TECHNO INDIA UNIVERSITY

WEST BENGAL

Detail Syllabus
(2024-2025)
For
Two Year
M. Sc. Chemistry

Department of Chemistry

Techno India University, West Bengal

EM-4/1, Sector-V, Salt Lake, Kolkata-700091

Course Structure
(2024-2025)
Syllabus

Semester-I

Course Code	Course Title	L	T	P	Credit
TIU-PCH-T107	Analytical Chemistry	3	0	0	3
TIU-PCH-T105	Inorganic Chemistry	3	0	0	3
TIU-PCH-T103	Organic Chemistry	3	0	0	3
TIU-PCH-T101	Physical Chemistry	3	0	0	3
TIU-PCH-L115	Inorganic Chemistry Lab-I	0	0	4	2
TIU-PCH-L113	Organic Chemistry Lab-I	0	0	4	2
TIU-PCH-L111	Physical Chemistry Lab-I	0	0	4	2
TIU-PCH-L121	Fundamentals of AI in Chemistry	1	0	2	2
	Total	13	0	14	**20**

Semester-II

Course Code	Course Title	L	T	P	Credit
TIU-PCH-T132	Biological Chemistry	3	0	0	3
TIU-PCH-T106	Inorganic Chemistry	3	0	0	3
TIU-PCH-T104	Organic Chemistry	3	0	0	3
TIU-PCH-T102	Physical Chemistry	3	0	0	3
TIU-PCH-L116	Inorganic Chemistry Lab-II	0	0	4	2
TIU-PCH-L114	Organic Chemistry Lab-II	0	0	4	2
TIU-PCH-L112	Physical Chemistry Lab-II	0	0	4	2
TIU-PCH-L122	Application of AI in Chemistry	1	0	2	2
	Total	13	0	14	**20**

Semester III

Course Code	Course Title	L	T	P	Credit
TIU-PCH-T223	Spectroscopy-I and Polymers	3	1	0	4
TIU-PCH-T231	Industrial Chemistry#	3	1	0	4
TIU-PCH-T233	Environmental Chemistry#				
TIU-PCH-T235	Green Chemistry#				
TIU-PCH-T215	Specialization Paper-I (I)*	3	1	0	4
TIU-PCH-T211	Specialization Paper-I (O)*				
TIU-PCH-T207	Specialization Paper-I (P)*				
TIU-PCH-T217	Specialization Paper-II (I)*	3	1	0	4
TIU-PCH-T213	Specialization Paper-II (O)*				
TIU-PCH-T209	Specialization Paper-II (P)*				
TIU-PCH-L211	Advance Inorganic Chemistry Lab (I)*	0	0	8	4
TIU-PCH-L213	Advance Organic Chemistry Lab (O)*				
TIU-PCH-L215	Advance Physical Chemistry Lab (P)*				
TIU-PCH-P291	Project-I	0	0	4	4
Total		12	4	12	**24**

* I-Inorganic Chemistry   O-Organic Chemistry   P-Physical Chemistry

***Specialization Papers (I and II)**
Physical Chemistry (P)
1. TIU-PCH-T207**:** Quantum Mechanics and Chemical Applications of Group Theory
2. TIU-PCH-T209**:** Electrochemistry

Organic Chemistry (O)
1. TIU-PCH-T211**:** Advanced Organic Chemistry-I
2. TIU-PCH-T213**:** Advanced Organic Chemistry-II

Inorganic Chemistry (I)
1. TIU-PCH-T215**:** Organometallic Chemistry of Transition Metals
2. TIU-PCH-T217**:**Advanced Bioinorganic Chemistry

#Elective Paper-I:

1. Environmental Chemistry
2. Industrial Chemistry
3. Green Chemistry

Semester-IV

Course Code	Course Title	L	T	P	Credit
TIU-PCH-T224	Spectroscopy-II and Supramolecules	3	1	0	4
TIU-PCH-T232	Advanced Materials Chemistry#	3	1	0	4
TIU-PCH-T234	Energy Conversion and Storage#				
TIU-PCH-T236	Chemical Biology#				
TIU-PCH-T238	Medicinal Chemistry#				
TIU-PCH-T210	Specialization Paper-III (I)*	3	1	0	4
TIU-PCH-T214	Specialization Paper-III (O)*				
TIU-PCH-T212	Specialization Paper-III (P)*				
TIU-PCH-P292	Project-II	0	0	12	6
	Total	9	3	12	**18**

* I-Inorganic Chemistry O-Organic Chemistry P-Physical Chemistry

***Specialization Paper (III)**
Physical Chemistry (I)
TIU-PCH-T212: Advanced Solid State Chemistry and Spectroscopy

Organic Chemistry (O)
TIU-PCH-T214: Advanced Organic Chemistry-III

Inorganic Chemistry (I)
TIU-PCH-T210: Inorganic Rings, Chains, and Clusters

#Elective Paper-II:
1. Advanced Materials Chemistry
2. Energy Conversion and Storage
3. Chemical Biology
4. Medicinal Chemistry

Note: Highlighted courses were added to the curriculum in the respective semesters

Program:M. Sc. Chemistry	**Year, Semester:** 1st Yr., 1st Sem.
Course Title:Analytical Chemistry	**Subject Code:**TIU-PCH-T107
Contact Hours/Week: 3–0–0 (L–T–P)	**Credit:** 3

COURSE OBJECTIVE:

Enable the student to:

1. Learn analytical methods for data organization, validation, and chemometrics.
2. Understand chemical equilibria in acid-base, redox, complexometric, and precipitation systems.
3. Explore sensing and separation techniques in chemical sensors and chromatography.

COURSE OUTCOME:

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

CO-1:	**Remember** the fundamental principles and objectives of analytical statistics, including method selection, sample processing, and data organization.	K1
CO-2:	**Understand** the concepts of chemical equilibria in aqueous media, including acid-base, redox, and precipitation reactions.	K2
CO-3:	**Understand** the different types of chemical sensors and their working principles based on modes of transduction and chemically sensitive materials.	K2
CO-4:	**Apply**the application of charge balance, mass balance, and equilibrium calculations in acid-base titrations.	K3
CO-5:	**Apply** chromatographic techniques such as paper chromatography, column chromatography, and HPLC for the separation and analysis of chemical compounds.	K3
CO-6:	**Analyze** the role of chemometrics and good laboratory practices in ensuring accuracy and reliability in analytical chemistry.	K4

COURSE CONTENT:

MODULE 1:	**Analytical Statistics**	**8 Hours**
Scope and objectives. Classification of analytical methods, Method selection, Sample processing, Steps in a quantitative analysis, Quantitative range (bispartite classification), Data organization, Analytical validations, Limit of detection and limit of quantization. The tools of analytical		

chemistry and good lab practices. Analytical chemometrics.		
MODULE 2:	**Treatment of Equilibria**	**20 Hours**
Solvents and solutions, General treatment of equilibria in aqueous medium involving monoprotic weak acid, weak base, and salts of weak acids and weak bases. Activity and concentration, Effect of electrolytes on chemical equilibria, Calculation of *p*H, Charge balance and mass balance equations, Acid-base titrations, Titration curves, theory of pH indicators. Complexation equilibria and complexometrictitrations. Redox equilibria and redox titration, Theory of redox indicators. Precipitation reactions and precipitation titrations, theory of adsorption indicators.		
MODULE 3:	**Chemical Sensors and Separation Techniques**	**8 Hours**
Least Squares method - Multivariate Linear Regression - Perceptron, Multiple Layer Perceptron - Support Vector Machines - Obtaining probabilities from Linear classifiers - Kernel methods for non-Linearity - Probabilistic models for categorical data – Naïve Bayes Classifier		
MODULE 4:	**Chromatographic Techniques**	**6 Hours**
Principles of chromatography, Classification of chromatography, Paper chromatography, Techniques of column chromatography, Thin layer chromatography, Gas Chromatography, High-performance liquid chromatography, Ion chromatography.		
TOTAL LECTURES		**42 Hours**

BOOKS

1. D. A. Skoog, Principles of Instrumental Analysis, 7th Edition (2018), Cengage Learning, Boston, MA.
2. D. A. Skoog, D.M. West, F.J. Holler, S.R. Crouch, Analytical Chemistry: An Introduction, 10th Edition (2013), Cengage Learning, Boston, MA.
3. Nirmalendu Nath, Kakoli Upadhyay, Avinash Upadhyay, Biophysical Chemistry: Principles and Techniques, 2nd Edition (2021), Himalaya Publishing House, New Delhi.
4. J. H. Kennedy, Analytical Chemistry: Principles, 3rd Edition (2005), Brooks/Cole, Cengage Learning, Belmont, CA.
5. G. W. Ewing, Instrumental Methods of Chemical Analysis, 6th Edition (1985), McGraw Hill Education, New York.
6. R. L. Pecsok, L. D. Shields, T. Cairns, and L.C. McWilliam, Modern Methods of Chemical Analysis, 3rd Edition (1994), John Wiley & Sons, New York.
7. G. D. Christian, Analytical Chemistry, 7th Edition (2003), John Wiley & Sons, New York.

CO-PO MAPPING

	PROGRAM OUTCOMES (PO)								**PROGRAM SPECIFIC OUTCOMES (PSO)**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**1**	**2**	**3**
CO-1	3	2	1	1	1	--	--	1	2	1	1
CO-2	3	2	2	1	1	--	--	1	2	1	1
CO-3	3	2	2	1	1	--	--	1	2	1	1
CO-4	3	2	2	1	1	--	--	1	2	1	1
CO-5	3	2	2	1	1	--	--	1	2	1	1

CO-6	3	2	2	2	1	--	1	1	2	1	1
Average	**3**	**2**	**1.83**	**1.16**	**1**	**--**	**1**	**1**	**2**	**1**	**1**

Program: M. Sc. Chemistry	**Year, Semester:** 1st Yr., 1st Sem.
Course Title: Inorganic Chemistry	**Subject Code:**TIU-PCH-T105
Contact Hours/Week: 3–0–0 (L–T–P)	**Credit:** 3

COURSE OBJECTIVE :

Enable the student to:

1. Understand chemical bonding through VB and MO theories for diatomic and polyatomic molecules.
2. Explore metal-ligand interactions using crystal field theory, molecular orbital theory, and electronic spectra of transition metal complexes.
3. Apply symmetry and group theory to molecular structures, character tables, and vibrational spectroscopy.

COURSE OUTCOME :

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

CO-1:	**Remember** the fundamental concepts of chemical bonding, including VB and MO theories for diatomic and polyatomic molecules.	K1
CO-2:	**Understand** the crystal field theory, ligand-field parameters, and electronic spectra of transition metal complexes.	K2
CO-3:	**Apply**the molecular orbital theory to analyze metal-ligand interactions and bonding characteristics.	K3
CO-4:	**Analyze** the effects of symmetry elements and group theory on molecular vibrations and spectroscopic transitions.	K4
CO-5:	**Analyze** Jahn-Teller distortions, spin selection rules, and charge transfer spectra in coordination complexes.	K4
CO-6:	**Understand** the classification of molecules based on point groups and construct character tables for symmetry analysis.	K2

COURSE CONTENT :

MODULE 1:	**Chemical Bonding**	**8 Hours**
VB and LCAO-MO treatments on H_2^+, H_2. Application to homo- and hetero- nucleardiatomic molecules/ ions of second period elements. Importance of bond order, MO's ofdiatomic and polyatomic molecules BeH_2, H_2O, NH_3, CH_4.		

MODULE 2:	Metal-Ligand Bonding in Transition Metal Complexes	10 Hours
Crystal field splitting diagrams in complexes of low symmetries. Spectrochemical and Nephelauxetic series. Thermodynamic and structural effects. Site selection in spinels, Jahn-Teller distortions. Experimental evidence for metal-ligand orbital overlap. Molecular orbital theory as applied to metal complexes, Brief introduction to angular overlap model.		
MODULE 3:	**Electronic spectra of Transition Metal Complexes**	**10 Hours**
The Russel-Saunders coupling, Microstates, Spectroscopic ground states of metal ions, Orgel and Tanabe-Sugano diagrams for transition metal complexes, Electronic spectra of octahedral and tetrahedral complexes, calculation of ligand-field parameters. Magnetic moment of transition metal complexes, orbital contributions, spin-orbit coupling. Charge transfer spectra.		
MODULE 4:	**Symmetry and Group Theory**	**14 Hours**
Symmetry elements and operations, determination of point group of a molecule, reducible and irreducible representations, definitions of classes and character, statement of Grand Orthogonality Theorem, construction of character table, reduction formula, direct product representation and its uses, symmetry of normal modes, normal mode analysis, selection rules for IR and Raman transitions.		
TOTAL LECTURES		**42 Hours**

BOOKS

1. D.F. Shriver, P.W. Atkins, Inorganic Chemistry, 5th Edition (2017), Oxford University Press, Oxford.
2. B. Douglas, D. McDaniel, J. Alexander, Concepts and Models of Inorganic Chemistry, 3rd Edition (2001), John Wiley and Sons, Inc., New York.
3. F.A. Cotton, G. Wilkinson, Advanced Inorganic Chemistry, 6th Edition (1999), John Wiley & Sons, New York.
4. James E. Huheey, Inorganic Chemistry, 4th Edition (1993), Addison-Wesley Pub. Co., New York.
5. R.S. Drago, Physical Methods in Inorganic Chemistry, International Edition (1971), Affiliated East-West Press, New Delhi.

CO-PO MAPPING

	PROGRAM OUTCOMES (PO)								PROGRAM SPECIFIC OUTCOMES (PSO)		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**1**	**2**	**3**
CO-1	3	2	1	1	1	--	--	1	2	1	1
CO-2	3	2	2	1	1	--	--	1	2	1	1
CO-3	3	2	2	1	1	--	--	1	2	1	1
CO-4	3	2	2	1	1	--	--	1	2	1	1
CO-5	3	2	2	1	1	--	--	1	2	1	1
CO-6	3	2	2	2	1	--	--	1	2	1	1
Average	**3**	**2**	**1.83**	**1.16**	**1**	**--**	**--**	**1**	**2**	**1**	**1**

Program: M. Sc. Chemistry	**Year, Semester:** 1st Yr., 1st Sem.
Course Title: Organic Chemistry	**Subject Code:**TIU-PCH-T103
Contact Hours/Week: 3–0–0 (L–T–P)	**Credit:** 3

COURSE OBJECTIVE :

Enable the student to:

1. Understand aromaticity in benzenoid, non-benzenoid, antiaromatic, and homoaromatic systems.
2. Analyze structure-reactivity relationships using linear free energy correlations and steric/solvent effects.
3. Explore nucleophilic substitutions and heterocycles with mechanisms, stereochemistry, and functional group transformations.

COURSE OUTCOME :

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

CO-1:	**Understand** the fundamental concepts of aromaticity, including benzenoid, non-benzenoid, antiaromatic, and homoaromatic systems.	K2
CO-2:	**Remember** the structure-reactivity relationships using the Hammett equation, Taft equation, and solvent/steric effects.	K1
CO-3:	**Apply**the linear free energy relationships to predict and interpret reaction mechanisms.	K3
CO-4:	**Analyze** the nucleophilic substitution mechanisms (SN^1, SN^2, SN^i, SN^{Ar}) with respect to stereochemistry and influencing factors.	K4
CO-5:	**Remember** the classification of the functional group protection and deprotection strategies for organic synthesis applications.	K1
CO-6:	**Analyze** the synthesis, reactivity, and applications of heterocyclic compounds like furan, thiophene, pyrrole, pyridine, and indole.	K4

COURSE CONTENT :

MODULE 1:	**Aromaticity**	**6 Hours**
Benzenoid and non-benzenoid systems, antiaromaticity, homoaromaticity,alternante and non-alternante hydrocarbons.		
MODULE 2:	**Structure-reactivity relationship: A quantitative approach**	**8 Hours**
Linear free energy relations: Hammett equation, Hammett's σ_x andρ values and their physical significance through-conjugation. deviations from straight line plots; Taft equation; steric and solvent effects: Grunwald-Winstein equation.		
MODULE 3:	**Nucleophilic Substitutions at Saturated Carbon**	**12 Hours**

Mechanism and Stereochemistry of S_N1, S_N2, S_Ni and $S_{N}Ar$ reactions. Reactivity: the effect of substrate structure, nucleophiles, leaving groups and reaction medium. Phase transfer catalysis and ultrasonic waves, Ambient nucleophiles, Regioselectivity. Competition between S_N1 and S_N2 mechanisms.		
MODULE 4:	**Protection and Deprotection of Functional Groups**	**6 Hours**
Protection of NH_2 and OH groups,diols, carbonyl groups, carboxyl groups, double bonds and triple bonds.		
MODULE 5:	**Heterocycles**	**10 Hours**
Nomenclature of heterocyclic compounds, Synthesis, reactivity and uses of the following heterocyclic compounds [containing one hetero-atom] and their derivatives: furan, thiophene, pyrrole, pyridine & indole.		
TOTAL LECTURES		**42 Hours**

BOOKS

1. D.1. P. S. Kalsi, Organic Reactions and Their Mechanisms, 3rd Edition (2020), New Age International Publication, New Delhi.
2. T. H. Lowry, K.S. Richardson, Mechanism and Theory in Organic Chemistry, 3rd Edition (2014), Addison-Wesley Longman Inc.
3. S. M. Mukherjee, S.P. Singh, Reaction Mechanism in Organic Chemistry, 2nd Edition (2017), MacMillan India Ltd, New Delhi.
4. Peter Sykes, A Guide Book to Mechanism in Organic Chemistry, 7th Edition (2016), Orient Longman Ltd, New Delhi.
5. R. T. Morrison, R.N. Boyd, Organic Chemistry, 7th Edition (2010), Prentice-Hall of India, New Delhi.
6. I. Fleming, Pericyclic Reactions, 1st Edition (2015), Oxford University Press, Oxford.
7. S. M. Mukherjee and S.P. Singh, Pericyclic Reactions, 2nd Edition (2021), MacMillan India Ltd.

CO-PO MAPPING

	PROGRAM OUTCOMES (PO)								**PROGRAM SPECIFIC OUTCOMES (PSO)**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**1**	**2**	**3**
CO-1	3	2	1	1	1	--	--	1	2	1	1
CO-2	3	2	2	1	1	--	--	1	2	1	1
CO-3	3	2	2	1	1	--	--	1	2	1	1
CO-4	3	2	2	1	1	--	--	1	2	1	1
CO-5	3	2	2	1	1	--	--	1	2	1	1
CO-6	3	2	2	2	1	--	1	1	2	1	1
Average	3	2	1.83	1.16	1	--	1	1	2	1	1

Program: M. Sc. Chemistry	**Year, Semester:** 1^{st} Yr., 1^{st} Sem.
Course Title: Physical Chemistry	**Subject Code:**TIU-PCH-T101
Contact Hours/Week: 3–0–0 (L–T–P)	**Credit:** 3

COURSE OBJECTIVE :

Enable the student to:

1. Understand thermodynamic principles in classical and statistical thermodynamics, including entropy, partition functions, and probability distributions.
2. Analyze reaction kinetics through composite reaction mechanisms, steady-state approximation, and chain reactions.
3. Explore nuclear chemistry covering radioactive decay, nuclear reactions, radiation interaction, and dosimetry.

COURSE OUTCOME :

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

CO-1:	**Remember** the fundamental concepts of classical and statistical thermodynamics, including entropy, partition functions, and thermodynamic probability.	K1
CO-2:	**Remember** the principles of chemical kinetics, composite reaction mechanisms, and rate-determining steps.	K1
CO-3:	**Apply**the statistical thermodynamics to derive thermodynamic functions and analyze gas entropy.	K3
CO-4:	**Analyze**the complex reaction mechanisms, including chain and oscillatory reactions, using steady-state and microscopic reversibility principles.	K4
CO-5:	**Remember** the classification of different types of radioactive decay, nuclear reactions, and radiation interactions with matter.	K1
CO-6:	**Apply** the nuclear stability, isomerism, dosimetry, and conservation laws in nuclear reactions.	K3

COURSE CONTENT :

MODULE 1:	**Classical Thermodynamics**	**6 Hours**
Brief review on basic concept of thermodynamics. Partial molar quantities and their significances. Third law of thermodynamics: Nernst heat theorem, variation of entropy with temperature, determination of absolute entropy of liquid and gases, residual entropy.		
MODULE 2:	**Statistical Thermodynamics**	**14 Hours**
Thermodynamic probability and entropy, Maxwell-Boltzmann distribution law; Bose-Einstein and Fermi-Dirac statistics, Partition function: rotational, translational, vibrational and electronic partition functions of diatomic molecules, Relation between partition functions with		

different thermodynamic functions, Entropy of a perfect gas: Gibb's paradox and Sackur-Tetrode equation.		
MODULE 3:	**Chemical Kinetics**	**10 Hours**
Brief review on basic chemical kinetics, Composite reactions-types of composite mechanisms, rate equations for composite mechanisms, simultaneous and consecutive reactions, steady state treatment, rate-determining steps, microscopic reversibility and detailed balance, dynamic chain (H_2-Br_2 reaction, decomposition of ethane and acetaldehyde) and oscillatory reactions (Belousov-Zhabotinskii reaction), branching chain: H_2-O_2 reaction.		
MODULE 4:	**Nuclear Chemistry**	**12 Hours**
Elements of radiation chemistry, General characteristics of radioactive decay, decay kinetics, parent daughter decay growth relationships, artificial radioactivity, Classification of nuclides, Nuclear stability, Nuclear isomerism and internal conversion, Interaction of nuclear radiation with matter, charged particles, neutrons and gamma rays, Unit of radiation absorption, radiation dosimetry, Types of nuclear reaction-fission and fusion, Conservation in nuclear reaction: linear momentum and mass- energy, Bohr's compound nucleus theory of nuclear reaction.		
TOTAL LECTURES		**42 Hours**

BOOKS

1. P.W. Atkins, Physical Chemistry, 11th Edition (2018), Oxford University Press, New York.
2. I.N. Levine, Physical Chemistry, 7th Edition (2013), Tata McGraw Hill Publication Co, Ltd, New Delhi.
3. H.J. Arnikar, Essentials of Nuclear Chemistry, 5th Edition (2005), Wiley Eastern Ltd, New Delhi.
4. G.W. Castellan, Physical Chemistry, 4th Edition (2004), Narosa Publishing House.

CO-PO MAPPING

	PROGRAM OUTCOMES (PO)								**PROGRAM SPECIFIC OUTCOMES (PSO)**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**1**	**2**	**3**
CO-1	3	2	1	1	1	--	--	1	2	1	1
CO-2	3	2	2	1	1	--	--	1	2	1	1
CO-3	3	2	2	1	1	--	--	1	2	1	1
CO-4	3	2	2	1	1	--	--	1	2	1	1
CO-5	3	2	2	1	1	--	--	1	2	1	1
CO-6	3	2	2	2	1	--	--	1	2	1	1
Average	3	2	1.83	1.16	1	--	--	1	2	1	1

Program: M. Sc. Chemistry	**Year, Semester:** 1st Yr., 1st Sem.
Course Title: Inorganic Chemistry Lab-I	**Subject Code:**TIU-PCH-L115
Contact Hours/Week: 0–0–4 (L–T–P)	**Credit:** 2

COURSE OBJECTIVE :

The course aims to provide practical skills on (i) qualitative and quantitative estimation of varieties of ions and selected compounds in solution; (ii) syntheses, purification and characterizations of inorganic metal complexes.

COURSE OUTCOME :

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

CO-1:	**Remember** the principles of chromatographic, gravimetric, volumetric, and spectrophotometric techniques for inorganic analysis.	K1
CO-2:	**Understand** the synthesis, characterization, and spectral interpretation of metal complexes with varying ligand field strengths.	K2
CO-3:	**Apply** paper chromatography for the separation of cations and anions in aqueous and non-aqueous media.	K3
CO-4:	**Analyze** inorganic ion concentrations using colorimetry, iodometry, and complexometric titration methods.	K4
CO-5:	**Analyze** electronic spectra and calculate ligand-field parameters of synthesized metal complexes.	K3
CO-6:	**Understand** essential inorganic compounds, including iodine in salt, phosphoric acid in beverages, and calcium in dairy products, using appropriate quantitative techniques.	K2

COURSE CONTENT :

Experiment 1: Separation of a mixture of cations/anions by paper chromatographic technique using aqueous/non-aqueous media.

Experiment 2: Quantitative separation and determination of pairs of metal ions using gravimetric and volumetric methods.

Experiment3: Synthesis of a series of metal complexes (with ligands of varying ligand field strength), electronic spectral interpretation and calculation of various ligand-field parameters.

Experiment 4: Quantitative estimation of inorganic ions by colorimetry

Experiment 5: Preparation of $[Ni(NH_3)_6]^{2+}$ and other similar metal complexes and their

structural analysis by different methods. **Experiment 6**: Estimation of iodine in iodized common salt using iodometry **Experiment 7:** Estimation of phosphoric acid in cola drinks by molybdenum blue method **Experiment 8**: Determination of the amount of calcium in milk powder by using complexometric titration withEDTA.	
TOTAL LECTURES	**56 Hours**

BOOKS

1. Vogel, A.I. Vogel's Textbook of Quantitative Chemical Analysis, 6th ed., 2021, Pearson Education Limited.
2. Elias, A.J. A Collection of Interesting General Chemistry Experiments, 2nd ed., 2020, Sangam Books.
3. Mukherjee, G.N. Advanced Experiments in Inorganic Chemistry, 2nd ed., 2018, U.N. Dhur & Sons (P) Ltd.

CO-PO MAPPING

	PROGRAM OUTCOMES (PO)								**PROGRAM SPECIFIC OUTCOMES (PSO)**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**1**	**2**	**3**
CO-1	2	1	1	2	1	1	1	1	1	3	2
CO-2	2	1	1	2	1	1	1	1	1	3	2
CO-3	2	1	1	2	1	1	1	1	1	3	2
CO-4	2	1	1	2	1	1	1	1	1	3	2
CO-5	2	1	1	2	1	1	1	1	1	3	2
CO-6	2	1	1	2	1	1	1	1	1	3	2
Average	**2**	**1**	**1**	**2**	**1**	**1**	**1**	**1**	**1**	**3**	**2**

Program: M. Sc. Chemistry	**Year, Semester:** 1st Yr., 1st Sem.
Course Title: Organic Chemistry Lab-I	**Subject Code:**TIU-PCH-L113
Contact Hours/Week: 0–0–4 (L–T–P)	**Credit:** 2

COURSE OBJECTIVE :

To develop proficiency in laboratory techniques for the separation, identification, and quantitative analysis of organic compounds in various mixtures.

COURSE OUTCOME :

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

CO-1:	**Remember** the fundamental principles of separation techniques based on physical properties of aromatic compounds.	K1
CO-2:	**Understand** the methods for the identification of organic compounds in binary and ternary mixtures.	K2
CO-3:	**Apply**the separation techniques to isolate and analyze organic compounds from complex mixtures.	K3
CO-4:	**Analyze** the composition of organic mixtures using qualitative and quantitative approaches.	K4
CO-5:	**Analyze** the experimental data to determine the presence of sulfur and nitrogen in organic samples.	K4
CO-6:	**Analyze**organic compounds using appropriate separation and analytical techniques.	K4

COURSE CONTENT :

Experiment 1: Separation of aromatic compounds utilizing their physical properties. **Experiment 2:** Separation and identification of organic compounds in a binary mixture. **Experiment 3:** Separation and identification of organic compounds in a mixture containing three components. **Experiment 4:** Quantitative analysis of sulfur and and nitrogen in organic samples.	
TOTAL LECTURES	**56 Hours**

BOOKS:

1. Middleton, H. Systematic Organic Qualitative Analysis, 2nd ed., 1995, Prentice Hall.
2. Vogel, A.I. Qualitative Organic Analysis, 5th ed., 1989, Longman Scientific & Technical.
3. Benson, J. A. Laboratory Experiments in Organic Chemistry, 4th ed., 2014, Cengage Learning.
4. Lloyd, D. Practical Organic Chemistry, 2nd ed., 2005, Wiley.

CO-PO MAPPING

	PROGRAM OUTCOMES (PO)								PROGRAM SPECIFIC OUTCOMES (PSO)		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**1**	**2**	**3**
CO-1	2	1	1	2	1	1	1	1	1	3	2
CO-2	2	1	1	2	1	1	1	1	1	3	2
CO-3	2	1	1	2	1	1	1	1	1	3	2
CO-4	2	1	1	2	1	1	1	1	1	3	2
CO-5	2	1	1	2	1	1	1	1	1	3	2
CO-6	2	1	1	2	1	1	1	1	1	3	2
Average	**2**	**1**	**1**	**2**	**1**	**1**	**1**	**1**	**1**	**3**	**2**

Program: M. Sc. Chemistry	**Year, Semester:** 1st Yr., 1st Sem.
Course Title: Physical Chemistry Lab-I	**Subject Code:**TIU-PCH-L111
Contact Hours/Week: 0–0–4 (L–T–P)	**Credit:** 2

COURSE OBJECTIVE :
In this course students learn about hand-on experiences of techniques for verifying physical and chemical properties and data interpretation.

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

CO-1:	**Remember** the fundamental principles of reaction kinetics, thermodynamics, and equilibrium in chemical systems.	K1
CO-2:	**Understand** the kinetics of saponification and acid-catalyzed hydrolysis using experimental data.	K2
CO-3:	**Apply** polarimetric, calorimetric, and equilibrium methods to determine rate constants and thermodynamic parameters.	K3
CO-4:	**Analyze** the energy of activation for saponification and the heat of solution of oxalic acid.	K4
CO-5:	**Apply** the concept of partial molal quantities and their significance in solution chemistry.	K3
CO-6:	**Analyze** the hydrolysis constant of ammonium chloride and evaluate its equilibrium behavior.	K4

COURSE CONTENT :

Experiment 1: Saponification of ethyl acetate by NaOH: determination of rate constant

Experiment 2: Determination of energy of activation of Saponification of ethyl acetate

Experiment 3: Determination of rate constant of acid catalyzed hydrolysis of sucrose by polarimetric method

Experiment 4: Determination of heat of solution of oxalic acid from its solubility at different temperature

Experiment 5: Determination of partial molal quantity

Experiment 6: Determination of hydrolysis constant of NH_4Cl

TOTAL LECTURES	**56 Hours**

BOOKS

1. James, A.M., Prichard, F.F. Practical Physical Chemistry, 3rd ed., 2021, Prentice Hall.
2. Levitt, B.P. Findlay's Practical Physical Chemistry, 10th ed., 2020, Prentice Hall.
3. Shoemaker, D.P., Haile, J., Moeller, W.J. Experimental Physical Chemistry, 3rd ed., 2014, Prentice Hall.

CO-PO MAPPING

	PROGRAM OUTCOMES (PO)								PROGRAM SPECIFIC OUTCOMES (PSO)		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**1**	**2**	**3**
CO-1	2	1	1	2	1	1	1	1	1	3	2
CO-2	2	1	1	2	1	1	1	1	1	3	2
CO-3	2	1	1	2	1	1	1	1	1	3	2
CO-4	2	1	1	2	1	1	1	1	1	3	2
CO-5	2	1	1	2	1	1	1	1	1	3	2
CO-6	2	1	1	2	1	1	1	1	1	3	2
Average	**2**	**1**	**1**	**2**	**1**	**1**	**1**	**1**	**1**	**3**	**2**

Program: M. Sc. Chemistry	**Year, Semester:** 1st Yr., 1st Sem.
Course Title: Fundamentals of AI in Chemistry	**Subject Code:**TIU-PCH-L121
Contact Hours/Week: 1–0–2 (L–T–P)	**Credit:** 2

COURSE OBJECTIVE :

Enable the student to:

1. Understand AI fundamentals and their applications in chemistry, including machine learning techniques and molecular representation methods.
2. Develop computational skills using Python for molecular property prediction, classification, and generative modeling.
3. Explore advanced AI techniques such as neural networks and reinforcement learning for cheminformatics and future applications in chemistry.

COURSE OUTCOME :

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

CO-1:	**Remember** the fundamental concepts of AI, machine learning, and their applications in chemistry.	K1
CO-2:	**Understand** the molecular representation techniques and cheminformatics data types used in AI-driven chemical analysis.	K2
CO-3:	**Apply**the machine learning models, including regression and classification, to predict molecular properties.	K3
CO-4:	**Analyze** neural networks and reinforcement learning techniques in computational chemistry.	K4
CO-5:	**Apply** the Python-based computational experiments for molecular property prediction and compound classification.	K2
CO-6:	**Apply** the generative models for molecular design and explore future AI trends in chemistry.	K3

COURSE CONTENT :

MODULE 1:	Basic Fundamentals of AI in Chemistry	6 Hours
Introduction to AI and its applications in chemistry, Fundamentals of machine learning (supervised and unsupervised learning), Data types in chemistry and cheminformatics, Molecular representation techniques, AI techniques: neural networks and reinforcement learning.		
MODULE 2:	**Computational Experiments**	**24 Hours**
Setting up the programming environment (Python), Predicting molecular properties using regression models, Classifying chemical compounds with classification algorithms, Generative models for molecular generation, Future trends and applications in AI and chemistry.		
TOTAL LECTURES		**30 Hours**

BOOKS:

1. M. Mitchell, Artificial Intelligence: A Guide for Thinking Humans, 1st ed. (2019) Penguin Press.
2. C. Bishop, Pattern Recognition and Machine Learning, 1st ed. (2006) Springer.
3. A. R. Leach, Chemoinformatics: Principles and Applications, 2nd ed. (2019) Royal Society of Chemistry.
4. B. Ramsundar, Deep Learning for the Life Sciences, 1st ed. (2019) O'Reilly Media.
5. A. R. Leach et al., Chemistry Meets Machine Learning, 1st ed. (2020) Royal Society of Chemistry.

CO-PO MAPPING

	PROGRAM OUTCOMES (PO)								PROGRAM SPECIFIC OUTCOMES (PSO)		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**1**	**2**	**3**
CO-1	3	2	2	2	1	--	--	1	2	3	2
CO-2	3	2	2	2	1	--	--	1	2	3	2
CO-3	3	2	2	2	1	--	--	1	2	3	2
CO-4	3	2	2	2	1	--	--	1	2	3	2
CO-5	3	2	2	2	1	--	--	1	2	3	2
CO-6	3	2	2	2	1	--	--	1	2	3	2
Average	**3**	**2**	**2**	**2**	**1**	**--**	**--**	**1**	**2**	**3**	**2**

Program: M. Sc. Chemistry	Year, Semester: 1st Yr., 2nd Sem.
Course Title: Biological Chemistry	**Subject Code:**TIU-PCH-T132
Contact Hours/Week: 3–0–0 (L–T–P)	**Credit:** 3

COURSE OBJECTIVE :

Enable the student to:

1. Understand the structure and function of biomolecules, including amino acids, proteins, enzymes, vitamins, lipids, carbohydrates, and nucleic acids.
2. Explore biochemical processes such as enzyme kinetics, gene expression, and metabolic pathways like glycolysis and oxidative phosphorylation.
3. Analyze the role of biomolecules in bioenergetics, molecular interactions, and physiological functions, including protein folding, enzyme regulation, and nucleic acid replication.

COURSE OUTCOME :

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

CO-1:	**Remember**the structure, classification, and functions of biomolecules such as amino acids, proteins, enzymes, lipids, carbohydrates, and nucleic acids.	K1
CO-2:	**Understand** the biochemical processes, including enzyme kinetics, protein folding, and metabolic pathways like glycolysis and oxidative phosphorylation.	K2
CO-3:	**Apply**the knowledge of protein purification, sequencing techniques, and enzyme regulation in biochemical studies.	K3
CO-4:	**Analyze** the structural and functional aspects of DNA, RNA, and their role in gene expression, replication, and transcription.	K4
CO-5:	**Analyze** the interactions of biomolecules in biological systems, such as enzyme-substrate binding, vitamin coenzyme functions, and bioenergetics.	K4
CO-6:	**Analyze**the impact of biochemical processes in physiological functions, including protein denaturation, lipid metabolism, and molecular transport mechanisms.	K4

COURSE CONTENT :

MODULE 1:	Biomolecules	30 Hours
Amino acids and Proteins: Amino acids (Structure, titration curve, iso-electric point, reactions involving amino acids) peptide bond, Structure of protein (Primary, secondary, tertiary and quartenery), Ramachandran plot, methods involved in C-/N- amino acid sequencing, Reactions (Ninhydrin reaction, Van Slyke reaction and others), Denaturation of proteins, factors effecting denaturation, structural aspect of protein with respect to		

haemglobulin and myoglobulin. Methods involved in protein purification, Bruce-Merrifield reaction (artificial peptide synthesis), Oxygen uptake proteins: Hemerythrin and hemocyanin. **Enzymes:** Classification, nomenclature, Kinetics of enzyme action, Enzyme inhibition, Regulation of enzyme (allosteric enzymes), isozymes, Enzyme active site, Metalloenzymes:Hydrolytic and redox enzymes: Carbonic anhydrase and superoxide dismutase, structure and function of Nickel and Zinc containing enzymes (Urease, Hydrogenase, Carboxy-peptidase etc.). **Vitamins and Hormones:** Fat soluble and water soluble vitamins, Vitamins as coenzymes and co-factors, NAD, FAD, TPP, Folic acid, Vit.B6, Vit.B2, Lipoic acid, Co ASH, Epinephrine, nor epinephrine. **Lipids and Steroids:** Principles of chromatography, Classification of chromatography, Paper chromatography, Techniques of column chromatography, Thin layer chromatography, Gas Chromatography, High-performance liquid chromatography, Ion chromatography. **Carbohydrates:** Classification, structure, reactions and importance in biology.		
MODULE 2:	**Nucleic Acids**	**8 Hours**
Structure of nucleic acid-nitrogen base pairing with reference to adenine, guanine, cytosine, thymine and uracil, Structure of DNA (double helical structure), RNA, base pairing, m-RNA structure, t-RNA structure, Reaction (cyclitization reaction) DNA binding protein- Zinc finger protein. Replication, Transcription and translation, Regulation of gene expression.		
MODULE 3:	**Bioenergetics**	**4 Hours**
Bioenergetics (concept), Glycolysis, citric acid cycle (TCA), electron transport chain, oxidative phosphorylation, Active and passive transport mechanism (pumps).		
TOTAL LECTURES		**42 Hours**

BOOKS

1. L. Stryer, Biochemistry, 5th edition (2002), Freeman & Co., New York.
2. D. L. Nelson and M. M. Cox, Lehninger, Principles of Biochemistry, 3rd edition (2002) McMillan North Publication.
3. M. N. Hughes, Inorganic Chemistry of Biological Processes, (1981) John Wiley.
4. M. B. Smith, Organic Synthesis, (1995) McGraw Hill Inc., New York.
5. D. Voet, J. G. Voet, Biochemistry 3rd Edition (2004), Wiley International Publication.

CO-PO MAPPING

	PROGRAM OUTCOMES (PO)								PROGRAM SPECIFIC OUTCOMES (PSO)		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**1**	**2**	**3**
CO-1	3	2	1	2	1	--	--	1	2	1	1
CO-2	3	3	2	2	1	--	--	1	2	1	1
CO-3	3	3	2	2	1	--	--	1	2	1	1
CO-4	3	3	2	2	1	--	--	1	2	1	1
CO-5	3	3	2	2	1	--	--	1	2	1	1
CO-6	3	3	2	2	1	--	--	1	2	1	1
Average	**3**	**2.83**	**1.83**	**2**	**1**	**--**	**--**	**1**	**2**	**1**	**1**

Program: M. Sc. Chemistry	**Year, Semester:** 1st Yr., 2nd Sem.
Course Title: Inorganic Chemistry	**Subject Code:**TIU-PCH-T106
Contact Hours/Week: 3–0–0 (L–T–P)	**Credit:** 3

COURSE OBJECTIVE :

Enable the student to:

1. Understand the kinetics and mechanisms of substitution and electron transfer reactions in coordination complexes.
2. Explore the structure, bonding, and reactivity of metal carbonyls and related compounds using spectroscopic and theoretical approaches.
3. Analyze the chemistry of lanthanides and actinides, including their electronic structure, oxidation states, spectral properties, and separation techniques.

COURSE OUTCOME :

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

CO-1:	**Remember** the fundamental principles of substitution reactions, electron transfer mechanisms, and coordination chemistry.	K1
CO-2:	**Remember** the kinetics and mechanistic aspects of acid hydrolysis, base hydrolysis, and anation reactions in metal complexes.	K1
CO-3:	**Apply**crystal field and Marcus-Husch theories to determine the reactivity and stability of coordination compounds.	K3
CO-4:	**Analyze** the bonding, spectral characteristics, and reactivity of metal carbonyls and related species.	K4
CO-5:	**Apply** the electronic structures, oxidation states, and spectral features of lanthanides and actinides.	K3
CO-6:	**Apply** the separation methods and chemical properties of lanthanides and actinides based on their unique characteristics.	K3

COURSE CONTENT :

MODULE 1:	**Kinetics and Mechanism of Substitution Reactions**	**12 Hours**
Nature of substitution reactions; prediction of reactivity of octahedral, tetrahedral and square-planar complexes in terms of crystal field activation energy and structure preference energy; rates of reactions; acid hydrolysis, base hydrolysis and anation reactions.		
MODULE 2:	**Electron Transfer Reactions**	**10 Hours**
Mechanism and rate laws; various types of electron transfer reactions, Marcus-Husch theory, correlation between thermal and optical electron transfer reactions; identification of intervalence transfer bands in solution.		
MODULE 3:	**Metal Carbonyls and related compounds**	**6 Hours**
Preparation, structure, and properties: bonding in metal carbonyls, variants of CO bridging, vibrational spectra of metal carbonyls, principal reaction types of metal carbonyls.		

MODULE 4:	Chemistry of Lanthanides and Actinides	12 Hours
Nuclear stability, terrestrial abundance and distribution, relativistic effect, electronic configuration, oxidation states, aqueous-, redox- and complex- chemistry, electronic spectra and magnetic properties, lanthanide and actinide contractions and their consequences, separation of lanthanides and actinides, organo-lanthanoids and actinoids.		
TOTAL LECTURES		**40 Hours**

Books:

1. F. Basalo, R. G. Pearson, Mechanism of Inorganic Reactions, 2ndEdn. (1967), Wiley Eastern Ltd., New Delhi.
2. D. F. Shriver, P. W. Atkins, Inorganic Chemistry, 3rdEdn. (1999), ELBS, London.
3. F. A. Cotton, G. Wilkinson, Advanced Inorganic Chemistry, 6thEdn. (1999), John Wiley & Sons, New York.
4. D. N. Sathyanarayana, Electronic Absorption Spectroscopy and Related Techniques, Universities Press (India) Ltd., Hyderabad (2001).
5. Keith F. Purcell, John C. Kotz, Inorganic Chemistry,W. B. Saunders Com. (1987), Hong Kong.
6. Martin L. Tobe, John Burgess, Inorganic Reaction Mechanisms,Longmans 1stEdn. (1999).

CO-PO MAPPING

	PROGRAM OUTCOMES (PO)								PROGRAM SPECIFIC OUTCOMES (PSO)		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**1**	**2**	**3**
CO-1	3	2	1	2	1	--	--	1	2	1	1
CO-2	3	3	2	2	1	--	--	1	2	1	1
CO-3	3	3	2	2	1	--	--	1	2	1	1
CO-4	3	3	2	2	1	--	--	1	2	1	1
CO-5	3	3	2	2	1	--	--	1	2	1	1
CO-6	3	3	2	2	1	--	--	1	2	1	1
Average	**3**	**2.83**	**1.83**	**2**	**1**	**--**	**--**	**1**	**2**	**1**	**1**

Program: M. Sc. Chemistry	**Year, Semester:** 1st Yr., 2nd Sem.
Course Title: Organic Chemistry	**Subject Code:**TIU-PCH-T104
Contact Hours/Week: 3–0–0 (L–T–P)	**Credit:** 3

COURSE OBJECTIVE :

Enable the student to:

1. Introduce the fundamental concepts of pericyclic reactions, including molecular orbital symmetry, selection rules, and stereochemical aspects.
2. Explain the mechanisms of esterification and ester hydrolysis, emphasizing steric and electronic effects in different reaction pathways.
3. Analyze the mechanisms and reactivity of electrophilic and nucleophilic aromatic substitution, elimination reactions, and enolate chemistry.

COURSE OUTCOME :

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

CO-1:	**Remember** the fundamental principles of pericyclic reactions, including molecular orbital symmetry and classification.	K1
CO-2:	**Understand**the stereochemical aspects and selection rules governing electrocyclic, cycloaddition, and sigmatropic rearrangement reactions.	K2
CO-3:	**Apply** the mechanistic concepts to esterification and ester hydrolysis, considering steric and electronic effects on reaction pathways.	K3
CO-4:	**Analyze** between electrophilic and nucleophilic aromatic substitution mechanisms and evaluate the factors affecting regioselectivity and reactivity.	K4
CO-5:	**Analyze** the elimination reaction mechanisms (E1, E2, and E1cB), predicting the orientation of double bonds and the competition between substitution and elimination.	K4
CO-6:	**Analyze**the formation and reactivity of enols and enolates, assessing their role in various organic transformations.	K4

COURSE CONTENT :

MODULE 1:	**Pericyclic reactions**	**14 Hours**
Molecular orbital symmetry, frontier orbitals of ethylene, 1,3-buta diene, 1,3,5-hexatriene and allyl systems. Classification of pericyclic reactions. Woodward-Hoffmann correlation diagrams. FMO and PMO approach, concept of aromaticity of pericyclic transition states. Selection rules and stereochemical aspects of electrocyclic reactions, cycloaddition and sigmatropic shifts. Electrocyclic reactions: conrotatory and disrotatory motions, 4n, 4n+2 and allyl systems. Cycloaddition reactions: antarafacial and suprafacial additions, 4n and 4n+2 systems; 2,2 addition of ketenes, 1,3 dipolar cycloadditions and		

cheleotropicreactions. Sigmatropic rearrangements: suprafacial and antarafacial shifts of H, sigmatropic shifts involving carbon moieties, 3,3- and 5,5-sigmatropic rearrangements. Sommelet-Hauser, Cope, Claisen, and aza-Cope rearrangements. Fluxional tautomerism. Ene reaction.		
MODULE 2:	**Esterification and hydrolysis of ester**	**6 Hours**
Evidence for tetrahedral intermediate in BAc2 and AAc2 mechanisms, steric and electronic effects, the AAc1 and other pathways involving alkyl to oxygen bond cleavage.		
MODULE 3:	**Substitution and elimination reactions**	**12 Hours**
Electrophilic and nucleophilic aromatic substitution: Electrophilic aromatic substitution: The Arenium ion mechanism, orientation and reactivity in monosubstituted benzene rings, ortho/para ratio, Ipso substitution. Nucleophilic aromatic substitution: The Aromatic S_N1, S_N2 and benzyne mechanisms. Reactivity-effect of substrate structure, leaving group, and attacking nucleophiles. **Elimination reaction mechanism:** The E1, E2, and E1cB mechanisms, Orientation of double bond, Hoffman elimination, Saytzeff elimination, Hoffman versus Saytzeff elimination, Pyrolytic-*syn*-elimination, competition between substitution and elimination reactions.		
MODULE 4:	**Formation and reactions of enol and enolate**	**8 Hours**
Enol and enolate, Stable enol, consequence of enolization, Reactions with enols and enolates as intermediate, Stable enolate ions, Preparation of enol ether, Reactions of enol ethers.		
TOTAL LECTURES		**40 Hours**

BOOKS

1. Clayden, Greeves, Warren, Wothers, Organic Chemistry, Oxford University Press, 2001.
2. M. B. Smith, Jerry March, Advanced Organic Chemistry, 5th Edition (2001), John Wiley & Sons, New York.
3. Peter Sykes, A Guide Book to Mechanism in Organic Chemistry, 6th Edition (1997), Orient Longman Ltd., New Delhi.
4. G. S. Zweifel, M. H. Nantz, Modern Organic Synthesis, (2007), Freeman and Company, New York.
5. S. M. Mukherjee, S.P. Singh, Reaction Mechanism in Organic Chemistry, 1st Edition (1990), Macmillan India Ltd., New Delhi.
6. T. H. Lowry, K. S. Richardson, Mechanism and Theory in Organic Chemistry, 3rd Edition (1998), Addison – Wesley Longman Inc. (IS Edition).
7. S. M. Mukherjee, S. P. Singh, Pericyclic Reactions, MacMillan India, New Delhi.
8. I. Fleming, Pericyclic Reactions, Oxford University Press, Oxford (1999).

CO-PO MAPPING

	PROGRAM OUTCOMES (PO)								PROGRAM SPECIFIC OUTCOMES (PSO)		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**1**	**2**	**3**
CO-1	3	2	1	2	1	--	--	1	2	1	1
CO-2	3	3	2	2	1	--	--	1	2	1	1
CO-3	3	3	2	2	1	--	--	1	2	1	1
CO-4	3	3	2	2	1	--	--	1	2	1	1
CO-5	3	3	2	2	1	--	--	1	2	1	1
CO-6	3	3	2	2	1	--	--	1	3	1	1
Average	**3**	**3**	**1.83**	**2**	**1**	**--**	**--**	**1**	**3**	**1**	**1**

Program: M. Sc. Chemistry	**Year, Semester:** 1st Yr., 2nd Sem.
Course Title: Physical Chemistry	**Subject Code:**TIU-PCH-T102
Contact Hours/Week: 3–0–0 (L–T–P)	**Credit:** 3

COURSE OBJECTIVE :

Enable the student to:

1. Introduce electrochemistry concepts like ion interactions, activity coefficients, and conductivity theories.
2. Explain surface chemistry topics such as adsorption, micellization, and surface reaction mechanisms.
3. Develop an understanding of quantum mechanics and its applications to chemical systems.

COURSE OUTCOME :

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

CO-1:	**Remember** the fundamental electrochemical principles, including ion interactions and conductivity theories.	K1
CO-2:	**Understand** adsorption isotherms, micelle formation, and surface reaction mechanisms.	K2
CO-3:	**Apply** Debye-Hückel and Onsager theories to examine electrolyte solutions.	K3
CO-4:	**Analyze**the impact of surface reactions on heterogeneous catalysis.	K4
CO-5:	**Apply** quantum mechanical concepts and their applications in chemical systems.	K3
CO-6:	**Analyze**the approximation methods like perturbation and variation techniques in quantum mechanics.	K4

COURSE CONTENT :

MODULE 1:	**Electrochemistry**	**10 Hours**
Quantitative treatment of Debye-Hückel theory of ion-ion interaction and activity coefficient, applicability and limitations of Debye-Hückel limiting law, its modification for finite-sized ions, effect of ion-solvent interaction on activity coefficient. Debye-Hückel-Onsager (D-H-O) theory of conductance of electrolyte solution, its applicability and limitations, Pair-wise association of ions (Bjerrum and Fuoss treatment), Modification of D-H-O theory to account for ion-pair formation, Determination of association constant (K_A) from conductance data.		
MODULE 2:	**Surface chemistry**	**12 Hours**
Reactions on surfaces: Adsorption, adsorption isotherms, unimolecular surface reaction, bimolecular surface reactions-reaction between a gas molecule and an adsorbed molecule, reaction between two adsorbed molecules, inhibition and activation energy of such		

<table>
<tr><td colspan="3">reactions, volcano curve.

Transition state theory of surface reactions: Rates of chemisorptions and desorption, unimolecular and bimolecular surface reaction, comparison of homogeneous and heterogeneous reaction rates.

Micelles: Surface active agents and their classifications, micellization, factors affecting cmc of surfactants, Thermodynamics of micellization: phase separation and mass action models, micro-emulsions, reverse micelles.</td></tr>
<tr><td>MODULE 3:</td><td>Quantum Mechanics</td><td>20 Hours</td></tr>
<tr><td colspan="3">Fundamentals of quantum mechanics: Black-body radiation, photoelectric effect, Davison and Germer experiment, Franck-Hertz experiment, Young's double slit experiment; identification of classical and quantum systems, Bohr's correspondence principle with examples, the uncertainty principle.

Operators in quantum mechanics: Eigenvalues and eigenfunctions, Hermitian operator and its application. Postulates of quantum mechanics, Angular momentum of a one-particle system, and its commutative relations, Ladder operator, Pauli spin operator, Pauli spin matrices-spin eigenfunctions and their properties, Schrodinger wave equation and its formulation as an eigenvalue problem.

Quantum mechanical treatmenton various systems: Translational motion of a particle, particle in one and three dimensional boxes, harmonic-oscillator, rotational motion of a particle: particle on a ring, particle on a sphere, rigid rotator, step-potential and tunneling, hydrogen atom.

Approximation methods: Stationary perturbation theory for non-degenerate and degenerate systems with examples, Variation method.</td></tr>
<tr><td colspan="2">TOTAL LECTURES</td><td>42 Hours</td></tr>
</table>

Books:

1. J. O'M. Bockris, A. K. N. Reddy, Modern Electrochemistry, Vol. 2 A & B, 2nd Edition, Plenum Press, New York (1998).
2. Samuel Glasstone, An Introduction To Electrochemistry, Affiliated East-West Press Pvt. Ltd.-New Delhi (2000)
3. A. J. Bard, L. R. Faulkner, Electrochemical Methods: Fundamentals and Applications; 2nd Edition (2001), John Wiley & Sons, New York.
4. Y. Moroi, Micelles: Theoretical and Applied Aspects, Plenum Press, New York (1992).
5. P. W. Atkins, Physical Chemistry, 7th& 8th Editions, Oxford University Press, New York
6. I. N. Levine, Quantum Chemistry, 5th Edition (2000), Pearson Educ., Inc. New Delhi.
7. D. A. McQuarrie, J. D. Simon, Physical Chemistry, A Molecular Approach, (1998), Viva Books, New Delhi.

CO-PO MAPPING

	PROGRAM OUTCOMES (PO)								PROGRAM SPECIFIC OUTCOMES (PSO)		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**1**	**2**	**3**
CO-1	3	2	1	2	1	--	--	1	2	1	1
CO-2	3	3	2	2	1	--	--	1	2	1	1
CO-3	3	3	2	2	1	--	--	1	2	1	1
CO-4	3	3	2	2	1	--	--	1	2	1	1
CO-5	3	3	2	2	1	--	--	1	2	1	1
CO-6	3	3	2	2	1	--	--	1	2	1	1
Average	3	3	1.83	2	1	--	--	1	2	1	1

Program: M. Sc. Chemistry	**Year, Semester:** 1st Yr., 2nd Sem.
Course Title: Inorganic Chemistry Lab-II	**Subject Code:**TIU-PCH-L116
Contact Hours/Week: 0–0–4 (L–T–P)	**Credit:** 2

COURSE OBJECTIVE :

The course aims to provide practical skills on (i) qualitative and quantitative estimation of varieties of ions and selected compounds in solution; (ii) syntheses, purification and characterizations of inorganic metal complexes, polymers, and macrocycles.

COURSE OUTCOME :

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

CO-1:	**Understand**the fundamental principles of complex formation and mole ratio methods.	K2
CO-2:	**Understand** the principles of colorimetric analysis in studying reaction kinetics.	K2
CO-3:	**Apply** chromatographic techniques to separate acetylated ferrocene derivatives.	K3
CO-4:	**Analyze** the photochemical properties and stability of potassium trioxalato ferrate (III).	K4
CO-5:	**Apply***cis*- and *trans*-isomers of cobalt complexes and compare their characteristics.	K3
CO-6:	**Analyze**the experimental data to evaluate coordination chemistry and reaction mechanisms.	K4

COURSE CONTENT :

Experiment 1: Determination of composition of complexes by continuous variation of mole ratios. **Experiment 2:** A colorimetric study of the kinetics on inorganic reaction. **Experiment 3**: Acetylation of ferrocene and separation of the acetyl derivative by column chromatography **Experiment 4**: Sythesis, analysis and photochemistry of Potassium trioxaltoferrate (III). **Experiment 5**: Preparation of *cis*- and *trans*-$[Co(en)_2Cl_2]Cl$.	
TOTAL LECTURES	**56 Hours**

Books:

1. Vogel, A.I. Vogel's Textbook of Quantitative Chemical Analysis, 6th ed., 2021, Pearson Education Limited.
2. Elias, A.J. A Collection of Interesting General Chemistry Experiments, 2nd ed., 2020, Sangam Books.
3. Mukherjee, G.N. Advanced Experiments in Inorganic Chemistry, 2nd ed., 2018, U.N. Dhur & Sons (P) Ltd.

CO-PO MAPPING

	PROGRAM OUTCOMES (PO)								**PROGRAM SPECIFIC OUTCOMES (PSO)**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**1**	**2**	**3**
CO-1	2	1	1	2	1	1	1	1	1	3	2
CO-2	2	1	1	2	1	1	1	1	1	3	2
CO-3	2	1	1	2	1	1	1	1	1	3	2
CO-4	2	1	1	2	1	1	1	1	1	3	2
CO-5	2	1	1	2	1	1	1	1	1	3	2
CO-6	2	1	1	2	1	1	1	1	1	3	2
Average	**2**	**1**	**1**	**2**	**1**	**1**	**1**	**1**	**1**	**3**	**2**

Program: M. Sc. Chemistry	**Year, Semester:** 1st Yr., 2nd Sem.
Course Title: Organic Chemistry Lab-II	**Subject Code:**TIU-PCH-L114
Contact Hours/Week: 0–0–4 (L–T–P)	**Credit:** 2

COURSE OBJECTIVE :

In this course students get the training on synthesis, extraction, purification and characterization of some important organic compounds.

COURSE OUTCOME :

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

CO-1:	**Remember**the fundamental principles of separation techniques for organic compounds.	K1
CO-2:	**Understand** the methodologies used in steam distillation, photo-isomerization, and thin-layer chromatography.	K2
CO-3:	**Apply** chromatographic techniques to separate and analyze plant pigments.	K3
CO-4:	**Analyze** the effectiveness of paper and column chromatography in isolating natural compounds.	K4
CO-5:	**Apply** the extraction and purification of caffeine from tea leaves using solvent extraction techniques.	K3
CO-6:	**Analyze** the experimental results to identify organic compounds in binary mixtures.	K4

COURSE CONTENT :

Experiment 1: Separation of binary mixtures of solid-solid/liquid-solid/liquid-liquid organic compounds and identification of individual components by chemical methods. **Experiment 2:** Techniques of organic chemistry: Experiments involving steam distillation, photo-isomerisation and thin layer chromatography etc. **Experiment 3**: Paper and column chromatography of plant pigments **Experiment 4:** Isolation of caffeine from tea leaves	
TOTAL LECTURES	**56 Hours**

Books:

1. Middleton, H. Systematic Organic Qualitative Analysis, 2nd ed., 1995, Prentice Hall.
2. Vogel, A.I. Qualitative Organic Analysis, 5th ed., 1989, Longman Scientific & Technical.
3. Benson, J. A. Laboratory Experiments in Organic Chemistry, 4th ed., 2014, Cengage Learning.
4. Lloyd, D. Practical Organic Chemistry, 2nd ed., 2005, Wiley.

CO-PO MAPPING

	PROGRAM OUTCOMES (PO)								PROGRAM SPECIFIC OUTCOMES (PSO)		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**1**	**2**	**3**
CO-1	2	1	1	2	1	1	1	1	1	3	2
CO-2	2	1	1	2	1	1	1	1	1	3	2
CO-3	2	1	1	2	1	1	1	1	1	3	2
CO-4	2	1	1	2	1	1	1	1	1	3	2
CO-5	2	1	1	2	1	1	1	1	1	3	2
CO-6	2	1	1	2	1	1	1	1	1	3	2
Average	**2**	**1**	**1**	**2**	**1**	**1**	**1**	**1**	**1**	**3**	**2**

Program: M. Sc. Chemistry	**Year, Semester:** 1st Yr., 2ndSem.
Course Title: Physical Chemistry Lab-II	**Subject Code:**TIU-PCH-L112
Contact Hours/Week: 0–0–4 (L–T–P)	**Credit:** 2

COURSE OBJECTIVE :

Enable the student to:

Develop practical skills in electrochemical and physicochemical analysis through conductometric, potentiometric, and phase equilibrium experiments.

COURSE OUTCOME :

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

CO-1:	**Remember** the principles of conductometric and potentiometric techniques in chemical analysis.	K1
CO-2:	**Understand** the kinetics of saponification and ion conductivity in electrolyte solutions.	K2
CO-3:	**Apply** conductometric methods to determine the strengths of acids in a mixture.	K3
CO-4:	**Analyze** the critical micelle concentration (CMC) of surfactants using conductometry.	K4
CO-5:	**Apply** the acid-base neutralization process using potentiometric titration.	K3
CO-6:	**Apply** the phase diagrams for a three-component system to understand liquid-liquid equilibria.	K3

COURSE CONTENT :

Experiment 1: Conductometric study of the kinetics of Saponification of methyl/ethyl acetate **Experiment 2**: Determination of equivalent conductance at infinite dilution of KCl at room temperature **Experiment 3**:Determination of strengths of strong and weak acids in a mixture conductometrically **Experiment 4**: Determination of CMC of a surfactant by conductometric method **Experiment 5**: Potentiometric titration of a strong acid with strong base using quinhydrone electrode **Experiment 6:** To construct the phase diagram of a three component system: Chloroform-acetic acid-water	
TOTAL LECTURES	**56 Hours**

Books:

1. James, A.M., Prichard, F.F. Practical Physical Chemistry, 3rd ed., 2021, Prentice Hall.
2. Levitt, B.P. Findlay's Practical Physical Chemistry, 10th ed., 2020, Prentice Hall.
3. Shoemaker, D.P., Haile, J., Moeller, W.J. Experimental Physical Chemistry, 3rd ed., 2014, Prentice Hall.

CO-PO MAPPING

	PROGRAM OUTCOMES (PO)								PROGRAM SPECIFIC OUTCOMES (PSO)		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**1**	**2**	**3**
CO-1	2	1	1	2	1	1	1	1	1	3	2
CO-2	2	1	1	2	1	1	1	1	1	3	2
CO-3	2	1	1	2	1	1	1	1	1	3	2
CO-4	2	1	1	2	1	1	1	1	1	3	2
CO-5	2	1	1	2	1	1	1	1	1	3	2
CO-6	2	1	1	2	1	1	1	1	1	3	2
Average	**2**	**1**	**1**	**2**	**1**	**1**	**1**	**1**	**1**	**3**	**2**

Program: M. Sc. Chemistry	**Year, Semester:** 1st Yr., 2ndSem.
Course Title:Applications of AI in Chemistry	**Subject Code:TIU-PCH-L122**
Contact Hours/Week: 1–0–2 (L–T–P)	**Credit:** 2

COURSE OBJECTIVE :

Enable the student to:

1. Introduce fundamental AI concepts and their applications in chemical analysis and material discovery.
2. Develop skills in AI-driven data analysis, reaction prediction, and cheminformatics for drug discovery.
3. Explore real-world AI applications, ethical considerations, and future trends in chemistry.

COURSE OUTCOME :

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

CO-1:	**Understand** the fundamental AI principles and their applications in chemical analysis and research.	K1
CO-2:	**Remember** the AI techniques used in spectroscopic data analysis, reaction prediction, and material discovery.	K2
CO-3:	**Apply**machine learning models to analyze chemical data and predict reaction outcomes.	K3
CO-4:	**Analyze** QSAR models and molecular docking techniques for drug discovery and virtual screening.	K4
CO-5:	**Analyze** the AI-driven approaches for environmental modeling and pollutant behavior prediction.	K4
CO-6:	**Apply**ethical considerations and future trends in AI applications within chemistry.	K3

COURSE CONTENT :

MODULE 1:	**Overview of AI principles and relevance in chemical analysis**	**10 Hours**
Spectroscopic Data Analysis: AI techniques for interpreting NMR, IR, and mass spectrometry data, Hands-on session using Python libraries for data analysis. Chemoinformatics in Drug Discovery: Introduction to QSAR models and molecular docking, Applications in virtual screening and target identification. AI in Reaction Prediction: Machine learning models for predicting chemical reactions and optimizing conditions. Material Discovery and Design: AI applications in discovering new materials and optimizing polymer properties. Environmental Applications: Use of AI to model pollutant behavior and predict environmental		

impacts.		
MODULE 2:	**Computational Experiments**	**20 Hours**
Case Studies in AI Applications: In-depth analysis of successful AI projects in various chemistry sectors. Future Trends in AI: Explore emerging technologies and their potential impact on the field of chemistry. Ethical Considerations: Discuss ethical implications of AI in chemical research, including bias and data privacy.		
TOTAL LECTURES		**30 Hours**

Books:

1. D. S. Johnson, AI Techniques in Chemical Analysis: Data Interpretation and Spectroscopy, 2nd ed. (2021) Wiley, Hoboken.
2. V. G. Arora, Chemoinformatics: Methods and Applications in Drug Discovery, 1st ed. (2020) Springer, Cham.
3. H. T. Nguyen, Machine Learning for Reaction Prediction and Optimization, 1st ed. (2023) Elsevier, Amsterdam.
4. L. J. O. F. Mathews, AI-Driven Material Discovery and Design: Principles and Applications, 3rd ed. (2022) Academic Press, San Diego.
5. S. R. I. K. Patel, Environmental Chemistry and AI: Modeling Pollutants and Impact Predictions, 1st ed. (2023) Royal Society of Chemistry, Cambridge.

CO-PO MAPPING

	PROGRAM OUTCOMES (PO)								**PROGRAM SPECIFIC OUTCOMES (PSO)**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**1**	**2**	**3**
CO-1	3	2	2	2	1	--	2	1	2	3	2
CO-2	3	2	2	2	1	--	2	1	2	3	2
CO-3	3	2	2	2	1	--	2	1	2	3	2
CO-4	3	2	2	2	1	--	2	1	2	3	2
CO-5	3	2	2	2	1	--	2	1	2	3	2
CO-6	3	2	2	2	1	--	2	1	2	3	2
Average	**3**	**2**	**2**	**2**	**1**	**--**	**2**	**1**	**2**	**3**	**2**

Program: M. Sc. Chemistry	**Year, Semester:** 2nd Yr., 3rd Sem.
Course Title: Spectroscopy-I and Polymers	**Subject Code:**TIU-PCH-T223
Contact Hours/Week: 3–1–0 (L–T–P)	**Credit:** 4

COURSE OBJECTIVE :

Enable the student to:

1. Introduce fundamental spectroscopic techniques and their interaction with matter, including rotational, vibrational, and electronic spectroscopy.
2. Explain the principles and applications of laser spectroscopy, photoelectron spectroscopy, diffraction methods, and magnetic resonance techniques.
3. Discuss polymerization kinetics, molecular weight determination, and thermodynamic aspects of polymer solutions.

COURSE OUTCOME :

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

CO-1:	**Remember** the fundamental concepts of electromagnetic radiation interaction with matter and selection rules in spectroscopy.	K1
CO-2:	**Understand**the principles of rotational, vibrational, Raman, and electronic spectroscopy, including spectroscopic instrumentation.	K2
CO-3:	**Apply**laser spectroscopy techniques for molecular analysis and investigate photoelectron spectroscopy and diffraction methods.	K3
CO-4:	**Analyze** nuclear magnetic resonance (NMR) principles, relaxation times, chemical shifts, and multi-pulse techniques.	K4
CO-5:	**Analyze** thedifferent polymerization mechanisms, molecular weight determination methods, and thermodynamic aspects of polymer solutions.	K4
CO-6:	**Apply**thrspectroscopic data to determine molecular structure, bonding, and reaction dynamics.	K3

COURSE CONTENT :

MODULE 1:	**Rotational and vibrational spectroscopy**	**12 Hours**
Introduction: Interaction of electromagnetic radiation with matter, Einstein coefficient, transition probability, transition dipole moments and selection rules, line-widths and line shapes, Fourier Transforms in spectroscopy. **Rotational and rotation-vibrational spectroscopy:** Microwave and Infrared spectroscopy of di- and polyatomic molecules, eigen values and eigenstates, selection rules, normal coordinates and their symmetry (CO_2), vibration and group frequency, FT-IR instrumentation. **Raman spectroscopy:** Raman Effect (basic principles only), rotational and rotation-vibrational Raman transitions, nuclear spin effects, polarization of Raman lines.		

MODULE 2:	Electronic spectroscopy, lasers and diffraction methods	16 Hours
Electronic spectroscopy: Vibronic spectroscopy of diatomic molecules, Franck-Condon factor, dissociation and pre-dissociation, rotational fine structure, solvent effects. **Lasers in spectroscopy:** Principles of laser action, laser characteristics, population inversion, Basic elements in laser (resonator, gain medium, pumping technique), pulsed lasers, laser cavity modes, Q-switching, mode locking, harmonic generation, different lasers: He-Ne, Nd-YAG, titanium-sapphire, dye lasers, semiconductor lasers, and applications of lasers. **Photoelectron Spectroscopy and Diffraction Methods:** Photoexcitation and photoionization, core level (XPS, ESCA) and valence level (UPS) photoelectron spectroscopy, XPS and UPS of molecules; Principle of electron, neutron and X-ray diffraction methods in determining the structure of molecules, synchrotron.		
MODULE 3:	**NMR spectroscopy**	**6 Hours**
Magnetic resonance: A review of spin angular momentum, basic principles and relaxation times, intensity of NMR signals, electronic shielding, NMR in liquids: chemical shifts, spin-spin couplings, NMR spectra of AX, A_3X and AB systems. **FT-NMR:** Rotating frame of reference, effect of RF pulses, FID, Multi pulse operation, measurement of T_1 by inversion recovery method, spin echo and measurement of T_2.		
MODULE 4:	**Polymers**	**10 Hours**
Polymer classification; two-dimensional polymerization kinetics; condensation and addition polymers; co-polymerization, chain transfer, initiation, propagation, and termination; types of molecular weights of polymers and their determination; heat, entropy, and free energy of mixing of polymer solutions.		
TOTAL LECTURES		**44 Hours**

Books:

1. J. M. Hollas, Modern Spectroscopy, 4thedition (2004) John Wiley & Sons, Ltd., Chichester.
2. C. N. Banwell and E.M. Mc Cash, Fundamentals of Molecular Spectroscopy, 4thedition (1994), Tata McGraw Hill, New Delhi.
3. A Carrington and A. D. Mc Lachlan, Introduction to Magnetic Resonance, (1979) Chapman and Hall, London.
4. R. K. Harris, Nuclear Magnetic Resonance Spectroscopy, (1986) Addison Wesley, Longman Ltd, London.
5. G. Herzburg, Infrared and Raman Spectra (1945), Spectra of Diatomic Molecules (1950), Van Nostrand, New York.
6. F. W. Billmayer, Jr., Text Book of Polymer Science, 3rd Edition (1984), Willey-Interscience, New York.
7. G. Odian, Principles of Polymerization, 3rd Edition (1991), John Wiley, Singapore.
8. P. Bahadur, N.V. Sastry, Principle of Polymer Sciences, Narosa Publishing House, New Delhi (2002)
9. V.R. Gowarikar, N.V. Vishwanathan, J. Shreedhar, Polymer Sciences, Wiley Eastern, New Delhi (1986)

CO-PO MAPPING

	PROGRAM OUTCOMES (PO)								PROGRAM SPECIFIC OUTCOMES (PSO)		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**1**	**2**	**3**
CO-1	3	2	1	2	1	--	--	1	3	2	1
CO-2	3	3	2	2	1	--	--	1	3	2	1
CO-3	3	3	2	2	1	--	--	1	3	2	1
CO-4	3	3	2	2	1	--	--	1	3	2	1
CO-5	3	3	2	2	1	--	--	1	3	2	1
CO-6	3	3	2	2	1	--	--	1	3	2	1
Average	**3**	**3**	**2**	**2**	**1**	**--**	**--**	**1**	**3**	**2**	**1**

Program: M. Sc. Chemistry	**Year, Semester:** 2nd Yr., 3rd Sem.
Course Title: Organometallic Chemistry of Transition Metals	**Subject Code:**TIU-PCH-T215
Contact Hours/Week: 3–1–0 (L–T–P)	**Credit:** 4

COURSE OBJECTIVE :

Enable the student to:

1. Understand the structure and bonding of organometallic compounds.
2. Analyze their reactions and catalytic applications.
3. Apply organometallic principles in chemistry and materials science.

COURSE OUTCOME :

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

CO-1:	**Remember** the structure and bonding patterns of various organometallic compounds.	K1
CO-2:	**Understand** the reaction mechanisms of organometallic complexes, including oxidative addition and reductive elimination.	K2
CO-3:	**Apply**the role of transition metal compounds in catalytic processes like hydrogenation and polymerization.	K3
CO-4:	**Analyze** the stereochemical non-rigidity and fluxional behavior of organometallic compounds.	K4
CO-5:	**Analyze** the different C-C and C-N coupling reactions in organic synthesis.	K4
CO-6:	**Apply** the principles of molecular magnetism to understand the properties of magnetic materials.	K3

COURSE CONTENT :

MODULE 1:	**Structure and bonding of various types of organometallic compounds**	**20 Hours**
Application of 18- electron and 16- electron rules; metal complexes of dioxygen and dinitrogen, nitrosyl, and phosphines; structure, bonding (pictorial mo-approach) and reactions of η^2-ethylinic , η^3-allylic and η^5-cyclo-pentadineyl compounds: $K[Pt(\eta^2-C_2H_4)Cl_3]$, $[(\eta^3-C_3H_5)PdCl]_2$, $(\eta^5- C_5H_5)_2Fe]$; carbene and carbyne complexes, Stereo-chemical non rigidity and fluxional behavior of organo-metallic compounds with typical examples; Metal-metal single and multiple bonding (pictorial mo –approach), bond orders, bonding in direhnium compounds; isolobal relationship and its applications.		
MODULE 2:	**Transition metal compounds in catalysis**	**10 Hours**
Substitution, insertion, oxidative addition, reductive elimination, insertion and elimination; electrophilic and nucleophilic reactions of coordinated ligands; metal hydrides (classical and non-classical), Agostic interaction, applications of NMR in studying hydrido complexes; stereochemical non-rigidity and fluxional behaviour of organometallic compounds.		
MODULE 3:	**Transition metal compounds in catalysis**	**10 Hours**

Hydrogenation, hydroformylation and polymerization; catalysis by organometallic, CH functionalizations. C-C and C-N coupling reactions (Suzuki, Heck, Negishi, Kumada, Hiama and Stille etc), asymmetric hydrogenations; metathesis reactions of alkenes and alkynes.		
MODULE 4:	**Molecular Magnetic Materials**	**4 Hours**
Types of magnetic interactions, inorganic and organic ferro-magnetic materials, low-spin–high-spin transitions, molecular magnets and applications.		
TOTAL LECTURES		**44 Hours**

Books:

1. F. A. Cotton and G. Wilkinson, Advanced Inorganic Chemistry, 6th Ed. (1999) John Wiley & Sons, NY.
2. J. E. Huheey, Keiter and Keiter, Inorganic Chemistry.
3. R. H. Crabtree, The Organometallic Chemistry of Transition Metals, John Wiley.
4. Ch. Elschenbroich and A. Salzer, Organometallics, VCH.
5. J. P. Collman, L. S. Hegedus, J. R. Norton and R.G. Finke, Principles and Applications of Organotransition metal Chemistry, Univ. Sci. Books, Mill Valley. California.
6. Oliver Kahn, Molecular Magnetism, VCH, Weinheim (1993).
7. R. S. Drago, Physical Methods in Chemistry, International Edition (1992), Affiliated East-West Press, New Delhi.

CO-PO MAPPING

	PROGRAM OUTCOMES (PO)								**PROGRAM SPECIFIC OUTCOMES (PSO)**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**1**	**2**	**3**
CO-1	3	2	1	2	1	--	--	1	3	2	1
CO-2	3	3	2	2	1	--	--	1	3	2	1
CO-3	3	3	2	2	1	--	--	1	3	2	1
CO-4	3	3	2	2	1	--	--	1	3	2	1
CO-5	3	3	2	2	1	--	--	1	3	2	1
CO-6	3	3	2	2	1	--	--	1	3	2	1
Average	**3**	**2.83**	**1.83**	**2**	**1**	**--**	**--**	**1**	**3**	**2**	**1**

Program: M. Sc. Chemistry	**Year, Semester:** 2nd Yr., 3rd Sem.
Course Title: Advanced Bioinorganic Chemistry	**Subject Code:**TIU-PCH-T217
Contact Hours/Week: 3–1–0 (L–T–P)	**Credit:** 4

COURSE OBJECTIVE :

Enable the student to:

Impart knowledge on different aspects of bioinorganic chemistry including (i) importance of metal ions in biology, (ii) structure and activity of various metalloproteins, and (iii) applications of metal complexes in medicine and toxic effects of some metals.

COURSE OUTCOME :

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

CO-1:	**Remember** the essential and trace metal ions in biological systems and their roles in biological processes.	K1
CO-2:	**Understand**the mechanisms of ion transport across biological membranes, including the Na^+/K^+ ion pump.	K2
CO-3:	**Apply** the structures and functions of dioxygen transport and storage proteins like hemoglobin, myoglobin, hemocyanin, and hemerythrin.	K3
CO-4:	**Analyze** the functions of electron transfer proteins such as cytochromes, ferredoxins, and cytochrome c oxidase.	K4
CO-5:	**Analyze**the mechanisms of metalloenzymes like catalase, peroxidase, SOD, and cytochrome C oxidase.	K4
CO-6:	**Apply** the toxicity of metal ions and the therapeutic applications of metal complexes in medicine.	K3

COURSE CONTENT :

MODULE 1:	**Metal ions in biology**	**12 Hours**
Essential and trace elements in the biological systems, metal of life, basic reactions in the biological systems and the roles of metal ions in biological process. Ion transport (active) across biological membrane and its significance, mechanism of Na^+ K^+ -ion pump.		
MODULE 2:	**Metalloproteins in biology**	**24 Hours**
Transport and storage of dioxygen: Active site structures and bio functions of O_2-uptake proteins: hemoglobin, myoglobin, hemocyanin and hemerythrin; model synthetic dioxygen complexes. **Electron transfer in biology:** Active site structures and functions of cytochromes, cytochrome *c*; iron-sulfur proteins (ferredoxines). cytochrome c oxidase. **Metalloenzymes:** Catalase, peroxidase, superoxide dismutase (SOD), cytochrome C oxidase, carbonic anhydrase, carboxypeptidase. **Redox enzymes:** Photosynthesis and chlorophylls, photosystem-I and photosystem-II and their roles in cleavage of water. Model systems. Biological and abiological nitrogen fixing		

systems. Molybdo enzymes: nitrate reductases, sulfite oxidase.		
MODULE 3:	**Toxicity and drugs**	**8 Hours**
Toxic effects of metal ions, detoxification by chelation therapy, metal dependent diseases and metal complexes as drugs, Pt, Ru, Rh and Au drugs.		
TOTAL LECTURES		**44 Hours**

Books:

1. M. N. Hughes, Inorganic Chemistry of Biological Processes, 2nd Ed. (1981), John-Wiley & Sons, New York.
2. W. Kaim and B. Schwederski, Bioinorganic Chemistry: Inorganic Elements in the Chemistry of Life, An Introduction and Guide, Wiley, New York (1995).
3. S. J. Lippard and J. M. Berg, Principles of Bioinorganic Chemistry, University Science Books, (1994).
4. I. Bertini, H. B. Grey, S. J. Lippard and J. S. Valentine, Bioinorganic Chemistry, Viva Books Pvt. Ltd., New Delhi (1998).

CO-PO MAPPING

	PROGRAM OUTCOMES (PO)								**PROGRAM SPECIFIC OUTCOMES (PSO)**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**1**	**2**	**3**
CO-1	3	2	1	2	1	--	--	1	3	2	1
CO-2	3	3	2	2	1	--	--	1	3	2	1
CO-3	3	3	2	2	1	--	--	1	3	2	1
CO-4	3	3	2	2	1	--	--	1	3	2	1
CO-5	3	3	2	2	1	--	--	1	3	2	1
CO-6	3	3	2	2	1	--	--	1	3	2	1
Average	**3**	**2.83**	**1.83**	**2**	**1**	**--**	**--**	**1**	**3**	**2**	**1**

Program: M. Sc. Chemistry	**Year, Semester:** 2nd Yr., 3rd Sem.
Course Title: Advanced Organic Chemistry-I	**Subject Code:**TIU-PCH-T211
Contact Hours/Week: 3–1–0 (L–T–P)	**Credit:** 4

COURSE OBJECTIVE :

Enable the student to:

1. Understand the principles of organic photochemistry and key photochemical reactions.
2. Explore important organic reactions and their applications in synthesis.
3. Apply synthetic strategies using phosphorus, silicon, and sulfur compounds in organic chemistry.

COURSE OUTCOME :

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

CO-1:	**Remember** the principles of organic photochemistry, including energy transfer and reaction pathways.	K1
CO-2:	**Understand** the mechanisms of photochemical transformations, including rearrangements and functionalization.	K2
CO-3:	**Apply** key organic reactions such as Hydroboration, Wittig, and Diels-Alder in synthetic strategies.	K3
CO-4:	**Apply** the role of photochemical and redox reactions in organic synthesis.	K3
CO-5:	**Analyze**the application of phosphorus, silicon, and sulfur compounds in synthetic organic chemistry	K4
CO-6:	**Apply** retrosynthetic approaches for designing complex organic molecules with stereochemical considerations.	K3

COURSE CONTENT :

MODULE 1:	**Organic Photochemistry-I**	**8 Hours**
Photochemical energy, Jablonski diagram, photosensitisation and quenching, Norrish Type-I and Type-II processes, Paterno-Buchi reaction, photochemistry of unsaturated compounds: rearrangement of unsaturated compounds; photo-induced reactions in aromatic compounds.		
MODULE 2:	**Organic Photochemistry-II**	**10 Hours**
Photo-induced functionalisation in organic molecules involving Barton reaction, Hofmann-Loffler-Freytag reaction; photochemical rearrangements, photo induced disproportion reaction, photo induced substitution reaction in aromatic systems, chemiluminescence in organic reactions.		
MODULE 3:	**Application of Important Organic Reactions in Organic Synthesis**	**10 Hours**

Application of Important Organic Reactions in Organic Synthesis, Hydroboration, Wittig Reaction, Birch Reduction, Grignard Reaction, Diels-Alder Reaction, Esterification and Amidation, Friedel-Crafts Acylation, Friedel-Crafts Alkylation.		
MODULE 4:	**Organic Synthetic Chemistry**	**16 Hours**
Organic synthetic process and uses of Phosphorus, Silicone and Sulphur compounds in synthetic organic chemistry, Planning a synthetic pathway; molecular characteristics: Retrosynthesis; method of formation of carbon skeleton: carbon to carbon bond formations, logistic and stereochemistry. Phospho ylide and sulphur ylide.		
TOTAL LECTURES		**44 Hours**

Books:

1. T. H. Lowry and K. C. Richardson, Mechanism and Theory in Organic Chemistry, 3rdEdn, Harper and Row, New York, 1998.
2. H. O. House, Modern Synthetic Reactions, 2ndEdn, Benjamin, 1971.
3. W. Caruthers, Modern Methods of Organic Synthesis, 3rdEdn, Cambridge University Press, Cambridge, 1996.
4. J. Clayden, N. Greeves, S. Warren, and P. Wothers, Organic Chemistry, Oxford University Press, Oxford, 2001.
5. O. L. Chapman, Some Aspects of Organic Photochemistry, Dekker, 1967.
6. J. M. Coxon and B. Halton, Organic Photochemistry, Cambridge University Press, Cambridge, 1974.
7. R. O. C. Norman and J. M. Coxon, Principles of Organic Synthesis, 3rdEdn, ELBS, 2003.
8. J. Singh and J. Singh, Photochemistry and Pericyclic Reactions, 3rdEdn, New Age International (P) Ltd, India, 2012.
9. A. Griesbeck, M. Oelgemoller and F. Ghetti, Organic Photochemistry and Photobiology, 3rd Edn, Vol I, CRC Press, Boca Raton, FL, 2012.
10. H.O. House, Modern Synthetic Reactions, 2nd Edition (1972), Benjamin/Cummings Publishing Company, California.
11. L.F. Fieser and M. Fieser, Reagents for Organic Synthesis, Vol. 1-16 (Vol. 1, 1967), Wiley-
Interscience, New York.
12. M.B. Smith and J. March, March's Advanced Organic Chemistry – Reactions, Mechanisms &Structure, 5th ed. (2001), Wiley-Interscience, New York.
13. M. B. Smith, Organic Synthesis, McGraw Hill Inc., New York (1995).
14. J. Clayden, N. Greeves, S. Warren, and E. Wothers, Organic Chemistry, Oxford Univ. Press, Oxford (2001).
15. P. R. Jenkins, Organometallic Reagents in Synthesis, Oxford science Publ., Oxford (1992)

CO-PO MAPPING

	PROGRAM OUTCOMES (PO)								**PROGRAM SPECIFIC OUTCOMES (PSO)**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**1**	**2**	**3**
CO-1	3	2	1	2	1	--	--	1	3	2	1
CO-2	3	3	2	2	1	--	--	1	3	2	1
CO-3	3	3	2	2	1	--	--	1	3	2	1
CO-4	3	3	2	2	1	--	--	1	3	2	1
CO-5	3	3	2	2	1	--	--	1	3	2	1
CO-6	3	3	2	2	1	--	--	1	3	2	1
Average	**3**	**2.83**	**1.83**	**2**	**1**	**--**	**--**	**1**	**3**	**2**	**1**

Program: M. Sc. Chemistry	**Year, Semester:** 2nd Yr., 3rd Sem.
Course Title: Advanced Organic Chemistry-II	**Subject Code:**TIU-PCH-T213
Contact Hours/Week: 3–1–0 (L–T–P)	**Credit:** 4

COURSE OBJECTIVE :

Enable the student to:

1. Understand the synthesis and reactivity of heterocyclic compounds.
2. Explore the structure and chemistry of steroids and prostanoids.
3. Analyze the classification and reactions of natural products.

COURSE OUTCOME :

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

CO-1:	**Remember** the synthesis and structural features of various heterocyclic compounds.	K1
CO-2:	**Understand** the chemistry and synthesis of steroids and prostanoids.	K2
CO-3:	**Understand**the structural classification and reactivity of alkaloids, terpenoids, and carotenoids.	K2
CO-4:	**Apply** retrosynthetic approaches to the synthesis of selected natural products.	K3
CO-5:	**Analyze** the stereochemical aspects and reaction mechanisms of bioactive compounds.	K4
CO-6:	**Apply**the synthetic strategies for complex natural products based on their molecular framework.	K3

COURSE CONTENT :

MODULE 1:	**Chemistry of heterocycles**	**18 Hours**
Synthesis, structure and reactions of the following heterocyclic compounds: (a) Three-membered rings: Aziridines. (b) Four-membered rings: Azetidines and their 2-oxo derivatives. (c) Five-membered rings containing two heteroatoms: Oxzoles, Imidazoles, Thiazoles, Isoxazoles, Pyrazoles. (d) Pyrimidines. (e) Purines: Uric acid and Caffeine. (f) Five-membered ring heterocycles with three or four heteroatoms		
MODULE 2:	**Steroids and Prostanoids**	**6 Hours**
Diels' hydrocarbon, Cholesterols, Chemistry, elucidation of structure and synthesis; Bile acids, Androsteron, Estrone		
MODULE 3:	**Chemistry of natural products**	**18 Hours**
Alkaloids, terpenoids, and carotinoids: structural classification, structure determination, and reactions. Syntheses, stereochemistry, and reactions of terpenoids and carotenoids, including β-		

carotene, abietic acid, santonin, and zingiberine. Stereochemistry, syntheses and reactions of selective alkaloids such as quinine, morphine, camptothecin, and newly identified bioactive natural compounds.	
TOTAL LECTURES	**42 Hours**

Books:

1. T. L. Gilchrist, Heterocyclic Chemistry, 3rd Edition (1997) Addison-Wesley Longman Ltd., England
2. R. K. Bansal, Heterocyclic Chemistry: Syntheses, Reactions and Mechanisms, 3rd Edition (1999), New Age International, Publisher, New Delhi.
3. A. R. Katritzky, C. A. Ramsden, J.A. Joule and V. V. Zhdankin, Handbook of Heterocyclic Chemistry, 3rd Edition (2010), Elsevier, Oxford, UK.
4. Heterocyclic Chemistry, 4th edition, J. A. Joule and K. Mills, Blackwell Publishing, Indian Reprint 2004.
5. Heterocyclic Chemistry Vol-III,III, 1st edition. R.R. Gupta, M. Kumar, V. Gupta Springer-Verlag, Berlin Heidelberg Publication (2005)
6. Aromatic Heterocyclic Chemistry: David T. Davies, (1992), Oxford University Press.
7. Classics in Total Synthesis (Vol I) - K.C. Nicolaou and E.J. Sorensen, Wiley-VCH
8. Classics in Total Synthesis II - K.C. Nicolaou and S.A. Snyder Wiley-VCH

CO-PO MAPPING

	PROGRAM OUTCOMES (PO)								**PROGRAM SPECIFIC OUTCOMES (PSO)**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**1**	**2**	**3**
CO-1	3	2	1	2	1	--	--	1	3	2	1
CO-2	3	3	2	2	1	--	--	1	3	2	1
CO-3	3	3	2	2	1	--	--	1	3	2	1
CO-4	3	3	2	2	1	--	--	1	3	2	1
CO-5	3	3	2	2	1	--	--	1	3	2	1
CO-6	3	3	2	2	1	--	--	1	3	2	1
Average	**3**	**2.83**	**1.83**	**2**	**1**	**--**	**--**	**1**	**3**	**2**	**1**

Program: M. Sc. Chemistry	**Year, Semester:** 2nd Yr., 3rd Sem.
Course Title: Quantum Mechanics and Chemical Applications of Group Theory	**Subject Code:** TIU-PCH-T207
Contact Hours/Week: 3–1–0 (L–T–P)	**Credit:** 4

COURSE OBJECTIVE :

Enable the student to:

1. Develop a deep understanding of quantum chemistry and advanced methods for solving many-body systems.
2. Utilize group theory principles to analyze molecular symmetry, structure, and spectroscopic properties.
3. Integrate quantum mechanics and group theory to interpret molecular bonding, hybridization, and electronic transitions.

COURSE OUTCOME :

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

CO-1:	**Remember** the fundamental postulates of quantum mechanics and approximation methods for solving many-body systems.	K1
CO-2:	**Understand** the application of quantum mechanical models to many-electron atoms and molecular structures.	K2
CO-3:	**Apply** group theory to determine molecular symmetry and its impact on vibrational spectroscopy.	K3
CO-4:	**Analyze** the selection rules for infrared and Raman spectroscopy using symmetry considerations.	K4
CO-5:	**Apply** the energy level splitting in crystal field theory and construct molecular orbital diagrams for simple molecules.	K3
CO-6:	**Analyze** the various quantum mechanical and group theoretical approaches for studying chemical systems.	K4

COURSE CONTENT :

MODULE 1:	**Quantum Mechanics**	**22 Hours**
Fundamentals: General formulation of Quantum Mechanics, Postulates of Quantum Mechanics, Review of rigid rotor, harmonic oscillator and Hydrogen atom problems. Angular momentum: commutative relations and ladder operators. **Approximation Methods:** Stationary perturbation theory for non-degenerate and degenerate systems with examples. Variation method. Ground state of Helium atom. Time-dependent perturbation theory. Radiative transitions. Einstein coefficients.		

<table>
<tr><td colspan="3">Many Electron Atoms: Hartee SCF method, Electron correlation, Addition of angular momenta – Clabsch-Gordan series, Spin-orbit interaction, Condon Slater rule.

Molecular Structure: Born-Oppenheimer approximation. Molecular orbital treatment for homonuclear molecule. Hückel MO treatment of simple polyenes.</td></tr>
<tr><td>MODULE 2:</td><td>Applications of Group theory to IR and Raman Spectroscopy</td><td>10 Hours</td></tr>
<tr><td colspan="3">Brief introduction to molecular vibrations; selection rules for fundamental vibrational transitions, symmetry of normal modes of molecules, Infrared and Raman activity of some typical molecules (molecules of C_{2v}, C_{3v}, C_{4v}, D_{2h}, D_{3h}, D_{4h}, T_d and O_h point groups).</td></tr>
<tr><td>MODULE 3:</td><td>Applications of Group theory to Crystal Field Theory and Molecular Orbital Theory</td><td>12 Hours</td></tr>
<tr><td colspan="3">Splitting of levels and terms in chemical environment, construction of energy level diagrams, selection rules and polarizations.
Introduction, transformation properties of atomic orbitals; hybridization schemes for σ− and π−bonding, hybrid orbitals as LCAOs; Molecular Orbital Theory for some typical AB_n types (n = 2, 3, 4, 6) of molecules (H_2O, NH_3 and BH_3).</td></tr>
<tr><td colspan="2">TOTAL LECTURES</td><td>44 Hours</td></tr>
</table>

Books:

1. P. W. Atkins and R. S. Friedman, Molecular Quantum Mechanics, 3rdedition (1997), Oxford University Press. Oxford.
2. I. N. Levine, Quantum Chemistry, 5th edition (2000), Pearson Educ., Inc., New Delhi.
3. D. A. McQuarrie and J. D. Simon, Physical Chemistry: A Molecular Approach, (1998), Viva Books, New Delhi.
4. A. K. Chandra, Introductory Quantum Chemistry, 4thedn. (1994), Tata McGraw Hill, New Delhi.
5. L. Pauling and E. B. Wilson, Introduction to Quantum Mechanics with Applications to Chemistry, (1935), McGraw Hill, New York.
6. F. A. Cotton, Chemical Applications of Group Theory, 3rdedn. (1999), John Wiley & Sons, New York.

CO-PO MAPPING

	PROGRAM OUTCOMES (PO)								PROGRAM SPECIFIC OUTCOMES (PSO)		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**1**	**2**	**3**
CO-1	3	2	1	2	1	--	--	1	3	2	1
CO-2	3	3	2	2	1	--	--	1	3	2	1
CO-3	3	3	2	2	1	--	--	1	3	2	1
CO-4	3	3	2	2	1	--	--	1	3	2	1
CO-5	3	3	2	2	1	--	--	1	3	2	1
CO-6	3	3	2	2	1	--	--	1	3	2	1
Average	**3**	**2.83**	**1.83**	**2**	**1**	**--**	**--**	**1**	**3**	**2**	**1**

Program: M. Sc. Chemistry	**Year, Semester:** 2nd Yr., 3rd Sem.
Course Title: Electrochemistry	**Subject Code:**TIU-PCH-T209
Contact Hours/Week: 3–1–0 (L–T–P)	**Credit:** 4

COURSE OBJECTIVE :

Enable the student to:

1. Understand ion-solvent interactions and their thermodynamic and structural properties.
2. Analyze electrical double layer models and electrode kinetics to interpret interfacial phenomena.
3. Apply electrochemical principles to real-world applications, including corrosion, cyclic voltammetry, and electrocatalysis.

COURSE OUTCOME :

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

CO-1:	**Remember** the fundamental concepts of ion-solvent interactions and models describing solvation.	K1
CO-2:	**Understand** the structure and potential distribution of the electrical double layer at metal/semiconductor-electrolyte interfaces.	K2
CO-3:	**Apply** different models of the electrical double layer to analyze interfacial electrochemical phenomena.	K3
CO-4:	**Analyze** electrode kinetics, including multistep reactions, rate-determining steps, and electrocatalytic activity.	K4
CO-5:	**Apply** key electrochemical parameters such as exchange current density, reaction order, and transfer coefficients.	K3
CO-6:	**Analyze** the electrochemical applications, including corrosion, cyclic voltammetry, and electrochemical cell performance.	K4

COURSE CONTENT :

MODULE 1:	**Ion-Solvent Interaction**	**5 Hours**
Introduction, Born model and Born equation, enthalpy of ion-solvent interaction and its evaluation, Eley-Evan model, solvation number and its determination.		
MODULE 2:	**Electrical Double Layer at Metal/Semiconductor-Electrolyte Interface**	**20 Hours**
OHP and IHP, potential profile across double layer region, potential difference across electrified interface, Structure of the double layer: Helmholtz-Perrin, Gouy-Chapman, and Stern models. Butler-Volmer equation under near equilibrium and non-equilibrium conditions, exchange current density, Tafel plot. Thermodynamics of double layer, Electrocapillary equation, Determination of surface excess and other electrical parameters-electrocapillarity, excess charge capacitance, and relative surface excesses.		

MODULE 3:	Electrode Kinetics	15 Hours
Polarizable and non-polarizable interfaces. Multistep reactions-a near equilibrium relation between current density and over potential, concept of rate determining step. Determination of reaction order, stochiometric number, and transfer coefficient. Electrocatalysis-comparison of electrocatalytic activity. Importance of oxygen reduction and hydrogen evolution reactions and their mechanisms.		
MODULE 4:	**Applications of Electrochemistry**	**4 Hours**
Electrochemical cells, Corrosion, Cyclic Voltammetry		
TOTAL LECTURES		**44 Hours**

Books:

1. J. O'M. Bockris and A. K. N. Reddy, Modern Electrochemistry, Vol. 1 & 2A and 2B, (1998) Plenum Press, New York.
2. A. J. Bard and L. R. Faulkner, Electrochemical Methods: Fundamentals and Applications, 2nd edition, (2001) John Wiley &Sons, New York.
3. Samuel Glasstone, An Introduction to Electrochemistry: Edition 1st, East-West Press Pvt Ltd New Delhi, India.

CO-PO MAPPING

	PROGRAM OUTCOMES (PO)								PROGRAM SPECIFIC OUTCOMES (PSO)		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**1**	**2**	**3**
CO-1	3	2	1	2	1	--	--	1	3	2	1
CO-2	3	3	2	2	1	--	--	1	3	2	1
CO-3	3	3	2	2	1	--	--	1	3	2	1
CO-4	3	3	2	2	1	--	--	1	3	2	1
CO-5	3	3	2	2	1	--	--	1	3	2	1
CO-6	3	3	2	2	1	--	--	1	3	2	1
Average	**3**	**2.83**	**1.83**	**2**	**1**	**--**	**--**	**1**	**3**	**2**	**1**

Program: M. Sc. Chemistry	**Year, Semester:** 2nd Yr., 3rd Sem.
Course Title: Industrial Chemistry	**Subject Code:**TIU-PCH-T231
Contact Hours/Week: 3–1–0 (L–T–P)	**Credit:** 4

COURSE OBJECTIVE :

Enable the student to:

1. Understand major industrial chemistry sectors and processes.
2. Analyze petroleum refining and renewable fuel technologies.
3. Apply quality, environmental, and safety standards in industries.

COURSE OUTCOME :

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

CO-1:	**Remember** the fundamental concepts of industrial chemistry, including key sectors and manufacturing processes.	K1
CO-2:	**Understand**thepetroleum refining techniques, alternative fuels, and their applications.	K2
CO-3:	**Apply** the quality control techniques and regulatory frameworks in chemical industries.	K3
CO-4:	**Apply** statistical quality control methods and ISO standards for industrial process evaluation.	K3
CO-5:	**Analyze**the environmental and safety regulations in chemical and fuel industries.	K4
CO-6:	**Understand** the waste management and sustainability practices in industrial processes.	K2

COURSE CONTENT :

MODULE 1:	**Industrial Chemistry Overview**	**24 Hours**
Introduction to Different Industries, Petroleum and Petrochemicals: Composition of Crude Oils (Paraffins, Naphthenes, Aromatics, Sulphur and Nitrogen Compounds), Distillation Methods (Atmospheric, Vacuum), Cracking Techniques (Thermal, Catalytic, Hydrocracking), Reforming and Hydrotreatment, Properties of Petroleum Products, and Alternative Fuels. Paper and Textile Industries: Raw Materials for Paper, Pulp Manufacturing, Evaluation of Paper Properties, Fiber Characteristics (Cotton, Wool, Silk), Synthetic Fibers, and Recycling Processes. Cosmetics and Healthcare: Raw Materials in Cosmetics, Quality Control of Products (Shampoo, Toothpaste, Skin Creams, Perfumes), and Stability Factors in Formulations. Pharmaceutical Industry: Overview of Drug Development Processes, Quality Control in Pharmaceuticals, Regulatory Standards, and Good Manufacturing Practices (GMP).		
MODULE 2:	**Advanced Petroleum Processing and Renewable Fuels**	**8 Hours**
Refining Processes: Caustic Washing, Merox Process, Hydrorefining, Methods for Improving		

Storage Stability, Filtration, Molecular Sieves, Overview of Synthetic and Renewable Fuels, Modern Fuels: Electrofuel, Solar Fuel, Syngas, and Their Applications.		
MODULE 3:	**Quality Control in Chemical Industries**	**6 Hours**
Quality Control in the Chemical Industry: Statistical Quality Control Techniques, Control Charts, Performance Evaluation, Validation of Analytical Methods, Quality Assurance Elements, Quality Management Systems (ISO 9001:2000), Case Studies on ISO 9001:2000 in Chemical Industries, ISO 14000 Series of Standards, Good Laboratory Practices (GLP), Good Manufacturing Practices (GMP) in Drugs and Pharmaceuticals, Accreditation of QC Laboratories, Tools and Mechanisms, ICH Guidelines.		
MODULE 4:	**Environmental and Safety Standards**	**6 Hours**
Environmental Considerations in Chemical Manufacturing, Health and Safety Standards in Chemical and Fuel Industries, Food Quality and Safety Standards in FMCG, Regulatory Frameworks for Chemical Industries, Best Practices for Waste Management and Sustainability in Industrial Processes.		
TOTAL LECTURES		**44 Hours**

Books:

1. I.B.H. Rao, Modern Petroleum Refining Process, 2nd ed. (2020) IBH Publications.
2. A. Maiti, Introduction to Petrochemicals (2019) IBH Publications.
3. G.A. Smook, Handbook for Pulp and Paper Technologists, 2nd ed. (2021) Angus Wilde Publications.
4. V.A. Shenai, Technology of Textile Processing: Technology of Dyeing, 4th ed. (1988) Sewak Publications, Bombay.
5. L. Shargel & A.B.C. Yu, Applied Biopharmaceutics and Pharmacokinetics, 4th ed. (1999).
6. A.H. Beckett & J.B. Stenlake, Practical Pharmaceutical Chemistry, Part I and Part II, 4th ed. (2000) The Royal Society of Chemistry.
7. G.H. Jeffery, J. Basset, J. Mendham, & R.C. Denny, Vogel's Textbook of Quantitative Chemical Analysis, 5th ed. (1989) ELBS.
8. M. Mahajan, Statistical Quality Control, 2nd ed. (1995) Dhanpat Rai and Sons.
9. M.A. Fryman, Quality Management: A Process Improvement Approach (2002) Cengage Learning.
10. D. Paranthaman, Quality Control (1987) Tata McGraw Hill.

CO-PO MAPPING

	PROGRAM OUTCOMES (PO)								PROGRAM SPECIFIC OUTCOMES (PSO)		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**1**	**2**	**3**
CO-1	3	2	1	2	1	1	1	1	2	1	2
CO-2	3	3	2	2	1	1	1	1	2	1	2
CO-3	3	3	2	2	1	1	1	1	2	1	2
CO-4	3	3	2	2	1	1	1	1	2	1	2
CO-5	3	3	2	2	1	1	1	1	2	1	2
CO-6	3	3	2	2	1	1	1	1	2	1	2
Average	**3**	**2.83**	**1.83**	**2**	**1**	**1**	**1**	**1**	**2**	**1**	**2**

Program: M. Sc. Chemistry	**Year, Semester:** 2nd Yr., 3rd Sem.
Course Title: Environmental Chemistry	**Subject Code:**TIU-PCH-T233
Contact Hours/Week: 3–1–0 (L–T–P)	**Credit:** 4

COURSE OBJECTIVE :

Enable the student to:

1. Understand environmental segments and cycles and their role in maintaining ecological balance.
2. Analyze sources, effects, and monitoring methods of air, water, and soil pollution.
3. Apply environmental sampling and analytical techniques for pollution assessment and control.

COURSE OUTCOME :

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

CO-1:	**Remember** the different environmental segments, natural cycles, and their significance in ecological balance.	K1
CO-2:	**Understand**the sources, effects, and chemical processes involved in air, water, and soil pollution.	K2
CO-3:	**Remember** the environmental quality standards and monitoring techniques for pollutants.	K1
CO-4:	**Apply** wastewater treatment and solid waste management techniques for pollution control.	K3
CO-5:	**Analyze** the toxicity of inorganic and organic pollutants, including heavy metals and pesticides.	K4
CO-6:	**Apply** environmental sampling and analytical methods for pollutant detection and emission control.	K3

COURSE CONTENT :

MODULE 1:	**Environmental segments**	**4 Hours**
Atmosphere, hydrosphere, lithosphere, and biosphere. Environmental cycles: water, oxygen, nitrogen, carbon, phosphorus, and sulfur cycles, composition and structure of the atmosphere, chemical and photochemical reactions in the atmosphere, ozone layer and its importance, greenhouse effect, acid rain, photochemical smog.		
MODULE 2:	**Environmental Chemistry and Analysis**	**18 Hours**
Air pollution: Air quality standards and norms (OSHA, NIOSH, CPCB and WBPCB), Monitoring and Determination of air pollutants: SO_x, NO_x, NH_3, hydrocarbons, VOC's, CO, SPM, RPM, $PM_{2.5}$, Indoor air pollutants, photochemical smog and acid rain, and Green house gas effect (concise) **Water pollution:**Water-quality parameters and standards (CPCB and MoEF): physical and chemical parameters, Dissolved oxygen (DO), BOD, COD, Total organic carbon, Total nitrogen,		

Total sulfur, Total phosphorus, Chlorine, Heavy metals (Pb, As, Hg) and Pesticides **Waste water treatment and solid waste:** Various types of waste water treatment: physical, chemical, aerobic and anaerobic (UASB) treatments, waste recycling, solid waste treatment and recycling **Soil pollution:** Identification of soil pollutants, Detrimental effects of soil pollutants, solid waste management, Soil conservation – Nitrogen pathways and NPK in soil.		
MODULE 3:	**Environmentally toxic substances**	**14 Hours**
Toxic inorganic substances – realizing toxicity from the SHAB standpoint. Health hazards of SPM [Suspended (inorganic) Particulate Matter]; IPM [Inhaleable (inorganic) Particulate Matter]; Methods of determination of SPM (High Volume Sampler) and IPM (Cascade Impactor); Mechanisms of some heavy metal toxicities and their impact on society; Pesticides; metallo-organic compounds and their toxicity; Application of analytical methods to determine toxic species. Polymers and Plastics and their environmental degradation, Introduction to green chemistry and its utility.		
MODULE 4:	**Environmental sample analysis**	**8 Hours**
Environmental sampling, analysis, emission, and control: Sampling techniques (Air/water/soil) Environmental sample analysis by UV-Vis Spectrophotometer, GC, and HPLC, Emission: Fugitive emission, BTX analysis, Emission control equipments.		
TOTAL LECTURES		**44 Hours**

Books:

1. G. W. Vanloon, S.J. Duffer, Environmental Chemistry - A Global Perspective, Oxford University Press (2000).
2. F. W. Fifield and W. P. J. Hairens, Environmental Analytical Chemistry, 2nd Edition (2000), Black Well Science Ltd.
3. Colin Baird, Environmental Chemistry, W. H. Freeman and Company, New York (1995).
4. A. K. De, Environmental Chemistry, 4th Edition (2000), New Age International Private Ltd., New Delhi.
5. Peter O. Warner, Analysis of Air Pollutants, 1st Edition (1996), John Wiley, New York.
6. S. M. Khopkar, Environmental Pollution Analysis, 1st Edition (1993), Wiley Eastern Ltd., New Delhi.
7. S. K. Banerji, Environmental Chemistry, 1st Edition (1993), Prentice-Hall of India, New Delhi.
8. C. Baird, Environmental Chemistry, 5th Edition (2017), W. H. Freeman, New York.
9. M. M. Benjamin, Water Chemistry, 2nd Edition (2015), Waveland Press, Long Grove, IL, ISBN 1-4786-2308-X.
10. S. S. Dara, Environmental Chemistry, 1st Edition (2006), S. Chand Publishing, New Delhi.
11. Mahajan, Environmental Chemistry, 1st Edition (2010), Prentice Hall, New Delhi.

CO-PO MAPPING

	PROGRAM OUTCOMES (PO)								PROGRAM SPECIFIC OUTCOMES (PSO)		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**1**	**2**	**3**
CO-1	3	2	1	2	1	--	2	1	2	1	1
CO-2	3	3	2	2	1	--	2	1	2	1	1
CO-3	3	3	2	2	1	--	2	1	2	1	1
CO-4	3	3	2	2	1	--	2	1	2	1	1
CO-5	3	3	2	2	1	--	2	1	2	1	1
CO-6	3	3	2	2	1	--	2	1	2	1	1
Average	**3**	**2.83**	**1.83**	**2**	**1**	**--**	**2**	**1**	**2**	**1**	**1**

Program: M. Sc. Chemistry	**Year, Semester:** 2nd Yr., 3rd Sem.
Course Title: Green Chemistry	**Subject Code:** TIU-PCH-T235
Contact Hours/Week: 3–1–0 (L–T–P)	**Credit:** 4

COURSE OBJECTIVE :

Enable the student to:

1. Understand the principles of green chemistry and their role in sustainable chemical processes.
2. Analyze green chemical strategies for improving reaction efficiency, reducing waste, and promoting cleaner production.
3. Apply green chemistry techniques such as catalysis, photochemical degradation, and sustainable reaction media in chemical synthesis and waste treatment.

COURSE OUTCOME :

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

CO-1:	**Remember** the fundamental principles and goals of green chemistry.	K1
CO-2:	**Understand** the concept of atom economy, reaction efficiency, and sustainable chemical processes.	K2
CO-3:	**Understand** the green solvents, catalysts, and reaction conditions for environmentally friendly chemical synthesis.	K2
CO-4:	**Apply** the green chemistry strategies such as microwave-assisted synthesis, bio-catalysis, and solvent-free reactions.	K3
CO-5:	**Analyze** the role of multicomponent reactions and nanocatalysts in sustainable organic synthesis.	K4
CO-6:	**Apply** the photochemical degradation methods for eco-friendly waste treatment and pollution control.	K3

COURSE CONTENT :

MODULE 1:	**General understanding of green chemistry**	**10 Hours**
Introduction to Green Chemistry, Need for Green Chemistry. Goals of Green Chemistry. An introduction to the tools of green chemistry and its fundamental principles. Principles of Green Chemistry: Prevention of waste / by-products, Hazardous products, Designing of safer chemicals- Selection of appropriate solvents and starting materials- Use of protecting groups and catalysis- Designing of biodegradable products.		
MODULE 2:	**Green Chemical Strategies for Sustainable Development**	**26 Hours**
Reaction mass balance-Atom Economy, Evaluation for Chemical Reaction Efficiency, Cleaner Production and Sustainable Development, Implementation of Cleaner Production, Change of Raw Materials, On Site Reuse and Recycling.		

Green Solvents/ reaction Media, Catalysis and Bio catalysis. Microwave oven as a reactor, Theory of Microwave Heating. Design, synthesis and applications of green catalysts in organic synthesis, nanocatalysts, surface modified catalysts, porous catalysts. Multicomponent reactions (MCRs) for heterocycles synthesis under green conditions: mechanochemistry (Ball-Milling), reactions in micellar media, reactions in aqueous medium, reactions under solvent-free conditions.		
MODULE 3:	**Photochemical approaches**	**8 Hours**
Photochemical Degradation: An Eco-friendly Approach of Waste Treatment. Photochemical Principles, Heterogeneous Photo-catalysis, Homogeneous Photo-degradation, photo oxidation, Direct Photo-degradation, Gas phase Detoxification, Equipments and applications.		
TOTAL LECTURES		**44 Hours**

Books:

1. V. K. Ahluwalia & M. Kidwai, New Trends in Green Chemistry, 1st Edition (2009), Ane Books, New Delhi.
2. V. K. Ahluwalia, Green Chemistry, 1st Edition (2006), University Press, Hyderabad.
3. P. T. Anastas & T. C. Williamson, Green Chemistry, 2nd Edition (1997), Oxford University Press, New York.
4. C. Kappe & C. Oliver, Microwaves in Organic and Medicinal Chemistry, 1st Edition (2009), Wiley-VCH, Weinheim.
5. R. R. Gupta, V. E. Eric & C. Oliver Kappe, Microwave Assisted Synthesis of Heterocycles, 1st Edition (2010), Wiley-VCH, Weinheim.
6. K. Tanka, Solvent-free Organic Synthesis, 1st Edition (2006), Wiley-VCH, Weinheim.

CO-PO MAPPING

	PROGRAM OUTCOMES (PO)								**PROGRAM SPECIFIC OUTCOMES (PSO)**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**1**	**2**	**3**
CO-1	3	2	1	2	1	--	2	1	2	1	1
CO-2	3	3	2	2	1	--	2	1	2	1	1
CO-3	3	3	2	2	1	--	2	1	2	1	1
CO-4	3	3	2	2	1	--	2	1	2	1	1
CO-5	3	3	2	2	1	--	2	1	2	1	1
CO-6	3	3	2	2	1	--	2	1	2	1	1
Average	3	2.83	1.83	2	1	--	2	1	2	1	1

Program: M. Sc. Chemistry	**Year, Semester:** 2nd Yr., 3rdSem.
Course Title: Advance Inorganic Chemistry Lab	**Subject Code:**TIU-PCH-L211
Contact Hours/Week: 0–0–8 (L–T–P)	**Credit:** 4

COURSE OBJECTIVE :

The course aims to provide practical skills on (i) qualitative and quantitative estimation of varieties of ions and selected compounds in solution; (ii) syntheses, purification and characterizations of inorganic metal complexes, polymers, and macrocycles.

COURSE OUTCOME :

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

CO-1:	**Remember** themajor and minor components in ores and alloys using volumetric, complexometric, and instrumental methods.	K1
CO-2:	**Remember** the separation techniques such as solvent extraction and chromatography for quantitative analysis.	K1
CO-3:	**Understand** the determination of composition and formation constants using pH-metric and spectrophotometric methods.	K2
CO-4:	**Apply**various synthesis techniques to prepare inorganic and coordination compounds with different ligand systems.	K3
CO-5:	**Analyze** the structural and chemical properties of synthesized compounds using characterization techniques.	K4
CO-6:	**Understand** the synthesis and properties of inorganic polymers for potential applications.	K2

COURSE CONTENT :

Experiment1: Quantitative analysis of major and minor components in ores and alloys by volumetric, complexometric, gravimetric and other instrumental methods after separation of the components by solvent extraction or chromatographic techniques. **Experiment 2**: Determination of composition and formation constants of selected systems by *p*H-metric and spectrophotometric methods. **Experiment3**: Preparation of inorganic and coordination compounds (bi-, tri- and polydentate ligands) and their characterization by various techniques. **Experiment 4**: Synthesis of inorganic polymer	
TOTAL LECTURES	**112 Hours**

Books:

1. James, A.M., Prichard, F.F. Practical Physical Chemistry, 3rd ed., 2021, Prentice Hall.
2. Levitt, B.P. Findlay's Practical Physical Chemistry, 10th ed., 2020, Prentice Hall.
3. Shoemaker, D.P., Haile, J., Moeller, W.J. Experimental Physical Chemistry, 3rd ed., 2014, Prentice Hall.

CO-PO MAPPING

	PROGRAM OUTCOMES (PO)								**PROGRAM SPECIFIC OUTCOMES (PSO)**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**1**	**2**	**3**
CO-1	2	1	1	2	1	1	1	1	2	3	2
CO-2	2	1	1	2	1	1	1	1	2	3	2
CO-3	2	1	1	2	1	1	1	1	2	3	2
CO-4	2	1	1	2	1	1	1	1	2	3	2
CO-5	2	1	1	2	1	1	1	1	2	3	2
CO-6	2	1	1	2	1	1	1	1	2	3	2
Average	**2**	**1**	**1**	**2**	**1**	**1**	**1**	**1**	**2**	**3**	**2**

Program: M. Sc. Chemistry	**Year, Semester:** 2nd Yr., 3rd Sem.
Course Title: Advance Organic Chemistry Lab	**Subject Code:**TIU-PCH-L213
Contact Hours/Week: 0–0–8 (L–T–P)	**Credit:** 4

COURSE OBJECTIVE :
In this course students get the training on synthesis, extraction, purification and characterization of some important organic compounds.

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

CO-1:	**Remember** the key intermediates and final products in multistep organic synthesis.	K1
CO-2:	**Understand** the principles of IR, NMR, and mass spectrometry for organic compound characterization.	K2
CO-3:	**Remember** the purification techniques such as recrystallization, TLC, and partition chromatography for organic synthesis.	K2
CO-4:	**Apply**multistep synthesis strategies to prepare selective organic compounds.	K3
CO-5:	**Analyze** reaction progress and product purity using spectroscopic and chromatographic techniques.	K4
CO-6:	**Analyze** thestructural properties of synthesized organic compounds using spectral data interpretation.	K4

COURSE CONTENT :

Experiment 1: Preparation of organic compounds involving several stages, characterization of intermediates and final products by IR and NMR spectroscopy. **Experiment 2:** Characterization of organic compounds or groups by spectroscopic methods **Experiment 3:** Syntheses (multistep) of selective organic compounds utilizing standard processes, followed by product purification (recrystallization, TLC, PC, R_f values, m.p/b.p.] and characterization by various spectroscopic techniques (NMR, IR, mass).	
TOTAL LECTURES	**112 Hours**

Books:

1. H. Middleton, Systematic Organic Qualitative Analysis, 3rd Edition (2020) Edward Arnold, London.
2. H.T. Clarke, Handbook of Organic Analysis, 4th Edition (2013) John Wiley & Sons, New York.
3. A.I. Vogel, Vogel's Textbook of Quantitative Chemical Analysis, 6th Edition (2023) Pearson Education Limited, Harlow.

CO-PO MAPPING

	PROGRAM OUTCOMES (PO)								**PROGRAM SPECIFIC OUTCOMES (PSO)**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**1**	**2**	**3**
CO-1	2	1	1	2	1	1	1	1	2	3	2
CO-2	2	1	1	2	1	1	1	1	2	3	2
CO-3	2	1	1	2	1	1	1	1	2	3	2
CO-4	2	1	1	2	1	1	1	1	2	3	2
CO-5	2	1	1	2	1	1	1	1	2	3	2
CO-6	2	1	1	2	1	1	1	1	2	3	2
Average	**2**	**1**	**1**	**2**	**1**	**1**	**1**	**1**	**2**	**3**	**2**

Program: M. Sc. Chemistry	**Year, Semester:** 2nd Yr., 3rd Sem.
Course Title: Advance Physical Chemistry Lab	**Subject Code:**TIU-PCH-L215
Contact Hours/Week: 0–0–8 (L–T–P)	**Credit:** 4

COURSE OBJECTIVE :

In this course students learn about hand-on experiences of techniques for verifying physical and chemical properties and data interpretation.

COURSE OUTCOME :

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

CO-1:	**Understand** the principles of spectrophotometric techniques for studying complexation, composition determination, and indicator constants.	K2
CO-2:	**Remember** key physical chemistry concepts such as Lambert-Beer's law, solubility product, and reaction kinetics.	K1
CO-3:	**Understand**the synthesis and characterization of nanomaterials using experimental techniques.	K2
CO-4:	**Apply** kinetic models to study autocatalytic and iodine clock reactions, as well as the effect of ionic strength on reaction rates.	K3
CO-5:	**Analyze** ternary phase diagrams, molecular weight determination by viscosity, and fluorescence quantum yield calculations.	K4
CO-6:	**Apply** the role of experimental parameters in influencing reaction mechanisms, solubility, and molecular interactions.	K3

COURSE CONTENT :

Experiment 1: Spectrophotometric study on hydrogen bonded complexation
Experiment 2: Verification of Lambert-Beer's law: Determination of concentration of unknown solution
Experiment 3: Spectrophotometric experiment - determination of composition of a complex (Job's method)
Experiment 4: Spectrophotometric experiment - Determination isosbestic point and indicatorConstant
Experiment 5: Synthesis and characterization of different nano materials
Experiment 6: Autocatalytic Reaction of Potassium Permanganate and Oxalic Acid
Experiment 7: Solubility Product (Ksp) Determination of Calcium Sulfate
Experiment 8: Ternary Phase Diagram Construction and Analysis
Experiment 9: Kinetics of the Iodine Clock Reaction
Experiment 10: Investigating the Effect of Ionic Strength on the Rate of Hydrolysis of Ethyl

Acetate in Sodium Chloride Solutions **Experiment 11:** Fluorescence Quantum Yield Calculation of a Fluorophore and Quenching Mechanisms in Solution **Experiment 12:** Calculation of molecular weight of a polymer by viscosity experiment	
TOTAL LECTURES	**112 Hours**

Books:

1. H. Middleton, Systematic Organic Qualitative Analysis, 3rd Edition (2020) Edward Arnold, London.
2. H.T. Clarke, Handbook of Organic Analysis, 4th Edition (2013) John Wiley & Sons, New York.
3. A.I. Vogel, Vogel's Textbook of Quantitative Chemical Analysis, 6th Edition (2023) Pearson Education Limited, Harlow.

CO-PO MAPPING

	PROGRAM OUTCOMES (PO)								PROGRAM SPECIFIC OUTCOMES (PSO)		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**1**	**2**	**3**
CO-1	2	1	1	2	1	1	1	1	2	3	2
CO-2	2	1	1	2	1	1	1	1	2	3	2
CO-3	2	1	1	2	1	1	1	1	2	3	2
CO-4	2	1	1	2	1	1	1	1	2	3	2
CO-5	2	1	1	2	1	1	1	1	2	3	2
CO-6	2	1	1	2	1	1	1	1	2	3	2
Average	2	1	1	2	1	1	1	1	2	3	2

Program: M. Sc. Chemistry	**Year, Semester:** 2nd Yr., 3rd Sem.
Course Title: Project-I	**Subject Code:**TIU-PCH-P291
Contact Hours/Week: 0–0–8 (L–T–P)	**Credit:** 4

COURSE OBJECTIVE :

Enable the student to:

1. Develop research skills through literature surveys, experimental techniques, and theoretical methodologies.
2. Enhance proficiency in instrumentation and analytical methods for scientific research.
3. Prepare students for careers in industry, academia, and PhD programs by strengthening research and problem-solving abilities.

COURSE OUTCOME :

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

CO-1:	**Apply**research methodologies and experimental techniques to conduct independent investigations in chemistry.	K3
CO-2:	**Analyze**experimental and theoretical data to interpret results and draw meaningful conclusions.	K4
CO-3:	**Evaluate**scientific literature to identify research gaps and formulate research hypotheses.	K5
CO-4:	**Create** an optimum experimental or theoretical approaches to optimize research methodologies and instrumentation.	K6
CO-5:	**Analyze** various research findings and integrate constructive feedback to enhance scientific communication.	K4
CO-6:	**Create** a comprehensive research dissertation and present findings with clarity and scientific rigor.	K6

COURSE CONTENT :

Project Dissertation

Each student will undertake an independent research project in a specialized area of chemistry, aligned with their interests and career aspirations. The project will be conducted over the entire semester under the supervision of a faculty mentor, allowing students to gain hands-on experience in research methodologies, experimental techniques, and data analysis.

Project Components:

1. **Literature Survey:**
   - Conduct a thorough review of relevant scientific literature to understand the background, existing research gaps, and the significance of the chosen topic.

- Formulate research objectives based on the identified gaps.

2. **Research Methodology:**
   - Develop a research plan, selecting appropriate experimental or computational techniques.
   - Understand and utilize laboratory instrumentation, chemical synthesis, analytical techniques, or theoretical models, depending on the nature of the project.
3. **Data Collection & Analysis:**
   - Perform experiments or simulations systematically to generate reliable data.
   - Use statistical and analytical tools to interpret results and identify trends.
4. **Results & Discussion:**
   - Compare experimental or theoretical findings with literature reports.
   - Discuss implications, limitations, and possible improvements.
5. **Scientific Writing & Reporting:**
   - Prepare a structured dissertation including an introduction, methodology, results, discussion, and conclusion.
   - Emphasize clarity, coherence, and proper referencing.
6. **Presentation & Evaluation:**
   - Present findings in a formal setting, demonstrating effective communication and critical thinking.
   - Incorporate feedback from faculty and peers to refine the dissertation.

TOTAL LECTURES	**112 Hours**

CO-PO MAPPING

	PROGRAM OUTCOMES (PO)								**PROGRAM SPECIFIC OUTCOMES (PSO)**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**1**	**2**	**3**
CO-1	3	3	3	3	2	1	1	3	3	3	3
CO-2	3	3	3	3	2	1	1	3	3	3	3
CO-3	3	3	3	3	2	1	1	3	3	3	3
CO-4	3	3	3	3	2	1	1	3	3	3	3
CO-5	3	3	3	3	2	1	1	3	3	3	3
CO-6	3	3	3	3	2	1	1	3	3	3	3
Average	**3**	**3**	**3**	**3**	**2**	**1**	**1**	**3**	**3**	**3**	**3**

Program: M. Sc. Chemistry	**Year, Semester:** 2nd Yr., 4th Sem.
Course Title: Spectroscopy-II and Supramolecules	**Subject Code:**TIU-PCH-T224
Contact Hours/Week: 3–1–0 (L–T–P)	**Credit:** 4

COURSE OBJECTIVE :

Enable the student to:

1. Understand Spectroscopic Techniques – Learn the principles and applications of NMR, EPR, Mössbauer, and NQR spectroscopy.
2. Analyze Molecular Structures – Interpret spectral data from various techniques, including mass spectrometry, for structural elucidation.
3. Explore Supramolecular Chemistry – Understand molecular interactions, recognition, and self-assembly in supramolecular systems.

COURSE OUTCOME :

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

CO-1:	**Remember** the fundamental principles of NMR, EPR, Mössbauer, and NQR spectroscopy.	K1
CO-2:	**Understand** the concepts of chemical shifts, spin interactions, and coupling constants in various spectroscopic techniques.	K2
CO-3:	**Apply**the spectroscopic methods to interpret molecular structures and bonding characteristics.	K3
CO-4:	**Analyze**themass spectrometry fragmentation patterns to determine molecular composition.	K4
CO-5:	**Analyze**the different spectroscopic techniques for structural elucidation of organic and inorganic compounds.	K4
CO-6:	**Understand** the key supramolecular interactions and their role in molecular recognition and self-assembly.	K2

COURSE CONTENT :

MODULE 1:	**NMR Spectroscopy**	**16 Hours**
PMR Spectroscopy: Interpretation of spectra, chemical shift, shielding mechanism and anisotropic effects, chemical exchange and chemical shifts in chiral molecules. Spin-spin, spin-lattice relaxations, Spin-spin interactions, naming spin systems, magnitude of coupling constant: Germinal, vicinal and long range couplings. Simplification of complicated spectra: Aromatic induced shifts spin decoupling, deuterium exchange, spectra at higher fields. Hindered rotation and rate processes. Nuclear Overhauser effect. **CMR Spectroscopy:** General considerations, chemical shift, calculation of approximate chemical shift values, coupling constants. Interpretation of simple CMR spectra. DEPT spectrum. **Advanced NMR Techniques in Structure Elucidation of Organic Compounds:** Application		

of DEPT, ^{1}H-^{1}H COSY, HMBC, HMQC, TOCSY, NOESY. **NMR Spectroscopy of Inorganic Molecules:** NMR spectra of paramagnetic coordination compounds, dipolar and contact shifts, ^{11}B, ^{19}F, ^{27}Al, ^{31}P – NMR spectroscopy with typical examples. **Nuclear Quadruple Resonance (NQR) Spectroscopy:** Qudrupole nuclei, qudrupole moments, electric field gradient, coupling constant, splitting and simple applications.		
MODULE 2:	**Mass spectroscopy and structure elucidation**	**8 Hours**
Mass Spectrometry: Introduction, ion production, fragmentation, single and multiple bond cleavage, rearrangements, cleavage associated with common functional groups, molecular ion peak, metastable ion peak, Nitrogen rule and interpretation of mass spectra. Structure elucidation based on spectroscopic data (IR, UV, NMR and Mass).		
MODULE 3:	**Inorganic spectroscopic techniques**	**10 Hours**
EPR: Hyperfine splitting in various systems, factors affecting the magnitude of g-value, Anisotropy in the hyperfine coupling constants, zero-field splitting and Kramers' degeneracy, nuclear quadrupole interactions, Application. **Mössbauer:** Gamma ray emission and absorption by nuclei, Mössbauer effect, Isomer shift, quadrupole splitting, Application to the elucidation of structure and bonding of Fe(III) and Fe(II), Sn(IV) and Sn(II) compounds, detection of oxidation states and in equivalent MB atoms. **Optical Rotatory Dispersion and Circular Dichroism:** Basic Principles of ORD and CD techniques. ORD and Cotton effect, Faraday and Kerr effects; Applications in determining absolute configuration of metal complexes.		
MODULE 4:	**Supramolecular Chemistry**	**10 Hours**
Concepts and terminology of supramolecular chemistry. Nature and types of supramolecular interactions (Hydrogen bonding, van der Waal interactions, π-stacking, C-H….π interactions etc.), Molecular recognition- Information and complementarity. Different types of receptors with special reference of Crown ethers, Cryptates and Calix[4]arene. Anion recognition and anion coordination chemistry. Molecular self-assembly formation and examples. Supramolecular chemistry of life, application of supramolecular chemistry.		
TOTAL LECTURES		**44 Hours**

Books:

1. R. M. Silverstein and F.X. Webster, Spectroscopic Identification of Organic Compounds, 6th Edition (2003) John Wiley, New York.
2. D. H. Williams and I.F. Fleming, Spectroscopic Methods in Organic Chemistry, 4th Edition (1988), Tata-McGraw Hill, New Delhi.
3. P. Y Bruice, Organic Chemistry, 2nd Edition (1998) Prentice-Hall, New Delhi.
4. E. A. V. Ebsworth, D. W. H. Rankin and S. Cradock, Structural Methods in Inorganic Chemistry, 1st Edition (1987), Blackwell Scientific Publications, Oxford, London.
5. R. S. Drago, Physical Methods in Chemistry, International Edition (1992), Affiliated East-West Press, New Delhi.
6. Jean-Marie Lehn, Supramolecular Chemistry, VCH, Weinheim (1995).
7. J. L. Atwood, J. W. Steed, and J. L. H. Smith, Supramolecular Chemistry, 2nd Edition (2006) Wiley, Chichester.

CO-PO MAPPING

	PROGRAM OUTCOMES (PO)								PROGRAM SPECIFIC OUTCOMES (PSO)		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**1**	**2**	**3**
CO-1	3	2	1	2	1	--	--	1	3	2	1
CO-2	3	3	2	2	1	--	--	1	3	2	1
CO-3	3	3	2	2	1	--	--	1	3	2	1
CO-4	3	3	2	2	1	--	--	1	3	2	1
CO-5	3	3	2	2	1	--	--	1	3	2	1
CO-6	3	3	2	2	1	--	--	1	3	2	1
Average	**3**	**2.83**	**1.83**	**2**	**1**	**--**	**--**	**1**	**3**	**2**	**1**

Program: M. Sc. Chemistry	**Year, Semester:** 2nd Yr., 4th Sem.
Course Title: Inorganic Rings, Chains, and Clusters	**Subject Code:**TIU-PCH-T210
Contact Hours/Week: 3–1–0 (L–T–P)	**Credit:** 4

COURSE OBJECTIVE :

Enable the student to:

1. Understand Cluster Chemistry – Learn the structure, bonding, and nomenclature of boranes and metal clusters.
2. Apply Bonding Theories – Use Wade's rules and the isolobal principle to analyze cluster stability.
3. Explore Inorganic Polymers – Study the types, synthesis, and applications of inorganic polymers.

COURSE OUTCOME :

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

CO-1:	**Remember** the structure, bonding, and nomenclature of boranes, heteroboranes, and metal clusters.	K1
CO-2:	**Understand** Wade's rules, Lipscomb's styx rules, and the isolobal principle in cluster chemistry.	K2
CO-3:	**Apply** bonding theories to predict the stability and structure of borane and metal clusters.	K3
CO-4:	**Analyze** the role of metal clusters in various chemical systems using Wade's-Mingo's and Lauhr's rules.	K4
CO-5:	**Analyze** the inorganic polymers with organic polymers based on their synthesis and properties.	K4
CO-6:	**Understand** the applications of metallaboranes, heteropoly anions, and inorganic polymers in real-world scenarios.	K2

COURSE CONTENT :

MODULE 1:	**Inorganic clusters**	**24 Hours**
Clusters and element-element bonds: Polyhedral boranes: Electron deficiency *vs* sufficiency. Types and IUPAC nomenclature. Wade's polyhedral skeleton electron pair theory(PSEPT). W. N. Lipscomb's styx rules and semi-topological structures of boranes. Equivalentand resonance structures. Wade's v*s* Lipscomb's methods of studying higher boranes. **Heteroboranes:** Types of heteroboranes with special reference to carboranes, structure, bonding and IUPAC nomenclature. Metallaboranes, Metallacarboranes, metal σ and μ bonded borane/carborane clusters. Resemblance of Metallaboranes/Metallacarboranes with ferrocene and related compounds. Applications of Metallaboranes/Metallacarboranes as drug delivery system. Applications of PSEPT over heteroboranes.		

Principle of Isolobility: Development and formulation of the concept of isolobility and its applications in the understanding of structure and bonding of heteroboranes.		
MODULE 2:	**Metal Clusters**	**10 Hours**
Low and high nuclearity carbonyl clusters, applications of PSEPT, Wade's-Mingo's and Lauhr's rule over metal carbonyl clusters. Capping rules. Metal halide and metal chalcogenide clusters, Zintl phase, Isopoly and heteropoly anions: syntheses, structures and applications, Chevrel phases, Bloomington schuffle in dinuclear tungsten clusters.		
MODULE 3:	**Inorganic Polymers**	**10 Hours**
Classification, Types of Inorganic Polymerization, Comparison with organic polymers, Boron-oxygen and boron-nitrogen polymers, silicones, coordination polymers, sulphur-nitrogen, sulphur-nitrogen-fluorine compounds, - binary and multicomponent systems, haemolytic inorganic systems.		
TOTAL LECTURES		**44 Hours**

Books:

1. F. A. Cotton and G. Wilkinson, Advanced Inorganic Chemistry, 6thEdn. (1999), John-Wiley & Sons, New York.
2. James E. Huheey, Inorganic Chemistry, 4thEdn. (1993), Addison Wesley Pub. Co., New York
3. N. N. Greenwood and A. Earnshaw, Chemistry of the Elements, 2ndEdn. (1997), Butterworth Heinemann, London.

CO-PO MAPPING

	PROGRAM OUTCOMES (PO)								**PROGRAM SPECIFIC OUTCOMES (PSO)**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**1**	**2**	**3**
CO-1	3	2	2	2	1	--	--	1	2	1	1
CO-2	3	3	2	2	1	--	--	1	2	1	1
CO-3	3	3	2	2	1	--	--	1	2	1	1
CO-4	3	3	2	2	1	--	--	1	2	1	1
CO-5	3	3	2	2	1	--	--	1	2	1	1
CO-6	3	3	2	2	1	--	--	1	2	1	1
Average	**3**	**2.83**	**2**	**2**	**1**	**--**	**--**	**1**	**2**	**1**	**1**

Program: M. Sc. Chemistry	Year, Semester: 2nd Yr., 4th Sem.
Course Title: Advanced Organic Chemistry-III	**Subject Code:** TIU-PCH-T214
Contact Hours/Week: 3–1–0 (L–T–P)	**Credit:** 4

COURSE OBJECTIVE :

Enable the student to:

1. Understand Oxidation Reactions – Learn the mechanisms and applications of various oxidation reagents in organic synthesis.
2. Explore Key Reagents and Reactions – Study the role of specialized reagents in organic transformations and their synthetic applications.
3. Apply Concepts in Organic Synthesis – Utilize retrosynthetic analysis, asymmetric synthesis, and stereoselective methods for designing complex organic molecules.

COURSE OUTCOME :

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

CO-1:	**Remember** the various oxidation reagents and their role in organic transformations.	K1
CO-2:	**Understand** the mechanisms and applications of key organic reagents in synthesis.	K2
CO-3:	**Apply**the retrosynthetic analysis to design synthetic routes for complex organic molecules.	K3
CO-4:	**Analyze** the asymmetric synthesis methods, including chiral auxiliaries and enantioselective reactions.	K4
CO-5:	**Analyze**the different stereoselective transformations and their effectiveness in organic synthesis.	K4
CO-6:	**Understand** the significance of notable total syntheses, such as Taxol and tetracycline antibiotics.	K2

COURSE CONTENT :

MODULE 1:	Oxidation	6 Hours
(i) Oxidation with peracids: Oxidation of carbon-carbon double bonds carbonyl compounds, allylic carbon-hydrogen bonds, (ii) Oxidation with selenium dioxide and Osmium tetraoxide, (iii) Oxidation with lead tetraacetate, mercuric acetate (iv) hypervalent iodine		
MODULE 2:	**Reagents and Reactions**	**8 Hours**
(i) Gilman's reagent – Lithium dimethylcuprate, (ii) Lithium diisopropylamide (LDA), (iii) Dicyclohexyl carbodiimide (DDC), (iv) 1,3-Dithiane (Umpolung reagent), (v) Peterson's synthesis, (vi) Bakers yeast, (vii) DDQ, (viii) Palladium catalysed reactions, (ix) Woodward and Prevost hydroxylation, (x) Iodotrimethyl silane and (xi) Ionic liquids		
MODULE 3:	**Concepts in organic synthesis**	**10 Hours**

Retrosynthesis, disconnection, synthons, linear and convergent synthesis, umpolung of reactivity and protecting groups; Notable total syntheses of natural compounds such as Taxol and tetracycline antibiotics.		
MODULE 4:	**Asymmetric synthesis**	**20 Hours**
Chiral auxiliaries, methods of asymmetric induction –substrate, reagent and catalyst controlled reactions; Stereoselective transformations of carbonyl compounds: enolate generation, alkylation processes, and chiral aldol reactions; Stereoselective processes involving alkenes: Diels-Alder reaction, sigmatropic rearrangements, stereoselective hydrogenation, epoxidation, hydroxylation, aminohydroxylation, and cyclopropanation; Kinetic resolution techniques; enantioselective synthesis of menthol (Takasago) and crixivan (Merck).		
TOTAL LECTURES		**44 Hours**

Books:

1. H. O. House, Modern Synthetic Reactions, 2nd Edition (1972), Benjamin/Cummings Publishing Company, California.
2. L. F. Fieser and M. Fieser, Reagents for Organic Synthesis, Vol. 1-16 (Vol. 1, 1967), Wiley-Interscience, New York.
3. M. B. Smith and J. March, March's Advanced Organic Chemistry – Reactions, Mechanisms & Structure, 5th ed. (2001), Wiley-Interscience, New York.
4. M. B. Smith, Organic Synthesis, McGraw Hill Inc., New York (1995).
5. J. Clayden, N. Greeves, S. Warren, and E. Wothers, Organic Chemistry, Oxford Univ. Press, Oxford (2001).
6. P. R. Jenkins, Organometallic Reagents in Synthesis, Oxford science Publ., Oxford (1992).

CO-PO MAPPING

	PROGRAM OUTCOMES (PO)								**PROGRAM SPECIFIC OUTCOMES (PSO)**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**1**	**2**	**3**
CO-1	3	2	2	2	1	--	--	1	2	1	1
CO-2	3	3	2	2	1	--	--	1	2	1	1
CO-3	3	3	2	2	1	--	--	1	2	1	1
CO-4	3	3	2	2	1	--	--	1	2	1	1
CO-5	3	3	2	2	1	--	--	1	2	1	1
CO-6	3	3	2	2	1	--	--	1	2	1	1
Average	**3**	**2.83**	**2**	**2**	**1**	**--**	**--**	**1**	**2**	**1**	**1**

Program: M. Sc. Chemistry	**Year, Semester:** 2nd Yr., 4th Sem.
Course Title: Advanced Solid State Chemistry and Spectroscopy	**Subject Code:**TIU-PCH-T212
Contact Hours/Week: 3–1–0 (L–T–P)	**Credit:** 4

COURSE OBJECTIVE :

Enable the student to:

1. Understand Solid State Chemistry – Learn solid-state reactions, phase transitions, and material properties.
2. Explore Electronic and Magnetic Properties – Study band theory, semiconductors, and magnetic behavior.
3. Apply Advanced Spectroscopy – Use modern spectroscopic techniques for material analysis.

COURSE OUTCOME :

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

CO-1:	**Remember** the principles of solid-state reactions, phase transitions, and thermal properties of materials.	K1
CO-2:	**Understand** the free electron theory, band theory, and the electronic structure of solids.	K2
CO-3:	**Apply**the band theory concepts to analyze the behavior of semiconductors and p-n junctions.	K3
CO-4:	**Analyze** the magnetic properties of materials and their temperature dependence.	K4
CO-5:	**Analyze** the various spectroscopic techniques and their applications in material characterization.	K4
CO-6:	**Understand** the role of advanced spectroscopy, including fluorescence and microscopy techniques, in studying material properties.	K2

COURSE CONTENT :

MODULE 1:	**Advanced Solid State Chemistry**	**26 Hours**
Solid State Reactions: General principles and experimental procedure of solid state reactions, growth of single crystals: Czochralski method, Bridgman and Stockbarger methods. **Phase Transitions:** Thermodynamic and Burger's classification of phase transition, kinetics of phase transition, nucleation and growth. **Thermal Properties of Solids:** Specific heat- lattice heat capacity, Einstein theory, Debye theory, Born's modification of the Debye theory. **Free electron theory of metals:** Free electron gas model of metals, free electron gas in a one-dimensional and three dimensional box, filling up of the energy levels. **Band theory of solids:** Wave functions in a periodic lattice and the Bloch theorem, The Kronig-		

Penny model, the tight binding approximation, Band theory of insulators and semiconductors, intrinsic semiconductors, extrinsic semiconductors, doped semiconductors, p-n junctions. **Magnetic Properties:** Behaviour of substances in a magnetic field, effect of temperature: Curie and Cuire-Weiss law, origin of magnetic moment, ferromagnetic, antiferromagentic and ferromagnetic ordering, super exchange, magnetic domains, hysteresis.		
MODULE 2:	**Advanced Spectroscopy**	**18 Hours**
Nonradiative transition, polarised light emission and absorption: anisotropy, solvation dynamics, resonance energy transfer, fluorescence quenching, and introduction of nonlinear spectroscopy. Application of lasers as excitation source, time resolved fluorimetry, transient absorption spectroscopy, surface plasmon spectroscopy, multiphoton spectroscopy, single molecule spectroscopy, fluorescence correlation spectroscopy, upconversion, microscopy (optical, phase contrast, confocal, FLIM), SERS, CARS.		
TOTAL LECTURES		**44 Hours**

Books:

1. A. R. West, Solid State Chemistry and its Applications, (1984) John Wiley and Sons, Singapore.
2. L.V. Azaroff, Introduction to Solids, (1977) Tata McGraw-Hill, New Delhi.
3. A. J. Dekker, Solid State Physics, Prentice Hall
4. C. Kittel, Introduction to Solid State Physics, John Wiley & Sons, Inc., New York, Chichester.
5. J. M. Hollas, Modern Spectroscopy, 4th edition (2004) John Wiley & Sons, Ltd., Chichester.
6. J.R. Lakowicz, Principles of Fluorescence Spectroscopy
7. W. Demtroder, Laser Spectroscopy.
8. B. K. Agarwal and M. Eisner, Statistical Mechanics, (1988) Wiley Eastern, New Delhi.
9. D. A. McQuarrie, Statistical mechanics, (1976) Harper and Row Publishers, New York.

CO-PO MAPPING

	PROGRAM OUTCOMES (PO)								**PROGRAM SPECIFIC OUTCOMES (PSO)**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**1**	**2**	**3**
CO-1	3	2	2	2	1	--	--	1	2	1	1
CO-2	3	3	2	2	1	--	--	1	2	1	1
CO-3	3	3	2	2	1	--	--	1	2	1	1
CO-4	3	3	2	2	1	--	--	1	2	1	1
CO-5	3	3	2	2	1	--	--	1	2	1	1
CO-6	3	3	2	2	1	--	--	1	2	1	1
Average	**3**	**2.83**	**2**	**2**	**1**	**--**	**--**	**1**	**2**	**1**	**1**

Program: M. Sc. Chemistry	**Year, Semester:** 2nd Yr., 4th Sem.
Course Title: Advanced Materials Chemistry	**Subject Code:**TIU-PCH-T232
Contact Hours/Week: 3–1–0 (L–T–P)	**Credit:** 4

COURSE OBJECTIVE :

Enable the student to:

1. Understand material types and properties – Learn the classification, structure, and properties of various materials.
2. Explore advanced and nanomaterials – Study emerging materials and their applications in technology.
3. Learn material characterization techniques – Gain knowledge of key techniques for analyzing material properties.

COURSE OUTCOME :

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

CO-1:	**Remember** the different types of materials based on their structure, properties, and applications.	K1
CO-2:	**Understand** the significance of advanced materials in various technological domains.	K2
CO-3:	**Apply** the fundamentals of nanomaterials, their synthesis, and size-dependent properties.	K3
CO-4:	**Analyze** the different types of advanced materials used in energy, electronics, and biomedical applications.	K4
CO-5:	**Understand**the suitable characterization techniques for analyzing material properties.	K2
CO-6:	**Apply** the data from various material characterization methods to understand material behavior.	K3

COURSE CONTENT :

MODULE 1:	**Introduction to materials**	**4 Hours**
Classification of materials, semiconducting materials, organic soft materials, ceramics, composites, material characterization techniques, correlation between materials structure and their properties, structure and properties of technologically important crystalline and 35 amorphous materials, recent breakthroughs in materials chemistry.		
MODULE 2:	**Different types of advanced materials and their utility**	**20 Hours**
Semiconducting Materials: Semiconductor Devices, Phase Change Materials in Memory Technology, Thermoelectric, Superconductors, Topological Insulators, Emerging materials in the device industry such as graphene and 2D materials. **Optical/Opto-electronic Materials:** Light Emitting Diodes, Photosensors, Photovoltaics.		

Structural & Basic Applied Materials: Structural Materials, Amorphous Materials, Smart & Responsive Materials, Bio-inspired materials. **Thermal Materials Application:** Thermochromics. **Energy Materials:** Batteries and Supercapacitors, Fuel Cells,Hydrogengeneration,Hydrogen storage, Carbon capture and sequestration. **Biomaterials:** Synthetic and naturally derived biomaterials, Organic and inorganic polymers, composite biomaterials, Clinical applications, Decellularization, Hydrogels, Tissue engineering, Regenerative medicine, Biodegradable materials.		
MODULE 3:	**Nanomaterials**	**10 Hours**
Fundamentals of nano science: definition, nano versus bulk, quantum confinement: nanoscale in 1D, 2D and 3D with examples, synthesis of nano materials: top-down and bottom-up approaches, size dependent properties; nanoclusters and nanowires, semiconductor nanoparticles, characterization of nanomaterials, applications of nano materials.		
MODULE 4:	**Instrumental Techniques for characterization of nanomaterials**	**10 Hours**
Basic principles and applications of electron microscopies (SEM, TEM), scanning probe microscopies (STM), atomic force microscopy (AFM), optical microscopies [confocal microscopy, scanning near field optical microscopy, particle size analysis (DLS)], thermal (DSC, DTA) and optical (IR, FTIR, Raman) methods.		
TOTAL LECTURES		**44 Hours**

Books:

1. B. Fahlman, Materials Chemistry, 3rd Edition (2011), Springer, New York.
2. J. B. Park & J. D. Bronzino, Biomaterials: Principles and Applications (2002), CRC Press, Boca Raton.
3. A. K. Das, Introduction to Nanomaterials (Year), Publisher, Location.
3. G. Cao, Nanostructures and Nanomaterials: Synthesis, Properties, and Applications (2004), Imperial College Press, London.
4. J. I. Goldstein et al., Scanning Electron Microscopy and X-Ray Microanalysis: A Textbook for Biologists, Materials Scientists, and Geologists, 2nd Edition (1992), Springer, New York.
5. H. Lodish et al., Molecular Cell Biology, 7th Edition (2013), Macmillan Publishers, New York.

CO-PO MAPPING

	PROGRAM OUTCOMES (PO)								PROGRAM SPECIFIC OUTCOMES (PSO)		
	1	2	3	4	5	6	7	8	1	2	3
CO-1	3	2	2	2	1	--	--	1	2	1	1
CO-2	3	3	2	2	1	--	--	1	2	1	1
CO-3	3	3	2	2	1	--	--	1	2	1	1
CO-4	3	3	2	2	1	--	--	1	2	1	1
CO-5	3	3	2	2	1	--	--	1	2	1	1
CO-6	3	3	2	2	1	--		1	2	1	1
Average	**3**	**2.83**	**2**	**2**	**1**	**--**	**--**	**1**	**2**	**1**	**1**

Program: M. Sc. Chemistry	**Year, Semester:** 2nd Yr., 4th Sem.
Course Title: Energy Conversion and Storage	**Subject Code:**TIU-PCH-T234
Contact Hours/Week: 3–1–0 (L–T–P)	**Credit:** 4

COURSE OBJECTIVE :

Enable the student to:

1. Understand power systems, transmission, distribution, and the role of various energy resources.
2. Explore energy conversion methods, including thermal, nuclear, solar, wind, and biomass, along with waste-to-energy technologies.
3. Analyze different energy storage techniques and their applications in industries, power plants, and renewable energy systems.

COURSE OUTCOME :

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

CO-1:	**Remember** the different power system components and energy resources based on their availability and utilization.	K1
CO-2:	**Understand** the various energy conversion methods, including thermal, nuclear, solar, wind, and biomass-based technologies.	K2
CO-3:	**Apply** the principles of waste-to-energy conversion and its role in sustainable energy production.	K3
CO-4:	**Analyze** the different energy storage methods and their applications in power systems and industries.	K4
CO-5:	**Understand** the suitable energy storage techniques for specific industrial and renewable energy applications.	K2
CO-6:	**Analyze** the impact of energy resources, conversion processes, and storage methods on efficiency and sustainability.	K4

COURSE CONTENT :

MODULE 1:	**Power system**	**5 Hours**
Introduction to Power System: Transmission and Distribution. Power crisis in India, future trends, economic considerations, significance of load factor and diversity factor, availability and utilization of modern resources like coal, petroleum, gaseous fuels, hydel and nuclear fuel, traditional resources, like firewood, cattle dung, animal power and solar sources.		
MODULE 2:	**Energy conversion**	**30 Hours**
Principles of energy conversion, heat engines, thermal power plants using coal, petroleumnuclear power plants using coal, petroleum nuclear fuels and hydel energy, fundamentalsof energy conversion using solar thermal, photovoltaic, wind pumps, wind turbine aerodynamics, fuel cell, biogas, firewood, windmini-hydel and tidal resources.		

Introduction, characterization of wastes; classification of wastes; energy production from wastes through incineration, gasification; management and treatment of hazardous and nonhazardous industrial waste; Municipal sewage waste- Energy production from organic waste through anaerobic digestion; Cultivation of algal biomass from wastewater, wastewater treatment and energy production from algae.		
MODULE 3:	**Energy storage**	**8 Hours**
Need of energy storage; Different modes of Energy Storage like mechanical Energy Storage, Thermal energy storage, electro-chemical energy storage, electromagnetic energy storage. Some areas of application of energy storage: Food preservation; Waste heat Recovery; Solar energy storage; Greenhouse heating; Power plant applications; Drying and heating for process industries.		
TOTAL LECTURES		**43 Hours**

Books:

1. S. Kuldeep, Basic Electrical Engineering, 1st Edition (2009), New Age International Publishers, New Delhi.
2. N. V. Khartchenko, Advanced Energy Systems, 1st Edition (2008), Taylor & Francis, Washington D.C.
3. C. S. Solanki, Solar Photovoltaics: Fundamentals, Technologies and Applications, 1st Edition (2011), Prentice Hall of India, New Delhi.
4. L. L. Freris, Wind Energy Conversion Systems, 1st Edition (1990), Prentice Hall, New Jersey.
5. D. A. Spera, Wind Turbine Technology: Fundamental Concepts of Wind Turbine Engineering, 1st Edition (1994), ASME Press, New York.
6. B. Mazumdar, A Textbook of Energy Technology: Both Conventional and Renewable Sources of Energy, 1st Edition (2012), New Age International Publishers, New Delhi.
7. G. D. Rai, Non-Conventional Energy Sources, 1st Edition (1989), Khanna Publishers, New Delhi.
8. J. Jensen & B. Sorensen, Fundamentals of Energy Storage, 1st Edition (1984), John Wiley & Sons, New York.

CO-PO MAPPING

	PROGRAM OUTCOMES (PO)								**PROGRAM SPECIFIC OUTCOMES (PSO)**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**1**	**2**	**3**
CO-1	3	2	2	2	1	--	1	1	2	1	1
CO-2	3	3	2	2	1	--	1	1	2	1	1
CO-3	3	3	2	2	1	--	1	1	2	1	1
CO-4	3	3	2	2	1	--	1	1	2	1	1
CO-5	3	3	2	2	1	--	1	1	2	1	1
CO-6	3	3	2	2	1	--	1	1	2	1	1
Average	**3**	**2.83**	**2**	**2**	**1**	**--**	**1**	**1**	**2**	**1**	**1**

Program: M. Sc. Chemistry	**Year, Semester:** 2nd Yr., 4th Sem.
Course Title: Chemical Biology	**Subject Code:**TIU-PCH-T236
Contact Hours/Week: 3–1–0 (L–T–P)	**Credit:** 4

COURSE OBJECTIVE :

Enable the student to:

1. Understand biomolecules, enzyme mechanisms, and their applications.
2. Explore cell structure, functions, and signaling processes.
3. Analyze biomolecular structure using NMR and X-ray techniques.

COURSE OUTCOME :

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

CO-1:	**Remember** the different biomolecules and their roles in biological systems.	K1
CO-2:	**Understand** the enzyme mechanisms and their applications in biotechnology.	K2
CO-3:	**Analyze** the cell structure, intracellular processes, and signaling pathways.	K3
CO-4:	**Understand** the prokaryotic and eukaryotic cell organization and transport mechanisms.	K2
CO-5:	**Apply** suitable techniques for determining biomolecular structures.	K3
CO-6:	**Analyze**the NMR and X-ray crystallography data for biomolecular structure determination.	K4

COURSE CONTENT :

MODULE 1:	**The molecules of life**	**16 Hours**
Nucleic acids, proteins and enzymes, carbohydrates, lipids. Mechanism in biological chemistry: (i) Mechanism of enzyme action, examples of enzyme mechanisms for chymotrypsin, ribonuclease, lysozyme and carboxypeptidase A (ii) Enzyme catalysed reactions – examples of nucleophilic displacement on a phosphorus atom, coupling of ATP cleavage to endergonic processes, proton transfer reactions to and from carbon (iii) Mechanism of reactions catalysed by cofactors including coenzyme A, NAD+, NADH, FAD and thiamine pyrophosphate; Chemical synthesis of peptides and proteins; Use of enzymes in organic synthesis; Structural analysis of proteins; Protein folding; Biotechnological applications of enzymes: Enzyme purification, immobilization of enzymes, enzyme therapy, enzyme and recombinant DNA technology.		
MODULE 2:	**Cell biology**	**12 Hours**
Introduction to cells and genomes; Internal organization of the cell, membrane structure, intracellular compartments and the cytoskeleton; Cell cycle and programmed cell death. Prokaryotic and eukaryotic cell organizations; intracellular compartments and transport: membrane bound organelles, protein sorting, and vesicular transport, secretory pathways, endocytosis pathways, phagocytosis and pinocytosis; cell communication: general principles of cell signaling, G-protein linked receptors and enzyme linked receptors.		
MODULE 3:	**Structure determination of Biomolecules**	**16 Hours**

Introduction to quantum spin states; Energy levels and transitions; Basic one-dimensional NMR experiment; Vector model; Product operators; Multi-dimensional NMR experiments; Relaxation; Fourier transformation and data processing; Spectrometer basics; Application to biological problems. Diffraction theory - waves, interference and complex numbers; Atoms, crystals and reciprocal space; X-ray sources: from generators to synchrotrons; Crystallization, data collection, processing, complications; The phase problem: introduction to phasing methods; Introduction to fitting, refinement and validation.	
TOTAL LECTURES	**44 Hours**

Books:

1. Voet, D., Voet, J. G., & Pratt, C. W. Fundamentals of Biochemistry: Life at the Molecular Level. Wiley, 2016.
2. Dobson, C. M., Gerrard, J. A., & Pratt, A. J. Foundations of Chemical Biology. Oxford University Press, 2002.
3. Nelson, D. L., & Cox, M. M. Principles of Biochemistry. CBS Publishers, 2017.
4. Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Scott, M. P., & Zipursky, S. L. Molecular Cell Biology, 7th ed. W.H. Freeman, 2013.
5. Cavanagh, J., Fairbrother, W. J., Palmer, A. G., Rance, M., & Skelton, J. J. Protein NMR Spectroscopy: Principles and Practice, 2nd ed. Academic Press, 2007.
6. Rupp, B. Biomolecular Crystallography: Principles, Practice, and Application to Structural Biology, 1st ed. Garland Science, 2009.

CO-PO MAPPING

	PROGRAM OUTCOMES (PO)								**PROGRAM SPECIFIC OUTCOMES (PSO)**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**1**	**2**	**3**
CO-1	3	2	2	2	1	--	--	1	2	1	1
CO-2	3	3	2	2	1	--	--	1	2	1	1
CO-3	3	3	2	2	1	--	--	1	2	1	1
CO-4	3	3	2	2	1	--	--	1	2	1	1
CO-5	3	3	2	2	1	--	--	1	2	1	1
CO-6	3	3	2	2	1	--	--	1	2	1	1
Average	**3**	**2.83**	**2**	**2**	**1**	**--**	**--**	**1**	**2**	**1**	**1**

Program: M. Sc. Chemistry	Year, Semester: 2nd Yr., 4th Sem.
Course Title: Medicinal Chemistry	**Subject Code:** TIU-PCH-T238
Contact Hours/Week: 3–1–0 (L–T–P)	**Credit:** 4

COURSE OBJECTIVE :

Enable the student to:

1. Understand drug synthesis, mechanisms, and structure-function relationships across various therapeutic categories.
2. Explore drug design principles, molecular modeling techniques, and pharmacodynamics, including drug-receptor interactions and pharmacokinetics.
3. Analyze nanomedicine applications, nanocarriers for drug delivery, and the toxicological aspects of nanomaterials.

COURSE OUTCOME :

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

CO-1:	**Remember** the different types of drugs based on their synthesis, mechanism of action, and therapeutic applications.	K1
CO-2:	**Understand** the principles of drug design, molecular modeling, and QSAR studies.	K2
CO-3:	**Understand** the pharmacodynamics, including drug-receptor interactions, binding forces, and pharmacokinetics.	K2
CO-4:	**Apply** various nanocarriers used in drug delivery and their biomedical applications.	K3
CO-5:	**Analyze**the structure-function relationships in antibiotics, antivirals, and anticancer drugs.	K4
CO-6:	**Analyze** the toxicological effects of nanomedicines and their impact on human health.	K4

COURSE CONTENT :

MODULE 1:	Synthetic strategy and structure-function relationship of different types of drugs	14 Hours
Synthesis, semi-synthesis, detailed mechanism of action and structural modifications of Penicillin antibiotics. General structure and antimicrobial activities of Cephalosporins, Tetracyclins and newer generation of antibiotics. General introduction on virus and mechanism of action of antiviral drugs towards DNA and RNA virus. General principle of vaccination strategy to combat with viral infection. Synthesis and mechanism of action of representative examples of antitumor, anticancer, DNA cleaving agents, analgesics, antidepressants, antipsdychotics, anti-inflammatory agents, cardiovascularagents, diuretics, antibacterials, antibiotics, antivirals, antimalarials, antiamoe		

bics, drugs for neoplastic diseases.		
MODULE 2:	**Drug design and pharmacodynamics**	**22 Hours**
Drug design and synthesis, Molecular and quantum mechanics; Drawing chemical structures, equations, and diagrams; 3D structures; Molecular modelling and Energy Minimization; Molecular properties, Conformational analysis, Docking Procedures, De novo design, Molecular Recognition, Receptor Based Molecular Modeling, QSAR studies, Antineoplastic agents, cardiovascular drugs, Local anti-infective drugs, Antimalarial, Antibiotics, Anticholenergic and CNS-active drugs. Pharmacodynamics: different types of drugs and drug targets, drug binding forces, role of enzymes. Drug – receptor interactions, mechanism of drug action, agonists, antagonists. Affinity, efficacy and potency of a drug, dose-response curves. Pharmacokinetics: drug absorption, distribution, metabolism (Phase–I and Phase– II transformations), excretion.		
MODULE 3:	**Nanomedicines**	**8 Hours**
Introduction to nanomedicine-Overview of nanotechnology from medical perceptive, different types of nanobiomaterials and their biomedical applications, Nanocarriers (e.g. liposomes, polymer capsules, nanoparticles, porous materials, nanogels), for drug delivery applications, Cellular nanomachines, Toxicology of nanomaterials.		
TOTAL LECTURES		**44 Hours**

Books:

1. A. K. Bose and M. S. Manhas, Beta Lactams (Vol I and II), 1st Edition, 2015, Springer.
2. G. L. Patrick, Medicinal Chemistry, 5th Edition, 2013, Wiley.
3. M. E. Wolff (Ed.), Burger's Medicinal Chemistry and Drug Discovery, 7th Edition, 2010, Wiley.
4. R. B. Silverman, The Organic Chemistry of Drug Design and Drug Action, 2nd Edition, 2004, Academic Press.
5. A. Lednicer and A. M. Dand, The Organic Chemistry of Drug Synthesis (Vol. I-VI), 1993, John Wiley & Sons.
6. M. P. S. Ishar and A. Faruk, Synthesis of Organic Medicinal Compounds, 2016, Elsevier.
7. G. Thomas, Fundamentals of Medicinal Chemistry, 2nd Edition, 2018, Wiley.
8. Dr. Parag Diwan and Ashish Bharadwaj (Eds.), Nano Medicines, 2006, Pentagon Press, ISBN 81-8274-139-4.
9. C. M. Niemeyer and C. A. Mirkin, Nanobiotechnology: Concepts, Applications, and Perspectives, 2004, Wiley-Interscience.

CO-PO MAPPING

	PROGRAM OUTCOMES (PO)								PROGRAM SPECIFIC OUTCOMES (PSO)		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**1**	**2**	**3**
CO-1	3	2	2	2	1	--	--	1	2	1	2
CO-2	3	3	2	2	1	--	--	1	2	1	2
CO-3	3	3	2	2	1	--	--	1	2	1	2
CO-4	3	3	2	2	1	--	--	1	2	1	2
CO-5	3	3	2	2	1	--	--	1	2	1	2
CO-6	3	3	2	2	1	--	--	1	2	1	2
Average	**3**	**2.83**	**2**	**2**	**1**	**--**	**--**	**1**	**2**	**1**	**2**

Program: M. Sc. Chemistry	**Year, Semester:** 2nd Yr., 3rd Sem.
Course Title: Project-II	**Subject Code:**TIU-PCH-P292
Contact Hours/Week: 0–0–12 (L–T–P)	**Credit:** 6

COURSE OBJECTIVE :

Enable the student to:

1. Develop research skills through literature surveys, experimental techniques, and theoretical methodologies.
2. Enhance proficiency in instrumentation and analytical methods for scientific research.
3. Prepare students for careers in industry, academia, and PhD programs by strengthening research and problem-solving abilities.

COURSE OUTCOME :

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

CO-1:	**Apply**research methodologies and experimental techniques to conduct independent investigations in chemistry.	K3
CO-2:	**Analyze**experimental and theoretical data to interpret results and draw meaningful conclusions.	K4
CO-3:	**Evaluate**scientific literature to identify research gaps and formulate research hypotheses.	K5
CO-4:	**Evaluate** experimental or theoretical approaches to optimize research methodologies and instrumentation.	K5
CO-5:	**Analyze** the research findings and integrate constructive feedback to enhance scientific communication.	K4
CO-6:	**Create** a comprehensive research dissertation and present findings with clarity and scientific rigor.	K6

COURSE CONTENT :

Project Dissertation

Each student will undertake an independent research project in a specialized area of chemistry, aligned with their interests and career aspirations. The project will be conducted over the entire semester under the supervision of a faculty mentor, allowing students to gain hands-on experience in research methodologies, experimental techniques, and data analysis.

Project Components:

1. **Literature Survey:**
    - Conduct a thorough review of relevant scientific literature to understand the background, existing research gaps, and the significance of the chosen topic.
    - Formulate research objectives based on the identified gaps.

2. **Research Methodology:**
    - Develop a research plan, selecting appropriate experimental or computational techniques.
    - Understand and utilize laboratory instrumentation, chemical synthesis, analytical techniques, or theoretical models, depending on the nature of the project.
3. **Data Collection & Analysis:**
    - Perform experiments or simulations systematically to generate reliable data.
    - Use statistical and analytical tools to interpret results and identify trends.
4. **Results & Discussion:**
    - Compare experimental or theoretical findings with literature reports.
    - Discuss implications, limitations, and possible improvements.
5. **Scientific Writing & Reporting:**
    - Prepare a structured dissertation including an introduction, methodology, results, discussion, and conclusion.
    - Emphasize clarity, coherence, and proper referencing.
6. **Presentation & Evaluation:**
    - Present findings in a formal setting, demonstrating effective communication and critical thinking.
    - Incorporate feedback from faculty and peers to refine the dissertation.

TOTAL LECTURES	**168 Hours**

CO-PO MAPPING

	PROGRAM OUTCOMES (PO)								**PROGRAM SPECIFIC OUTCOMES (PSO)**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**1**	**2**	**3**
CO-1	3	3	3	3	2	1	1	3	3	3	3
CO-2	3	3	3	3	2	1	1	3	3	3	3
CO-3	3	3	3	3	2	1	1	3	3	3	3
CO-4	3	3	3	3	2	1	1	3	3	3	3
CO-5	3	3	3	3	2	1	1	3	3	3	3
CO-6	3	3	3	3	2	1	1	3	3	3	3
Average	3	3	3	3	2	1	1	3	3	3	3