alloys
- Analysis of organic compounds using chemical analysis
- Identification of molecules and ions present in organic compounds.
- Classification and properties of fuels
- Analysis of fuels to determine their properties

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1.	Basic knowledge of methods used in analysis of complex materials	K1-K2
2.	Toidentify the procedure to analyze the chemical nature of Ore and alloy samples	K2-K4
3.	To summaries the chemical reactions involved in analysis of materials	K3-K4
4.	To understand the principle and assimilate the various steps involved in chemical analysis	K3-K5
5.	To estimate and critically assess properties of complex materials	K4-K5
6.	To device a protocol to analyze any ores, alloys, organic compounds and fuels that is provided using classical analytical procedures	K5 - K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1	Ore and Alloy Analysis	15 hours

Ore and Alloy Analysis – Sample preparation – Decomposition and dissolution of the sample, Fusion process, use of fluxes – acid and alkaline fluxes.

General procedure of complete analysis of Ores and Alloys – Oxide Ore- Haematite, Carbonate Ore – Dolomite, Alloys – Solder and Brass.

Unit:2	Analysis of Organic Compounds	15 hours

Elemental analysis – Decomposition of organic compounds – Dry and wet ashing. Fusion - alkali metal fusion. Analysis of carbon, nitrogen and hydrogen in organic compounds.

Determination of traces of water in liquids and solids. Direct and indirect methods – use of Karl- Fischer's reagent, Dean and Stark method.

Functional group analysis: Amine, phenolic – OH, alcoholic – OH, vicinal hydroxyl, aldehyde and ketonic group analysis. Unsaturation in oils and fats – Bromination and iodine number. Rancidity Atomic Absorption Spectrometry – Theory, instrumentation (flame and flameless atomization) and applications.

Unit:3	Fuel Analysis	15 hours
Fuel Analysis - Solids, liquids and gaseous fuels – Sampling procedure, ultimate and proximate analysis, specific volatile index, ash content, Calorific value by bomb calorimeter and Junker's gas calorimeter. Liquid fuels – Flash point, viscosity, carbon residue, aniline point, pour point – Determination and significance		
	Contemporary learning	**15 hours**
Expert lectures, YouTubes Videos, Animations, NPTEL, MOOC videos, online seminars – webinars for strengthening the subject matters.		
	Total Lecture hours	**45 hours**

Text Book(s)	
1	Text book of Quantitative Inorganic Analysis – A.I. Vogel, ELBS, III Edn., 1982.
2	Vogel's Text Book of Quantitative Chemical Analysis – A.I. Vogel, Pearson Education Ltd, VI Edition, 2001.
3	Instrumental Methods of Analysis – Willard, Merit, Dean and Settle, CBS Publ. & Distributors, VI Edition, 1986.
4.	Instrumental Analysis – Gary D. Christian & James, E. O'Reilly, Allyn & Bacon Inc, II Edition, 1986
5.	Principles of Instrumental Analysis – Douglas A. Skoog, Saunders College Publ. III Edition, 1985.
6	Text Book of Quantitative Inorganic Analysis – A.I. Vogel, ELBS, III Edition, 1976, and IV Edition, 1985.
7	Fundamentals of Analytical Chemistry – D.A. Skoog and D.M. West, Holt Rinehart and Winston Publications, IV Edition, 1982.
8	Quantitative Organic Analysis – S. Siggia and J.G. Hanna, Wiley –Intersci. Publ. IV Edition, 1979.
Reference Books	
1	Fuel Testing – G.W. Himus, Leonard Hill, 1954
2	Technical Methods of Analysis – R.C. Griffin, McGraw Hill, 1965.
3	Analytical Chemistry – J.G. Dick, McGraw Hill Publishers, 1975.
4	Chemistry of Engineering Materials – C.V. Agarwal, TARA Publicaions, II Edition, 1965.
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1.	https://youtu.be/KgUmNQD6m5Q-Alloy and their Properties
2.	https://youtu.be/m-5EnGAMKF4-Determination of Copper in Brass
3.	https://youtu.be/qu1v60L1Chk- Proximate Analysis of Fuel/Coal
4.	https://youtu.be/_GqBl83Koig- Testing for Hydrogen, Oxygen, Carbon Dioxide, Ammonia
	Course Designed By: Dr. Deepa P Nambiar and Dr. K. Ravichandran

Mapping with Programme Outcomes*										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	M	S	M	L	M	M	M	S	L
CO2	S	S	S	S	S	S	S	M	M	M
CO3	S	S	S	S	M	M	S	M	S	S
CO4	M	S	S	S	M	S	S	M	S	S
CO5	S	M	S	M	S	M	S	S	S	S

*S-Strong; M-Medium; L-Low

Course	**Elective (II)**
Course Code	**CHE E202**
Title of the Course	**FUNCTIONAL GROUP TRANSFORMATION IN ORGANIC CHEMISTRY**
Credits:	**3**
Pre-requisites, if any	Students should know about various types of functional groups as well as organic reactions
Course Objectives	• To learn various types of functional group transformations involving different types of oxidation reactions • To learn functional group transformations involving different types of reducing agents • To understand different types of functional group transformations involving miscellaneous category of reagents/name reactions • To identify suitable reagents for carrying specific synthetic transformations.
Course Outcomes	On the successful completion of the course, student will be able to:
CO 1	Understand different types of functional group transformations involving oxidizing agents (K2-K5)
CO 2	Familiarize with functional group transformations involving reducing agents (K2-K6)
CO 3	Understand functional group transformations involving miscellaneous category of reagents/name reactions (K2-K5)
CO 4	Identify suitable reagents to perform chemo-selective functional group transformations (K1-K6)
CO 5	Evaluation of different types of synthetic transformations involving oxidizing, reducing and miscellaneous category of reagents (K1-K6)
K1-Remember; **K2**-Understand; **K3-**Apply; **K4**-Analyze; **K5**-Evaluate; **K6**-Create	
Unit – I **(15 hrs)**	
FUNCTIONAL GROUP TRANSFORMATIONS USING OXIDIZING REAGENTS Use of Chromium reagents (CrO3, K2Cr2O7, CrO2Cl2, PCC, PDC and PFC). Use of Manganese reagents (KMnO4, MnO2, CTAP). Use of RuO4, KBrO3, DMSO, NCS, NaIO4, peracids and boranes.	
Unit – II **(15 hrs)**	
FUNCTIONAL GROUP TRANSFORMATIONS USING REDUCING REAGENTS Use of NaBH4, NaCNBH3, LiAlH4 and Bu3SnH; Use of Sn/HCl, Zn/HCl, Hydrazine, Li-NH3, Na/alcohol, Pd/H2 and Raney Ni.	

Unit – III	**(15 hrs)**
FUNCTIONAL GROUP TRANSFORMATIONS USING MISCELLANEOUS TYPE OF REAGENTS Use of SOCl2, PBr3, PPh3-CCl4, LiBr, NaI, NBS, PPh3-X2, Lawesson's reagent, Mitsunobu reagent, CH2N2, TMSCHN2 and Barbier-Weiland degradation. Conversion of aldehyde to ketone and vice versa; Conversion of aldehyde to cyanide, Conversion of cyanide to ester, Conversion of ketone/aldehyde to phenol; conversion of ketone to enone.	
Contemporary Learning **15 hours** Expert lectures, YouTube Videos, Animations, NPTEL, MOOC videos, online seminars – webinars for strengthening the subject matters. Assignment and class room seminar	
Total Lecture hours	**45 hours**
Reading List (Print and Online)	• Organic Chemistry Portal: https://www.organic chemistry.org/ reactions.htm • Organic Synthesis Portal: http://www.orgsyn.org/ • Organic Chemistry notes: https://chemistrynotes.com/pages/organic- chemistry-notes • https://nptel.ac.in/content/storage2/courses/104103071/pdf/mod8.pdf • YouTube http://Leah4sci.com/chirality; • YouTube: https://www.youtube.com/watch?v=yZ8JDDnyxC4
Recommended Texts/Reference books	• Jerry March. (2006); Advanced Organic Chemistry, 4th Edition, Wiley. • Carey, F. A. & Sundberg, R. J. (2008); Advanced Organic Chemistry- Part A and B. 5th Edition, Springer. • Clayden, J, Greeves, N. Warren, S. (2017); Organic Chemistry, 2nd Ed, Oxford University Press. • Graham Solomons, T. W, Fryhle, C. B. (2014); Organic Chemistry, 10th Edition, Wiley. • Smith, M. B. (2015); March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure, 7th Edition, John Wiley & Sons, Inc.

Mapping with Programme Outcomes*

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	L	L	S	S	S	M	M	L	M	M
CO2	M	M	S	S	S	L	L	M	L	M
CO3	M	M	S	M	S	M	L	L	M	S
CO4	M	M	M	M	S	S	L	M	L	S
CO5	M	M	S	M	S	M	L	L	L	M

***S-Strong M-Medium L-Low**

Course Code	CHE E302	Elective	Credits - 3
Title of the course	MACROMOLECULAR CHEMISTRY - I		

Course Objectives:

The main objectives of this course are,

- To provide knowledge about nomenclature of polymer, degree, types, mechanism and kinetics of polymerization.
- To understand the principles of polymer reactivity, stereochemistry of polymerization and various methods of polymerization.
- To know the polymer crystallization, glass transition temperature and Physical and mechanical properties of crystalline and amorphous polymers.
- To improve their analytical skill to analysis and testing of polymer by FT-IR, NMR, XRD, TGA/DTA/DSC.
- To recognize the importance of specialty polymers.

Pre-requisites, if any:

Students should know the UG level fundamental aspects on polymer chemistry.

Course Outcomes:

After completion of this course successfully, the students will be able to,

- **CO1:** Recall the introductory aspects of polymer chemistry. (**K1**)
- **CO2:** Understand the synthesis and characterization methods. (**K2**)
- **CO3:** Apply the knowledge of polymers in diverse areas of basic sciences. (**K3**)
- **CO4:** Analyze and Evaluate the research problems in different areas of polymer chemistry. (**K4** and **K5**).
- **CO5:** Create new concepts to expand the dimensions of polymer chemistry. (**K6**)

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

UNITS

UNIT - I: Basic Concepts of Polymer Chemistry (9 Hours)

Definition, nomenclature of polymers, functionality of monomers, degree of polymerization. Vinyl monomers, initiators, Kinetic chain length, Percentage conversion, chain transfer agents, Mayo's relation, inhibitor, modifiers, and retarders.

Types of polymerization: addition, condensation and copolymerization. Mechanism and kinetics of free radical, cationic and anionic polymerization. Copolymerization: free radical, ionic. Copolycondensation. Types of copolymers, copolymerization reaction, copolymer – comonomer equation, reactivity ratios. Mark Howink equation.

UNIT - II: Polymerization Reactions and Techniques (9 Hours)

Principles of polymer reactivity: Photolytic, photosensitized polymerization. Cyclo, electro- initiated, cross-linking, graft and block copolymerization. Polymer reagents, polymer catalysis.

Stereochemistry of Polymerization: Types of stereoisomerism in polymers, properties of stereoregular polymers. Stereospecific polymerization. Ziegler-Natta polymerization.

Various methods of polymerization: solution, bulk, emulsion and suspension. Electropolymerisation. Comparative accounts. Recycling of polymers.

UNIT - III: Crystal Structure and Properties of Polymers (9 Hours)

Polymer crystallization, factors affecting crystallisability. Morphology of crystalline polymers, effect of crystallisability on the properties of polymers. Glass transition temperature(Tg) and its determination. Dependence of Tg on polymer structure. Melting temperature.

Physical and mechanical properties of crystalline and amorphous polymers. Thermal treatment of polymers, Zimmplot.

UNIT - IV: Characterization of Polymers (9 Hours)

Number average, weight average and viscosity average molecular weight of polymers. Molecular weight determination by light scattering, osmotic, centrifuge and viscosity methods.Gel permeation chromatography. Analysis and testing of polymer by FT-IR, NMR, XRD, TGA/DTA/DSC.

UNIT - V: Specialty Polymers (9 Hours)

Polymers in catalysis and drug delivery, Thermosensitive and photo-sensitive polymers, Thermally stable polymers, Biodegradable polymers, Conducting polymers, Fire retardant polymers, polymer electrolytes, Liquid crystalline polymers, Dentrimers, Adhesives, Foams, Fibers.

Contemporary Learning 15 hours

Expert lectures, YouTube Videos, Animations, NPTEL, MOOC videos, online seminars – webinars for strengthening the subject matters. Assignment and class room seminar

Total Lecture hours 45 hours

Text Books:

1. F.W. Billmeyer, Text Book of polymer science Wiley Interscience, 1984.
2. A. Rudin, the elements of polymer science and engineering. An introductory text for engineers and chemists, Academic Press, New York, 1982.
3. M.S. Bhatnagar, A Textbook of Polymers. Vol I. S.Chand & Company Ltd 2004.
4. Bill Meyer. A Text Book of Polymer Chemistry, Singapore: John Wiley & Sons 1994,
5. E.C. Carraher, Introduction to Polymer Chemistry. Taylor & Francis, Inc. 2006.

6. Gowariker & Viswanathan, Polymer Science. Wiley Eastern, 1986.
7. S.P. Mishra, Polymer Chemistry. New Delhi: Wiley Eastern Ltd 1993.

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]

1. https://www.youtube.com/watch?v=54urJPOnaeU&list=PLyqSpQzTE6M_KQ5MqUkoOqAxxOrdvFOMB
2. https://www.youtube.com/playlist?list=PLcCIZORoVQghF126hJD0yU6JZ6ngbOb5a
3. https://www.youtube.com/watch?v=nSAvyQajVzE

Mapping with Programme Outcomes: (S-Strong, M-Medium, L-Low)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	S	S	M	M	S	M	M	S	M	S
CO 2	S	M	S	M	M	M	S	M	M	S
CO 3	M	S	L	S	M	S	M	L	S	M
CO 4	M	S	L	L	M	M	S	M	S	M
CO 5	M	M	S	S	S	M	S	M	M	S

SEMESTER III

Core/ Elective /Supportive	Course Code	Title of the Course	Credits
Core	**CHEC601**	**PHYSICAL METHODS IN CHEMISTRY**	**4**

Course Objectives:

The main objectives of this course are

- To provide the deep understanding of electronic and structural changes of metal coordination complexes upon interaction with visible light.
- To understand basic theory& instrumentation involved in the origin of spectroscopy.
- To understand UV, IR, NMR and Mass spectra and their significance in the characterization of organic compounds.
- To illustrate the basic principle of splitting of spectral line of inorganic complexes in the presence of magnetic field upon interaction with electromagnetic radiation.
- To study the role of optical spectroscopy (UV, IR), NMR spectroscopy to understand the structure of organic compounds.
- To learn ESR and their importance in the characterization of radicals.
- To understand basic theory & instrumentation of analytical techniques of characterization

Pre-requisites, if any:

Students should know the the fundamental aspects on spectroscopy and their importance in the characterization of chemical compounds. Basic knowledge on UV-Vis, IR, NMR and Mass spectroscopic techniques will be advantageous.

Course Outcomes:

After completion of this course successfully, the students will be able,

- **CO1:** To interpret absorption bands in the visible, IR and microwave regions, to understand bonding, geometry and reactivity of inorganic coordination complexes. (**K1** – **K4**)
- **CO2:** To understand the basic concept, interpretation and application of electronic spectra of hydrogen and many electron atoms, and to derive angular momentum of many electron atoms and term symbols of atoms. (**K2 – K4**)
- **CO3:**TogainKnowledgeonvibrational,ATRandimagingmodestocharacterizechemicalcompo unds
- **CO4:** To understand the basic theory as well as instrumentation techniques for recording UV, IR, NMR, MS, XRD, Raman, Mossbauer and Thermal spectra of chemical compounds. (**K2– K5**)
- **CO5: To** Record and interpret UV, IR, NMR, TGA, DSC, XRD, Raman, Mossbauer, ESR and MS spectra of chemical compounds. (**K3&K4**).
- **CO6:**To understand the nature of functional groups present in chemical compounds using destructive as well as non-destructive spectral techniques. (**K5 &K6**)

K1-Remember; **K2**-Understand;**K3**-Apply;**K4**-Analyze;**K5** -Evaluate; **K6** –Create

UNITS

UNIT-I: Electronic Spectroscopy (PHYSICAL&INORGANIC) (15Hours)

Spectra of hydrogen and many electron atoms, angular momentum of many electron atoms, term symbols, spectra of many electron atoms- Zeeman effect. Spectra of diatomic molecules, Representation of electronic states through potential energy diagrams-Frank Condon principle.

Intensities of electronic transitions-theoretical treatment of absorption intensities, transition dipole moment integral, oscillator strength, selection rules parity, spin and symmetry considerations, Factors inducing forbidden transitions vibronic and spin orbit coupling, polarization bands.

Spectra of formaldehyde, but adiene and benzene –group theoretical discussion.

Electronic spectra of inorganic complexes – Selection rules (Laporte, orbital and spin selection rules), band intensities, band widths, spectra in solids, spectra of aqueous solutions ofd1-d9 ions in Oh and Td environments.

UNIT-II: Spectroscopy (ANALYTICAL) (15 Hours)

Mossbauerspectroscopy–Introduction,principle,instrumentation,recoilenergy, Doppler effect, number of MB signals , isomer shift, quadrupole splitting, magnetic hyper fine splitting applications to57Fe, 119Sn and 129Icompounds

Raman Spectroscopy: SERS, SERRS. ATR techniques – UV, IR, Raman. Principle & application of ORD and CD in the identification of complexes.

Thermal methods of analysis–TGA, DTA and DSC –Principle and applications.

UNIT-III:NMR (ORGANIC) (15 Hours)

Origin of NMR spectrum-Nuclear spin states – NMR active nuclei – Nuclear magnetic moment– Larmor equation–AbsorptionofenergyandResonance–Populationdensityofnuclear spin states.

Saturation phenomena – Relaxation mechanisms, Bloch equation (only significance and derivation not required).Comparison of C W and F T instrument – Chemical shift - Standards in NMR – Shielding and Deshielding – Factors affecting chemical shift – electronegativity, hybridization, hydrogen bonding - anisotropic effect – double, triple bond, aromatic compounds and carbonyl compounds. Spin-spin coupling – splitting origin and rules –factors affecting coupling constant: cis, trans, gem, ortho, meta, para coupling – exchange with deuterium. Vicinity of the proton, Long range coupling, Karplus equation and curve. 1J, 2J, 3J, 4Jand 5J coupling in NMR, order of NMR spectrum. Spin systems: Two interacting nuclei: A2, AB, AX, AA'BB', dd, pair of doublet, AB quartet.

UNIT-IV:UV,IR and MS(ORGANIC) (15 Hours)

Electronic absorption-Beer-Lamberts law, Types of electronic excitation. Chromophore and Auxochrome-Bathochromic and Hypsochromic shift. UV-vis spectra of simple organic compounds such as alkenes, phenols, anilines, carbonyl compoundsand1,3- diketones. Wood ward and Fieser rule for calculation of λ-max values of dienes and unsaturated ketones. Infrared Spectra: Identification of functional groups in Organic Compounds, Finger printregion. Inter and Intramolecular hydrogen bonding Origin, basics and bloc diagram of Mass spectrum-Various types of Ionization techniques- Stability of Molecularions, Metastableions. Base peaks and Isotope peaks. Fragmentation patterns of organic molecules.

Contemporary Learning

Expert lectures, YouTube Videos, Animations, NPTEL, MOOC videos, online seminars – webinars for strengthening the subject matters. Assignment and class room seminar

Total Lecture hours **60 hours**

Text Books:

- Basic Principles of Spectroscopy, R.Chang, McGraw Hill
- Fundamentals of Molecular Spectroscopy, Fourth Edition, Colin N. BANWELL and Elaine M. Mc CASH Kemp,W.(2016)
- Organic Spectroscopy, 3rd Edition, Palgrave. Kalsi, P.S (2016)
- Spectroscopy of Organic Compounds, 7th Edition, New Age International. Silverstein, R.M, Webster, F.X, Kiemble, D. J, Bryce, D.L(2015)
- Spectrometric Identification of Organic Compounds, 8th Edition, Wiley.Jag Mohan (2016)
- Organic Spectroscopy Principles & Applications, 3rd Edition, Narosa Publishing House. Pavia, L, Lapman, G. M, Kriz, S, Vyvyan, J.- R(2015)
- Introduction to Spectroscopy, Cengage Learning, ISBN13: 978-81-315-2916-4. PhysicalMethodsinChemistry,R.S. Drago,W.B.Saunders Co.,1977. E. Huheey, E. A. Keiter, R. L. Keiter, O. K. Medhi
- Inorganic Chemistry: Principles of Structure and Reactivity, 4th ed. Pearson Education, 2006.
- Principles of Instrumental Analysis – Douglas A. Skoog, F. Holler, Stanley Crouch,7thEdnBrooks/Cole publish; 7th edition, 2017

Reference Books:

1. Structural Methods in Inorganic Chemistry, E.A.V. Ebsworth, D.W.H. Rankin and S. Craddock, ELBS.
2. Physical Methods For Chemists, Russell S. Drago Second Edition,2016.
3. Huheey, J.E.- Inorganic Chemistry,4th Edition, Harper and Row.
4. Lambert, J.B, Shurvell, H.F, Lightner, D.A, Graham Cooks,R (1998); Organic Structural Spectroscopy, Prentice Hall, ISBN: 0-13-258690-8.
5. Macomber, R.S(1998); A complete introduction to Modern NMR Spectroscopy, John Wiley, ISBN: 0-471-15736-8.
6. Willard, H.H.; Merritt, L.L. Jr.; Dean, J.A.; Settle, F. A. Jr., CBS Publishers & Distributors; 7th edition (2004).

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]

1. https://nptel.ac.in/content/storage2/courses/102103044/pdf/mod2.pdf
2. https://www.slideshare.net/LOKESHPANIGRAHI/spectroscopy-134933430
3. https://www.slideshare.net/guest824336/introduction-to-spectroscopy
4. http://web.iyte.edu.tr/~serifeyalcin/lectures/chem305/cn_1.pdf
5. https://www.youtube.com/watch?v=qtpVfccYEHE&t=98shttp://www.digimat.in/nptel/courses/video/104106122/L54.html

6. https://pubs.rsc.org/en/content/articlelanding/2018/cs/c6cs00565a
7. https://chem.libretexts.org/Bookshelves/Physical_and_Theoretical_Chemistry_Textbook_Maps/Supplemental_Modules_(Physical_and_Theoretical_Chemistry)/Spectroscopy/Magnetic_Resonance_Spectroscopies/Electron_Paramagnetic_Resonance/EPR%3A_Application

Mapping with Programme Outcomes: (S-Strong, M-Medium, L-Low)

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
CO1	M	S	S	M	M	S	M	M	L	L
CO2	S	M	S	S	M	M	S	M	L	L
CO3	S	M	S	M	L	M	S	L	L	L
CO4	M	S	S	S	L	S	M	L	L	L
CO5	S	S	S	M	L	L	S	L	L	L
CO6	S	M	S	M	L	M	S	L	L	L

Course	**Core**
Course Code	**CHEC204**
Title of the Course	**ORGANIC CHEMISTRY PRACTICAL - II** **DOUBLE STAGE ORGANIC PREPARATIONS**
Credits	**3**
Prerequisites, if any	Basic knowledge on simple organic preparations will be essential
Course Objectives	The main objectives of this course are to: ● To provide practical training on double stage organic preparations ● Learn about the purification techniques of organic compounds by recrystallization and column chromatography ● To understand the mechanism and intermediates inorganic reaction. ● To characterize the structure of the purified organic compound by IR and NMR.
Course Outcomes	On the successful completion of the course, student will be able to:
CO1	Gainpracticalskillsondoublestagepreparationsoforganiccompounds(K1- K6)
CO2	Monitoring the progress of the reaction by TLC(K2-K5)
CO3	Have experience on purification of organic compounds by recrystallization or column chromatography(K2-K4)
CO4	Get adequate knowledge in synthetic organic chemistry(K3-K5)
CO5	Characterization of prepared compounds by IR, ^{1}H NMR and Mass spectra(K2-K5)
K1-Remember;**K2**-Understand;**K3-**Apply;**K4**-Analyze; **K5**-Evaluate;**K6**-Create	
DOUBLE STAGE ORGANIC PREPARATIONS **(60 Hours)**	
1. Synthesis of organic compounds involving Friedel- Crafts alkylation and acylation reactions 2. Synthesis of nitro compounds 3. Synthesis of halogenated compounds 4. Synthesis of aldehydes involving formylation reactions 5. Synthesis of organic compounds by using Pd- catalyzed coupling reactions 6. Synthesis of organic compounds involving nucleophilic substitution reactions	
Reading List (Print and Online)	● Organic Chemistry notes: YouTube https://www.youtube.com/watch?v=N96JaRnE7n0 YouTube https://w ww.youtube.com/watch?v=0RwDowIgXqk

Recommended Text / Reference Books	• Furniss, B.S.; Hannaford, A.J.; Smith ,P. W. G.; & Tatchell, A. R. (2003); Vogel's Textbook of Practical Organic Chemistry, 5th Edition., Pearson Education • Mohan, J. (2010); Organic Analytical Chemistry, Theory and Practice, Narosa. • Mann, F. G & Saunders, B. C. (2009); Practical Organic Chemistry, fourth edition, Pearson Education India • Gnanaprakasam, N. S. & Ramamurthy, G. (2009); Organic Chemistry Lab Manual, Viswanathan, S., Printers& Publishers Pvt Ltd. • Ahluwalia, V. K. Bhagat, P. & Agarwal, R. (2013); Laboratory Techniques in Organic Chemistry, I K International Publishing House Pvt. Ltd

Mapping with Programme Outcomes*

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M	M	M	L	M	M	M	M	M	M
CO2	M	L	L	M	M	M	M	M	M	M
CO3	S	L	M	L	M	M	M	M	S	S
CO4	M	M	M	M	M	L	L	S	L	L
CO5	L	M	S	M	L	M	M	L	L	L

***S-Strong M-Medium L-Low**

Course	**Core**
Course Code	**CHEC205**
Title of The Course	**ORGANIC CHEMISTRY PRACTICAL -III** **MULTI-STAGE ORGANIC PREPARATIONS**
Credits	**3**
Pre-requisites, if any	Basic knowledge on simple organic preparations will be essential
Course Objectives	The main objectives of this course are to: ● To provide practical training on multi-stage organic preparations ● Learn about the purification techniques of organic compounds by recrystallization and column chromatography ● Learn about preparation of dry solvents to carryout moisture sensitive organic reactions ● To understand the mechanism and intermediates in organic reaction ● To characterize the structure of the purified organic compound by IR and NMR
Course Outcomes	On the successful completion of the course, student will be able to:
CO1	Gain practical skills in the preparations of organic compounds involving multi-steps (K1-K6)
CO2	Monitoring the progress of the reaction by TLC (K2-K5)
CO3	Have experience on preparation of dry solvents to carry out moisture sensitive organic reactions and purification of organic compounds by recrystallization or column chromatography(K2-K4)
CO4	Get adequate knowledge in synthetic organic chemistry (K3-K5)
CO5	Characterization of prepared compounds by IR, ^{1}HNMR and MS (K2-K5)
K1-Remember; **K2**-Understand; **K3-**Apply; **K4**-Analyze; **K5**-Evaluate; **K6**-Create	
Units - MULTI-STAGE ORGANIC PREPARATIONS **(60 Hours)**	
1. Synthesis of organic compounds involving condensation reactions 2. Synthesis of heterocycles 3. Synthesis of olefinic compounds using Wittig reactions 4. Synthesis of organic compounds involving oxidation/reductions 5. Synthesis of organic compounds involving protection/deprotection reactions 6. Synthesis of organic compounds involving Lewis acid/Bronsted acid mediated cyclization reactions	
Reading List (Print and Online)	● Organic Chemistry notes: YouTube https://www.youtube.com/watch?v=N96JaRnE7n0 YouTube: https://www.youtube.com/watch?v=0RwDowIgXqk

Recommended Text/Reference Books	• Furniss, B. S.; Hannaford, A. J.; Smith, P.W.G. &Tatchell, A.R. (2003); Vogel's Textbook of Practical Organic Chemistry, 5th Edition., Pearson Education • Mohan, J. (2010); Organic Analytical Chemistry, Theory and Practice, Narosa. • Mann, F. G & Saunders, B. C. (2009); Practical Organic Chemistry, fourth edition, Pearson Education India • Gnanaprakasam, N. S. & Ramamurthy, G. (2009); Organic Chemistry Lab Manual, Viswanathan, S., Printers & Publishers Pvt Ltd • Ahluwalia, V. K.; Bhagat, P. &Aggarwal, R. (2013); Laboratory Techniques in Organic Chemistry, I K International Publishing House Pvt. Ltd

Mapping with Programme Outcomes*

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M	M	M	L	M	M	M	M	M	M
CO2	M	L	L	M	M	M	M	M	M	M
CO3	S	L	M	L	M	M	M	M	S	S
CO4	M	M	M	M	M	L	L	S	L	L
CO5	L	M	S	M	L	M	M	L	L	L

***S-Strong, M-Medium, L-Low**

Course	**Elective (III)**
Course Code	**CHE E601**
Title of the Course	**BIOLOGICAL CHEMISTRY**
Credits	**3**
Prerequisites, if any	Student able to understand the role of bio-organic compounds. Students should know about the fundamental aspects on biological system, mechanism, kinetics and analytical tools.
Course Objectives	• To understand the function of carbohydrate in biological chemistry, determination of ring size and study of starch and cellulose. • To understand the significances of amino acids, proteins nucleic acids in biological system. • Illustrate the importance of the various elements in the biological system and to gain more insights into the binding of metal complexes with biomacromolecules and transport and storage mechanism involving in the metalloenzymes. • To understand the role of heavy metals in the human body- therapeutic and toxicity levels.
Course Outcomes	On the successful completion of the course, students will acquire knowledge: • **CO1 -** To learn about structural and functions of carbohydrates, lipids, membranes, amino acids, proteins, antibiotics and vitamins(K1-K5) • **CO2 –** Understand structure and biological importance of RNA and DNA (K2-K4) • **CO3 -** Understand the key function of metal ions such as Fe, Co, Ni Zn and Cu in living system, particularly in transports (energy and O2), storage, electron- and proton transfer, hydrolysis, etc. which are taking place at the active site of metalloproteins and enzymes(K1-K4) • **CO4 –** Toxicity of metals and their effects in the biological system(K1-K4) • **CO5 –** To evaluate toxicity of drugs used in cancer and radio diagnosis (K5&K6)
K1-Remember;**K2**-Understand;**K3**-Apply;**K4**-Analyze; **K5**-Evaluate;**K6**-Create	
Units	
Unit I	**BIO-ORGANICCHEMISTRY (12 Hours)**

Carbohydrates: Pyranose and furanose forms of aldo-hexose and ketohexose- methods used for the determination of ring size-conformation ofaldo- hexopyranose-structure and synthesis of lactose and sucrose. A brief study of starch and cellulose.

Lipids and Membranes: Molecular structure of lipids. FattyAcids,Triglycerides Types of membrane lipids

Amino acids and Proteins: Amino acids and Protein structure, Analysis of N-terminal and C- terminals in a polypeptide. Sanger method , Edman degradation and Enzymatic analysis. Primary, secondary and tertiary structure of proteins. Structure of collagen, myoglobin and haemoglobin.

Nucleic acids: Chemistry of nucleic acids, nucleosides and nucleotides – Structure RNA and DNA and their biological importance.

Unit – II	**BIO-INORGANICCHEMISTRY**	**(11 Hours)**

Essential and trace metal ions: Enzymes – Nomenclature and classification – Coenzymes-Vitamin B12, Carboxy peptidase and superoxide dismutase – Heme-enzyme-Peroxidase and catalases. Oxygen carriers: Hemeproteins - Hemoglobin, myoglobin - Structure Oxygenation and stereochemistry – Bohr effect. Non-heme oxygen carriers - Hemerythrin and hemocyanin. Nitrogen fixation: Introduction, types of nitrogen fixing microorganisms. Nitrogenase enzyme-Metalclusters in nitrogenase- redox property-Dinitrogen complexes- transition metal complexes of dinitrogen - Nitrogen fixation via nitride formation and reduction of dinitrogen to ammonia.

Unit - III	**BIO-PHYSICALCHEMISTRY**	**(11 Hours)**

Thermodynamicsandbiology-Basicconceptsofstructureandfunctionality- membranes-structure, function transport properties, aspects of electrochemical phenomena– active transport, ionophores, biological energy storage systems–stepwise mechanism of photosynthesis versus potential. Enzymes-Nomenclature and classification, chemical kinetics, the free energy of activation and the effects of catalysts, kinetics of enzyme catalyzed reactions – Michaelis - Menten equation – Effect of pH, temperature onenzymereactions,Factorscontributingtothecatalyticefficiencyofenzymes.

Unit – IV	**BIO-ANALYTICALCHEMISTRY**	**(11 Hours)**

Essentials of trace elements and chemical toxicology: Trace elements in biological system. Metal ion toxicity - classes of toxic metal compounds– detoxification. Metals in medicine: Anti-arthritis drugs – Au and Cu in rheumatoid arthritis – Li in psychiatry – Pt, Au and metallocenes in anti- cancer drugs-metals in radio diagnosis, radiotherapy and magnetic resonance imaging. Transport and storage of metals: Mechanism – Fe, Cu, Zn and V storage and transport – metallothioeins. Molecular mechanism of iron transport across the membrane – sodium and potassium ion pumps.

Contemporary Learning 15 hours

Expert lectures, YouTube Videos, Animations, NPTEL, MOOC videos, online seminars – webinars for strengthening the subject matters. Assignment and class room seminar

Total Lecture hours 45 hours

Reading List(Print and Online)

- https://www.youtube.com/watch?v=iuW3nk5EADg
- https://www.youtube.com/watch?v=aeC7M9PDjQw
- https://www.youtube.com/watch?v=DhwAp6yQHQI
- https://www.youtube.com/watch?v=ZqoX2W1N6l0
- https://www.youtube.com/watch?v=lsNalwRnaq0&list=PLbMVogVj5nJSHhL_cMKfzLv556ddrIT90
- https://www.youtube.com/watch?v=pXztk04J7u0&list=PLFW6lRTa1g83-gUOcT3ay875UG3a9Mu11

Recommended Text/ Reference Books

- Zubay, G,L.(1997); Biochemistry,4thEdition, Brown (WilliamC.) Co
- Nelson, D, L Lehninger, A,L Cox M, M.(2008); Principles of Biochemistry, 5thEdition, NewYork: W.H. Freeman.
- John McMurray, (2008); Organic Chemistry, 8th Edition, Brooks/Cole.
- Finar,I.L.Vol2(2018);Organic Chemistry: Stereochemistry and the Chemistry of Natural product, IIIrd Edition, Pearson
- Williams D.R.(1976); Introduction to Bioinorganic Chemistry, Thomas, ISBN-13:978-0398034221.
- Kaim, W, Schwederski, B, Klein, A.(2013);Bioinorganic chemistry: Inorganic Elements in the chemistry of life,2nd Edition, Wiley.
- DasAsimK.(2007);BioinorganicChemistry,1stEdition,BooksandAllied (P)Limited.
- Mugherjee G.N, Arabinda D,(1993);Elements of Bioinorganic Chemistr y,4thEdition,U.N.Dhur&SonsPvt.Ltd.
- Satake M. Mido Y.(1996); Bioinorganic Chemistry,ISBN81-7141-301- 1,Discovery Publishing House, New Delhi.
- Eichorn,G,(1973); Inorganic Bio-Chemistry Vol. I and II, IVEdition, Elsevier.
- Zhimin,T,(2008); Analysis of Cytotoxicity of Anticancer Drugs,VDM Verlag Dr.Mueller E.K.ISBN:9783639063486,3639063481

Mapping with Programme Outcomes*

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	L	M	L	M	M	M	M	M	L	M
CO2	L	M	L	S	L	M	L	M	M	M
CO3	L	L	M	S	L	L	M	L	L	M
CO4	L	L	L	M	L	M	L	M	L	L
CO5	M	L	M	M	L	L	M	L	L	S

***S-Strong M-Medium L-Low**

Course	**Elective(IV)**
Course Code	**CHE E604**
Title of the Course	**CHEMISTRY OF HETEROCYCLES, ORGANOLITHIUM AND ASYMMETRIC SYNTHESIS**
Credits	**3**
Prerequisites, If any	Students should know about the basic concept of five and six member heterocycles and asymmetric synthesis
Course Objectives	• Understanding different type of heterocycles and their stability • Reactivity pattern of different types of heterocyclic structures • Biological significance of heterocyclic frameworks • To correlate the selectivity and reactivity pattern of heterocycles • Various types of asymmetric synthesis and their synthetic utility • Importance of heterocyclic frame works as drug intermediates

Course Outcomes

On the successful completion of the course, student will be able to:

- **CO1 –** Understand the Importance of heterocycles and their stability (K1 &K2)
- **CO2-** Understand the synthesis and reactivity of heterocycles (K1& K2)
- **CO3-** Understand the significance and utility of heterocycles as drugs/drug in term ediates(K3-K5)
- **CO4-** Understandthesignificanceofnaturallyoccurringheterocyclicframeworks(K4-K6)
- **CO5 –** Understand and design the synthesis of chiral compounds (K3-K6)

K1-Remember;**K2**-Understand;**K3**-Apply;**K4**-Analyze; **K5**-Evaluate;**K6**-Create

Units

Unit - I	**FIVE MEMBER HETEROCYCLES WITH ONE HETEROATOM (11 Hours)**

Furan, pyrrole and thiophene. Synthesis, reactions including lithiation, electrophilic substitution, Nucleophilic substitution, aromatic character, Comparative study of their reactivity.

Unit - II	**FIVE MEMBER HETEROCYCLES WITH TWO HETERO ATOMS (11 Hours)**

Imidazole, oxazole, thiazole and their benzo analogues- Synthesis, reactivity including lithiation and aromatic character. Comparative study oftheir reactivity. Isoxazole, isothiazole and pyrazole- Synthesis and reactivity including lithiation. Indole, benzo[*b*]thiophene and benzo[*b*]furan-Synthesis and reactivity including lithiation.

Unit- III	**SIXMEMBER HETEROCYCLES WITH ONE HETERO ATOM (11 Hours)**
	Pyridine-Synthesis and reactivity; Pyridine-N-oxide-Synthesis and reactivity; quinoline and isoquinoline-synthesis and reactivity. Pyrimidines and Purines-Synthesis and reactivity (lithiation also included)

Unit- IV	ASYMMETRIC SYNTHESIS	(12 Hours)

Selectivity, Resolution-Kinetic resolution reactions, Desymmetrization, Asymmetric Induction, Chiral auxiliary.Generationof Asymmetric synthesis-Substrate-Auxiliary-Reagent and Catalyst Control.

Auxiliary controlled Alkylation of chiral enolates, Evans oxazolidones, chiral hydrozones and chiral imines. Enders RAMP/SAMP and chiral sulfoxide. Asymmetric Diels's Alder reaction, Simmon's- Smith reaction and Aldol reaction.

Asymmetric oxidation [dihydroxylation, epoxidation Sharpless, Jacobsen, Shi] and Asymmetric reduction (Noyori, Corey, Pfaltz) - Boranes reduction.

Contemporary Learning 15 hours

Expert lectures, YouTube Videos, Animations, NPTEL, MOOC videos, online seminars – webinars for strengthening the subject matters. Assignment and class room seminar

Total Lecture hours 45 hours

Reading List (Print and Online)

- Organic Chemistry Portal: https://www.organic- chemistry.org/reactions.htm
- Organic Synthesis Portal: http://www.orgsyn.org/
- Organic Chemistry notes: https://chemistrynotes.com/pages/organic- chemistry-notes
- https://nptel.ac.in/content/storage2/courses/104103071/pdf/mod8.pdf
- YouTube http://Leah4sci.com/chirality
- YouTube: https://www.youtube.com/watch?v=yZ8JDDnyxC4

Recommended Text/Reference Books

- Bansal, R. K (2014); Heterocyclic Chemistry, 5th Edition, NewAge International
- Joule, J. A& Mills, K(2010);HeterocyclicChemistry, 5th Edition, Wiley
- Finar,I.L.Vol2(2018); Organic Chemistry: Stereochemistry and the Chemistry of Natural product, III rd Ed, Pearson
- Clayden, J, Greeves, N. Warren, S. (2017); Organic Chemistry, 2nd Edition, Oxford University Press
- Wade, L. G(2018); Organic Chemistry, 8th Edition, Pearson India
- Graham Solomons, T. W, Fryhle, C. B.(2014); Organic Chemistry, 10th Edition,Wiley
- Li,J.J(2010),Name Reactions in Heterocyclic Chemistry; Wiley (India), ISBN: 978-81-265-2387-0
- Gawley,R.E & Aubé,J (2012); Principles of Asymmetric Synthesis, 2nd Edition, Elsevier
- Caprio,V,Williams, J. M.J(2009); Catalysis in Asymmetric Synthesis, 2nd Edition, Wiley
- Kagan,H.B (1997); Asymmetric Synthesis: Fundamentals and Applications, ISBN-13:978-313137101
- Noyori,R(1994); Asymmetric Catalysis in Organic Synthesis, ISBN: 978-0- 471-57267-1

Mapping with Programme Outcomes*

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M	M	M	S	S	S	L	M	L	L
CO2	L	M	L	S	S	M	M	L	L	L
CO3	M	M	M	S	L	L	L	M	S	S
CO4	L	L	M	S	M	S	M	L	M	M
CO5	L	L	S	S	M	L	M	L	L	L

*S-Strong; M-Medium; L-Low

Semester -III	UOMS 147	SOFTWARE PACKAGE FOR CHEMISTS – MATLAB, ORIGIN AND CHEMDRAW	
Core/Elective /Supportive	SOFTSKILS		Credit-2
Pre-requisite	Basic knowledge on spread sheets, simple matrix formation, programming and chemical structures		

Course Objectives:

The main objectives of this practical course is able to:

- Understand the basic principles of MATLAB, programming and plotting
- Illustrates various plotting functions and formulate the graphs with various fitting analysis
- Draw the simple chemical structure to complex structure and mechanism of various chemical reactions

Expected Course Outcomes (CO):

On the successful completion of the course, student will be able to:

1	Equipthe students with deep knowledge on the matrix programming for various chemical process and convert respective data functions into plots	K1-K3
2	Learn various mathematical functions for various plot functions including 3D plots and gain knowledge on the peak fitting, which is applicable for data analysis	K3-K6
3	Develop the skill to draw various chemical compounds, which is applicable for their projects and research fields	K3-K5

K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 - Create

UNIT:1	MATLAB	10 hours

Basic concepts of MATLAB – Important functions – Addition, multiplication and subtraction of 2x2, 3x3 and 5x5 matrix – Programming in MATLAB – Plot functions and programming – 2-D plots (two vectors) and 3-D plots with three vectors – Additional 2D plots

UNIT:2	ORIGIN	10 hours

Spread sheets – Basic of origin – various mathematical functions for plotting, statistical calculations – Drawing of various plots and its functions – Background correction for various plots – Plot fitting, linear, exponential, Gaussian and Loren Tzian with multiple peak fitting – Bar chats- 3D plotting – error bars in plotting.

UNIT:3	CHEDRAW	10 hours

Basic concepts of chemdraw – Functions – various arrows used in the chemical equations – concept of drawing of chemical equations – Concepts of valance of atoms in a molecules– Drawing of simple molecules, macro molecules, inorganic complex, organometallic complex, peptides and dendrimers – drawing of catalytic cycles and organic reaction mechanism

Total Lecture hours	30 hours

Text Books	
1.	Amos Gilat, MATLAB: An Introduction with Applications, 4ed , 2012
2.	S.N. Alam, S.S. Alam, Understanding Matlab: A Textbook for Beginners,2019, Dreamtech Press
3.	Jake Woods, Chemdraw Professional (Tutorial User Guide) Kindle Edition, 2019.
4.	https://www.originlab.com/doc/Tutorials

Mapping with Programme Outcomes*										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	L	L	S	M	L	L	L	M	L	L
CO2	L	L	L	M	L	L	M	S	S	L
CO3	L	M	L	L	M	M	L	L	S	L

*S-Strong; M-Medium; L-Low

Course code		**ADVANCED METHODS IN MATERIALS CHARACTERISATION**	**Credits – 2**
Skill enhancement course / Value added courses		**Value added course**	
Pre-requisite		Students should know about Materials characterisation to identify the materials structure and nature	

Course Objectives:

The main objectives of this course are to:

- Ability to analyze the materials
- Knowledge of procedures to be used for different types of characterization techniques
- Spectral Interpretation to find out the structure of the materials

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1.	Basic knowledge about characterization of the materials	K1-K2
2.	To learn the procedure of Spectroscopic methods to characterize the materials	K2-K4
3.	To summaries the data and interpret the structure of materials	K3-K4
4.	To assess the critical structure of the materials	K4-K5
5.	To device a protocol to analyze the materials	K5 - K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Valued added course	**Advanced methods in Materials characterisation**	**15 hours**

1. X-Ray Diffraction analysis
2. FT-IR Analysis
3. UV-Vis Analysis
4. BET and Chemisorption Analysis
5. Thermogravimetric Analysis
6. Scanning electron microscopy
7. Solid-NMR spectroscopy

SEMESTER IV

Course	**Core**
Course Code	**CHE C206**
Title of the Course	**ORBITAL SYMMETRY, PHOTOCHEMISTRY, AROMATICITY AND NON-CONVENTIONAL TECHNIQUES IN ORGANIC SYNTHESIS**
Credits	**4**
Pre-requisites, if any	Basic knowledge on molecular orbitals, photochemistry and non- conventional techniques will be essential.
Course Objectives	The main objectives of this course are to: • Understand the concept of pericyclic reactions and analysis of the symmetry of the molecular orbitals to predict allowed and forbidden reactions. • Able to predict the con-rotatory and dis-rotatory electrocyclic ring- opening and ring-closure reactions along with stereochemical outcome of the reactions under thermal and photochemical conditions. • Understand the mechanisms of different types of pericyclic reaction: cycloadditions, electrocylic reactions, sigmatropic reactions and group transfer reactions. • Realize the concept of photochemistry and reactions along with synthetic utility of various Photochemical Reactions • To learn criteria for aromaticity and effect of structure on reactivity of the organic compounds • To understand basic principles (green chemistry/atom economy) and applications of non-conventional techniques and their comparison with conventional methods of organic synthesis
Course Outcomes	On the successful completion of the course, student will be able to:
CO 1	Learn about different aspects of pericyclic reactions and skills for the utilization of these reactions in the organic synthesis (K1-K5)
CO 2	Able to predict the relevant *con*-rotatory and *dis*-rotatory rotation in electrocyclic ring-opening and ring-closure reactions (K2-K4)
CO 3	To understand reaction feasibility and selectivity by applying the Woodward–Hoffmann rules (K1-K6)
CO 4	Understand the concepts of photochemistry and to study the synthesis & applications of various types of photochemical reactions (K1-K5)
CO 5	Able to identify aromatic, non-aromatic and anti-aromatic systems; To understand basic principles, importance and applications of non- conventional techniques (K1-K6)

K1-Remember; **K2**-Understand; **K3**-Apply; **K4**-Analyze; **K5**-Evaluate; **K6**-Create

Units

Unit - I	**BASIC CONCEPT OF MOLECULAR ORBITAL THEORY AND PERICYCLIC REACTION IN ORGANIC REACTIONS**	**(15 Hrs).**

Basic concept of conservation of orbital symmetry, electrocyclic and cycloaddition reactions, correlation diagram, FMO, PMO treatment. Ring closure reaction focusing system such as butadiene, pentadienylanion, pentadienyl cation, allyl anion, allyl cation, hexatriene, heptatrienyl cation, heptatrienyl anion, and octatetraene. Application of electrocyclic reactions in synthesis of terpenes, steroids and alkaloids. Stereoselectivity, regioselectivity, periselectivity and site selectivity in cycloaddition. 1,3- dipolar cycloaddition, click reaction, 2 + 2, 4 + 2, 4 + 4, 6 + 2, and 6 + 4 cycloaddition reactions. Secondary orbital interactions in cycloadditions.

Normal and Inverse electron demand Diels-Alder reaction.

Unit- II	**PERICYCLIC REACTION IN ORGANIC REACTIONS**	**(15 Hrs).**

Sigmatropic and Cheleotropic reactions, correlation diagram, FMO & PMO treatment. Hydrogen migration. Carbon migration with symmetric and asymmetric centre. C-C bond migration, Orbital treatment for Cope, Claisen and 2,3-Sigmatropic reaction. Extrusion of CO2, CO, SO2 orbital symmetry treatment. Applications of Sigmatropic and Cheleotropic reactions in organicsynthesis. Combination of cheleotropic reaction with cycloaddition

Unit - III	**ORGANIC PHOTOCHEMISTRY**	**(15 Hrs).**

Organic photochemistry: Principles of photochemistry, Fate of excited state: Physical and Chemical process; [2 + 2] photochemical cycloaddition; Paterno-Büchi reaction; Photochemistry of cyclohexadienones, Norrish type I & II reactions. Oxidation and reduction reactions: Reaction with singlet oxygen. Selected reactions: Photo Fries, Barton, di-π methane, oxa & aza di- π methane rearrangements

Unit - IV	**AROMATICITY AND NON-CONVENTIONAL TECHNIQUES**	**(15 Hrs).**

Aromaticity - Study of benzenoid and non-benzenoids compounds in the light of Huckel's rule. Aromaticity of annulenes.

Basic principles of non-conventional techniques: Microwave, Sonication, Ball-milling techniques in organic reaction. Organic reactions in aqueous phase; Ionic liquids and their applications in organic synthesis. Tandem, cascade and domino reactions in organic synthesis. Concept of green chemistry. Atom economy.

Contemporary Learning

Expert lectures, YouTube Videos, Animations, NPTEL, MOOC videos, online seminars

– webinars for strengthening the subject matters. Assignment and class room seminar

Total Lecture hours **60 hours**

Reading List (Print and Online)

- Organic Chemistry Portal: https://organic chemistry data.org/ hansreich/ resources/ pericyclic/ ?page=pericyclic00%2F
- Organic Synthesis Portal: http://www.stereoelectronics.org/webPR/PRhome.html

  Organic Chemistry Videos:

- https://nptel.ac.in/courses/104/106/104106077/
- https://nptel.ac.in/courses/104/105/104105038/
- https://courses.mookit.in/course/course009

Recommended Text/Reference Books

- Singh, J (2019); Photochemistry and Pericyclic Reactions, New Age International Publishers.
- Sankararaman, S (2005); Pericyclic Reactions- A Textbook: Reactions, Applications and Theory, Wiley-VCH.
- Halton, B & Coxon, J. M (2011); Organic Photochemistry, Cambridge University Press.
- Kumar, S. Kumar, V & Singh, S. P (2015); Pericyclic Reactions, IEdition, Academic Press.
- Norman, R.O.C & Coxon, J. M (1993); Principles of Organic Synthesis,II Edition, CRC Press.
- Finar, I. L. (2002); Organic Chemistry Vol 2: Stereochemistry and the Chemistry of Natural product, 5th Edition, Pearson Education India. Bruice, P. Y. (2014); Organic Chemistry, 7th Edition, Dorling Kindersley Pvt Ltd
- Fleming, I (2009); Molecular Orbitals and Organic Chemical Reactions-Student Edition, Wiley.
- Carey, F. A. & Sundberg, R. J. (2008); Advanced Organic Chemistry-Part A and B, V Edition, Springer.
- Clayden, J, Greeves, N, Warren, S & Wothers, P (2000); Organic Chemistry, Oxford University Press.
- Warren, S (2008) Organic Synthesis, 2 Edition, Wiley.
- Corey, E. J & Cheng, X-M (1995); The Logics of Chemical Synthesis,I Edition, Wiley.

Mapping with Programme Outcomes*

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	L	M	L	S	S	M	L	M	L	M
CO2	M	M	L	S	S	M	M	L	L	L
CO3	L	M	M	S	M	M	L	L	L	M
CO4	M	M	M	S	S	M	M	L	L	S
CO5	L	M	M	S	M	L	M	L	L	S

***S-Strong M-Medium L-Low**

Course	**Core**	
Course Code	**CHE C207**	
Title of the Course	**CHEMISTRY OF NATURAL PRODUCTS**	
Credits	**4**	
Pre-requisites, if any	Students should know about the routine organic name reactions and basic synthetic transformations	
Course Objectives	• Understanding different types of Total Synthesis and their importance • Realizing the importance of Natural Products and their Biological Significance • Acquiring knowledge to design any Targeted Synthesis • Analyzing Retrosynthetic pattern and designing Total Synthesis of natural products • Understanding the role of key reaction in designing skeletal framework of natural products • Understanding the biosynthetic pattern of natural products	
Course Outcomes	On the successful completion of the course, student will be able to:	
CO 1	Design retro-synthetic pattern of any given target compound (K1-K3)	
CO 2	Well versed with design and total synthesis of natural products (K2-K4)	
CO 3	Understand the significance of the key reactions in assembling skeletal framework of natural products (K3-K5)	
CO 4	Learn about the synthetic utility of organic reactions to achieve the total synthesis of natural products (K2-K6)	
CO 5	Understand the biosynthetic pattern of any given natural products (K2- K6)	
K1-Remember; **K2**-Understand; **K3-**Apply; **K4**-Analyze; **K5**-Evaluate; **K6**-Create		
Units		
Unit - I	**ALKALOIDS**	**(15 Hrs).**
Total Synthesis of the following alkaloids: Preussin, Swainsonine, Horsifiline, Epibatidine, Camptothecin, Ellipticine, Ibogamine and Reserpine (Racemic as well as Chiral Syntheses wherever applicable)		
Unit-II	**STEROIDS**	**(15 Hrs).**
Total Synthesis of Steroids: Androsterone, Testosterone, Estrone, Estradiol, 2-Methoxyestradiol and Progesterone (Racemic as well as Chiral Synthesis wherever applicable). Conversion of Cholesterol into the above mentioned steroids. Chiral as well as Racemic synthesis of Prostaglandins PGE1, PGE2 and PGE3		
Unit - III	**TERPENES**	**(15 Hrs).**
Total Synthesis of Terpenes: Cedrene, Caryophyllene and Longifolene (Racemic as well as Chiral Synthesis wherever applicable). Menthol, Hirsutene, Capnellene, Silphiperfolene and 5-Oxosilphiperfolene (Racemic as well as Chiral Syntheses wherever applicable).		

Unit - IV	BIOSYNTHESIS	(15 Hrs).
Biosynthesis of Alkaloids, Steroids, Terpenes and Prostaglandins.		
Contemporary Learning Expert lectures, YouTube Videos, Animations, NPTEL, MOOC videos, online seminars – webinars for strengthening the subject matters. Assignment and class room seminar		
	Total Lecture hours	**60 hours**

Reading List (Print and Online)

- https://organicchemistrydata.org/hansreich/resources/syntheses/?page=a bscisic-acid-constantino%2F
- https://people.chem.umass.edu/mcdaniel/chem269/experiments/trimyrist in/Natural-product-synthesis-an-art.pdf
- https://authors.library.caltech.edu/25034/31/BPOCchapter30.pdf
- https://w3pharm.u-shizuoka-ken.ac.jp/~yakuzo/pass-eng/pdf-eng.html

Recommended Text/ Reference Books

- Finar, I. L. Vol 2 (2018); Organic Chemistry: Stereochemistry and the Chemistry of Natural product, IIIrd Edition, Pearson
- Carey, F. A. & Sundberg, R. J. (2015); Advanced Organic Chemistry-Part A & B, Vth Edition, Springer, ISBN 978-81-322-0426-8
- Norman R. O. C & Coxon, J. (2017); Principles of Organic Synthesis, 3rd Edition, CRC Press
- Wyatt, P & Warren, S. (2013); Organic Synthesis: Strategy and Control, Wiley
- Corey, E. J & Cheng, X.-M (2011); The Logics of Chemical Synthesis, VCH, ISBN: 978-81-265-3034-2
- Nicolau, K. C & Sorenson, E. J (1996); Classics in Total Synthesis, VCH, ISBN: 978-3-527-29231-8

Mapping with Programme Outcomes*

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M	S	M	S	M	S	L	M	M	S
CO2	M	S	L	S	S	M	L	M	L	M
CO3	L	S	L	S	S	M	M	L	M	M
CO4	M	S	L	S	S	S	M	L	M	M
CO5	L	M	S	M	S	M	L	L	L	M

*S-Strong; M-Medium; L-Low

Course	**Elective (V)**
Course Code	**CHE E204**
Title of the Course	**MODERN SYNTHETIC METHODOLOGY AND SPECTROMETRIC IDENTIFICATION OF ORGANIC COMPOUNDS**
Credits	**3**
Pre-requisites, if any	Basic idea about the concept of retrosynthetic analysis and synthetic utility of common organic reactions are essential. Interpretation of UV, IR, NMR and Mass spectral of simple organic compounds will be an added advantage.
Course Objectives	• To understand the concept of retrosynthetic analysis which is heart ofthe organic synthesis • To study about various types of 1,3-dipolar cycloaddition andcyclization methodologies • To study the concept of domino and tandem reactions along with theirsynthetic utility. • The students are expected to learn organic spectroscopy techniques todetermine the structure of complex organic compounds • To understand 2D-NMR techniques and interpretation for structurallycomplex Organic compounds.
Course Outcomes	On the successful completion of the course, student will be able to:
CO 1	Understand the principles and application of tandem, cascade and dominoreactions in organic synthesis (K2-K6)
CO 2	Apply of retrosynthetic analysis for synthesis of organic compounds (K2 andK3)
CO 3	Understand the synthetic utility and applications of various types ofcyclization as well as 1,3-dipolar cycloaddition reactions (K2-K6)
CO 4	Student can able to solve the problems related to structure of organic compounds using spectral data (K1-K5) and apply organic spectroscopy knowledge to their research problems (K2-K4)
CO 5	To differentiate isomeric compounds using 2 D NMR Spectra of Organic Compounds COSY (HSQC, HMBC) and NOESY (K2-K5)

K1-Remember; **K2**-Understand; **K3-**Apply; **K4**-Analyze; **K5**-Evaluate; **K6**-Create

Units

Unit - I	**RETROSYNTHESIS, CYCLIZATION & TANDEM REACTIONS**	**(12 Hrs).**

Synthons (acceptor and donor)-Retrosynthetic analysis, Umpolung, Anti-thesis.

Synthetic utility of 1,3-dithiane and TOSMIC. Various types of cyclization and ring formation reaction: anionic, cationic, radical and transition metal mediated cyclizations. Concept of Tandem, cascade and domino reactions in organic synthesis.

Unit - II	CYCLOADDITION & ANNULATION REACTIONS	(11 Hrs).
1,3-Dipolar cycloaddition methodologies (Azide, nitrile oxide, azomethine ylides and carbonyl ylides). Annulation using phosphorous Ylides. Sulfur and Sulfonium ylides and their reactions, C=C bond forming reactions (Wittig, Wittig-Horner, Peterson and Julia olefination). Protective groups in Organic Synthesis		
Unit - III	**ADVANCED SPECTRAL TECHNIQUES FOR STRUCTURAL CHARACTERIZATION OF ORGANIC COMPOUNDS**	**(11 Hrs).**
UV Spectra of organic molecules-Types of electronic transitions and Substituent and Solvent effects on λmax values of organic compounds. Application of Woodward- Fieser rules for calculation of λmax values of dienes as well as α,β-unsaturated ketones. IR spectroscopy–Position of IR absorption frequencies of organic compounds. NMR Spectroscopy- Interpretation of ^{1}H and ^{13}C NMR and DEPT spectral data of organic compounds. Illustration of 2 D NMR Spectra of Organic Compounds COSY(HOMO, HETERO), HSQC, HMBC. NOE and NOESY of Organic Compounds.		
Unit - IV	**DETERMINATION OF STRUCTURE OF ORGANIC COMPOUNDSUSING SPECTRAL DATA**	**(11 Hrs).**
Interpretation of mass spectral splitting pattern of organic compounds– Determination of structure of organic compounds using UV, IR, NMR andMass spectral data.		
Contemporary Learning 15 hours Expert lectures, YouTube Videos, Animations, NPTEL, MOOC videos, online seminars – webinars for strengthening the subject matters. Assignment and class room seminar		
	Total Lecture hours	**45 hours**

Reading List (Print and Online)

- https://www.slideshare.net/guest824336/introduction-to-spectroscopy
- https://nptel.ac.in/courses/104/105/104105087/
- https://www.youtube.com/watch?v=WKP0m1DuBag
- https://www.youtube.com/watch?v=0_AxTP0HsuA
- https://www.youtube.com/watch?v=umgfQyQCLSQ
- https://www.slideshare.net/anthonycrasto64/2d-nmr-organic- spectroscopy-by-dr-anthony-crasto
- https://www.youtube.com/watch?v=g_u1tR0cZHE
- https://www.youtube.com/watch?v=ElNtU_BB1fs
- https://www.vanderbilt.edu/AnS/Chemistry/Rizzo/Chem220b/Ch13.pdf

Recommended Text/ Reference Books

- Carey, F. A. & Sund berg, R. J. (2015); Advanced Organic Chemistry-PartA & B, Vth Edition Springer, ISBN 978-81-322-0426-8
- Norman R. O. C & Coxon, J. (2017); Principles of Organic Synthesis, 3rdEdition, CRC Press
- Wyatt, P & Warren, S. (2013); Organic Synthesis: Strategy and Control,Wiley
- Kalsi, P. S (2017); Organic Synthesis through Disconnection Approach,ISBN-13: 978-938599846
- Warren, S. & Wyat. P. (2008); Organic Synthesis: Disconnection Approach, II Edition, Wiley
- Corey, E. J & Cheng, X.-M (2011); The Logics of Chemical Synthesis,VCH, ISBN: 978-81-265-3034-2
- Silverstein, R. M, Webster, F. X, Kiemble, D. J, Bryce, D. L (2015); Spectrometric Identification of Organic Compounds, 8th Edition, Wiley
- Pavia, L, Lapman, G. M, Kriz, S, Vyvyan, J.-R (2015); Introduction to Spectroscopy, Cengage Learning, ISBN 13: 978-81-315-2916-4
- Lambert, J. B, Shurvell, H. F, Lightner, D. A, Graham Cooks, R (1998);Organic Structural Spectroscopy, Prentice Hall, ISBN: 0-13-258690-8
- Macomber, R. S (1998); A complete introduction to Modern NMR Spectroscopy, John Wiley, ISBN: 0-471-15736-8

Mapping with Programme Outcomes*

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M	S	M	S	M	S	M	M	M	M
CO2	M	M	L	S	S	M	L	M	L	L
CO3	S	S	L	S	S	S	L	L	M	L
CO4	M	S	S	S	S	S	M	L	M	S
CO5	L	S	M	S	S	M	L	L	L	M

*S-Strong; M-Medium; L-Low

Course	**Elective (VI)**
Course Code	**CHE E603**
Title of the Course	**NOVEL REAGENTS IN ORGANIC SYNTHESIS**
Credits	**3**
Pre-requisites, if any	Students should learn about the basics of metal-catalyzed organic synthesis, including understanding mechanism, role of catalyst and other additives. In addition, students must be aware of the difference in the reaction mechanism involving typical organic reaction Vs carbon-metal catalyzed reaction.
Course Objectives	• To understand various types of metal-catalyzed organic syntheses, including Ring Closing Metathesis, synthesis of cyclic and acyclic molecules, new carbon-carbon & C-N bond formation and C-H activation. • To know utility of silicon compounds in the generation of reactive diene like ortho-quinodimethane and its application. • To understand the mechanism and synthetic application of trifluoromethylation using Ruppert-Prakash reagent • To study the correlation between structure, properties and reactivity of various types metal carbon bond compounds • Understanding the homogeneous and heterogeneous metal-carbon bond catalyzed reactions and their mechanism
Course Outcomes	On the successful completion of the course, the students will acquire knowledge of:
CO 1	Metal-catalyzed organic reactions and their synthetic utility (K1-K4)
CO 2	Study the various types of carbon-carbon formation reactions and synthesis of cyclic and acyclic frameworks (K2-K5)
CO 3	To study specific reaction by comparing theoretical and/or experimental data (K2-K4)
CO 4	To get new ideas or innovation in the field of organometallic chemistry and their applications in organic synthesis (K1-K6)
CO 5	To design suitable organometallic compounds for activation of highly stable and symmetrical molecules such as CO2 and methane for the synthesis of industrially important intermediates/compounds (K3-K6)
K1-Remember; **K2**-Understand; **K3-**Apply; **K4**-Analyze; **K5**-Evaluate; **K6**-Create	

Units		
Unit - I	**APPLICATION OF FOLLOWING D & P BLOCK ELEMENTS IN ORGANIC SYNTHESIS**	**(12 Hrs).**
Synthetic utility of Samarium iodide, Ruthenium (Ring Closing Metathesis- RCM) Zirconium (Schwartz's reagent) and Cobalt (Pauson-Khand reaction and Nicholas reaction) in organic synthesis. Asymmetric Reformatsky reaction using Samarium. Homogeneous hydrogenation. Application of Titanium in organic synthesis – Mc Murry coupling. Tin in organic synthesis. Use of – Bu3SnH and Tin mediated carbon-carbon bond formation in the synthesis of cyclic and acyclic molecules.		
Unit - II	**ROLE OF PALLADIUM AND NICKEL CATALYST IN ORGANIC REACTIONS.**	**(11 Hrs).**
Both Pd(0), Ni(0) and Pd(II), Ni(II) complexes are included. Typical reaction involving Heck, Negishi, Suzuki-Miyaura, Kumada, Sonogashira, Stille and Hiyama coupling for the carbon-carbon bond formation. Buchwald-Hartwig coupling for the carbon-heteroatom bond formation reactions. Transition-metal catalyzed C- H bond activation in organic synthesis.		
Unit - III	**SILICON COMPOUNDS**	**(11 Hrs).**
Use of trimethylsilyl chloride and t-butyldimethylsilyl chloride as a productive group. Use of trimethylsilyl iodide and trimethylsilyl cyanide. Vinylsilanes-Silyl Peterson olefination reaction. Trichloro silane and triethyl silane as reducing agents. Role of trimethylsilyl group in the generation of reactive diene like ortho-quinodimethane. Generation and reactions of α and β silyl-carbanions. Conjugate addition using lithium organo cuprates (Gilman's reagent) 1,2 vs 1,4 addition. Umpolung-aldehyde ketone and acid synthesis from 1,3 dithiane. Trifluoromethylation using Ruppert-Prakash reagent.		
Unit - IV	**METAL CARBONYL REACTIONS**	**(11 Hrs).**
Substituted metal carbonyls, cis-labilising effect, metal-metal bonded carbonyl and cluster-insertion reaction-CO insertion, CO2 insertion, SO2 insertion, methyl migration, phenyl migration, carbon hydrogen bond activation-Oxo reaction, Wacker process and Reppe synthesis- photochemical reaction of metal carbonyls-Chromium, Manganese, Iron, Rhenium and Ruthenium. Oxidative addition-Hydrogen, organic halides- Fischer Tropsh process.		
Contemporary Learning 15 hours Expert lectures, YouTube Videos, Animations, NPTEL, MOOC videos, online seminars – webinars for strengthening the subject matters. Assignment and class room seminar		
	Total Lecture hours	**45 hours**

Reading List (Print and Online)

- https://www.youtube.com/watch?v=s8VqAqibrr8
- https://www.youtube.com/watch?v=YAkAKsHsLyU
- https://www.youtube.com/watch?v=8pqCeN7GoMc&list=PLbMVogVj5nJR65WP0IQaDCBtCRq_HAuI

Recommended Text/Reference Books

- Colvin, E. W. (1981); Silicon in Organic Synthesis, 1st Edition, Elsevier
- Carruthers, W. (2015); Modern Methods of Organic Synthesis, 4th Edition, Cambridge University Press
- Smith,M, (2016); Organic Synthesis, 4th Edition, Academic Press
- Huheey, J. E, (2014); Inorganic Chemistry, 4th Edition, Pearson
- Purcell K. F, Kotz, J. C. (1980); Inorganic Chemistry, 1st Edition, Thomson Learning
- Weber, W. P. (1983); Silicon Reagents for Organic Synthesis, Springer- Verlag, ISBN 978-3-642-68661-0
- Tsuji, J. (2004); Palladium Reagents and Catalysts, Wiley, ISBN: 978-0- 470-85032-9
- Hegedus, L. S. (2009); Transition Metals in the Synthesis of Complex Organic Molecules, 3rd Edition, University Science Books
- Crabtree. R. H. (2019); The Organometallic Chemistry of the Transition Metals, Wiley

Mapping with Programme Outcomes*

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M	M	L	S	M	M	M	M	L	L
CO2	M	M	M	S	S	M	M	L	M	M
CO3	M	M	M	M	S	M	S	L	M	L
CO4	L	M	L	S	M	L	M	M	L	L
CO5	M	M	M	S	M	L	M	L	M	M

***S-Strong M-Medium L-Low**

Core/ Elective/ Supportive	Course Code	Title of the Course – Soft skill	Credits
Supportive	**UOMS117**	**CHEMISTRY DATABASES – SCIFINDER, MENDELEY, SCOPUS, WEB OF SCIENCE AND GOOGLE SCHOLAR**	**2**

Course Objectives:

The main objectives of this course are,

- To analyze, categorize and refine the Scifinder database based on the different components of research article.
- To learn Mendeley for the management of references and Scopus for analysis of research database.
- To train Web of Science and Google Scholar database to analyze, categorize and refine the different components of research articles.
- To know the systematic procedure for collecting literature in the identified research area using scientific resources.
- To develop skill for creating a new synthetic scheme or protocol based on the literature search.

Pre-requisites, if any:

Students should know the components of journal and research article.

Course Outcomes:

After completion of this course successfully, the students will be able to,

- **CO1:** Recall different components of research article and literature search. (**K1**)
- **CO2:** Understand the importance of SciFinder, Mendeley, Scopus, Web of Science and Google Scholar in scientific data collection. (**K2**)
- **CO3:** Apply the systematic procedure for collecting literature in the identified research area using different scientific resources. (**K3**)
- **CO4:** Analyze and Evaluate research problems using different scientific data collection resources. (**K4** and **K5**).
- **CO5:** Create new research problems using the systematic collection of literatures. (**K6**)

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

UNITS

UNIT - I: SciFinder Database **(6 Hours)**

Components of SciFinder, Analyzing, Categorizing and Refining the Scifinder database based on Research topic, Author name, Company name, Molecular formula, Molecular structure, Chemical reaction, Journals, Patents, Physical Properties. Importance of Scifinder database in planning a research problem.

UNIT - II: Mendeley **(6 Hours)**

Mendeley Reference Manager – Application; Reference file - Collection, Insertion, Library organization, Notebook; Citation database - analyze- visualize - research. h- Index, h- graph Cite Score, SJR (SCImago Journal Rank) and SNIP (Source Normalized Impact Paper). ORCHID, Citable documents, Citations, Self Citations - Document types- Alternative Metrics. Overview, citations, Scholarly commentary, Citation Benchmarking, Advanced Search,

UNIT - III: Scopus **(6 Hours)**

Components of Scopus, Analyzing, Categorizing and Refining the Scopus database based on different options. Importance of Scopus database in planning a research problem. Proximity characters in Scopus.

UNIT - IV: Web of Science **(6 Hours)**

Web of Science – History, Components of Web of Science, Analyzing, Categorizing and Refining the Web of Science database based on different options. Importance of Web of Science database in planning a research problem.

UNIT-V: Google Scholar **(6 Hours)**

Google Scholar – History, Features and specifications, Ranking algorithm, Groups and access to literature - Limitations and citations, Search engine. Citations, H-index and i10 index – Keywords search - Steps to create google scholar ID and Addition/Removal of articles – Profile updates – My library- Metrics- Alerts -Merits and Demerits of Google Scholar ID.

References:

1. https://www.cas.org/support/training/scifinder
2. https://www.cas.org/sites/default/files/documents/scifinder_search_references_workbook.pdf
3. https://www.mendeley.com/reference-management/mendeley-cite
4. https://www.elsevier.com/solutions/scopus
5. https://clarivate.libguides.com/webofscienceplatform/alldb
6. Jensenius, F., Htun, M., Samuels, D., Singer, D., Lawrence, A., &Chwe, M. (2018). "The Benefits and Pitfalls of Google Scholar" PS: Political Science & Politics, 51(4), 820-824.

Mapping with Programme Outcomes: (S-Strong, M-Medium, L-Low)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	M	S	L	M	S	S	S	M	M	L
CO 2	S	M	S	L	L	M	S	M	L	S
CO 3	M	S	L	M	S	M	S	M	M	S
CO 4	S	S	M	S	M	S	S	L	S	M
CO 5	S	M	S	M	S	S	M	M	M	L