BACHELOR OF SCIENCE IN CHEMISTRY

(04 Yrs.)

B.Sc. Chemistry (Research/Honours)

Syllabus

Learning Outcomes-Based Curriculum Framework as per National Education Policy (NEP)-2020

CENTRAL UNIVERSITY OF KARNATAKA

Department of Chemistry

School of Chemical Sciences

Central University of Karnataka

Department of Chemistry
School of Chemical Sciences
Central University of Karnataka, Kalaburagi

VISION

To be one of the well-recognized Departments of Chemistry for higher learning in India and the world in terms of producing skilled and employable chemists, researchers, teachers and entrepreneurs who are go-getters in meeting the challenges in chemistry and society.

MISSION

MS1: To impart quality education at undergraduate, postgraduate and doctoral levels through the well-designed curriculum to meet the demands of academia, research laboratories and industry.

MS2: To provide the state-of-art research facilities to carry out pioneering research in the cutting-edge areas of Chemistry.

MS3: To become a hub for human resource development and sponsored research projects with funding from national and global agencies.

MS4: To associate with national and international reputed institutions for academic excellence and collaborative research.

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Curriculum and Credit Framework for Under Graduate Program B.Sc. with Research/Honors in Chemistry

Semester	Major Course	Minor Course	Multidisciplinary Course	Ability Enhancement Course	Skill Enhancement Course / Internship / Dissertation	Value Added Course	Total Credits
I	4+2	4+2	3	2	3	2	22
II	4+2	4+2	3	2	3	2	22
*Students exiting the programme after **securing 44 credits will be awarded UG Certificate** in the relevant Discipline /Subject provided they secure 4 credits in work based vocational courses offered during summer term or internship / Apprenticeship in addition to 6 credits from skill-based courses earned during first and second semester.*							**44**
III	4+2	4	3	2	3	2	20
IV	4+2+2+2+2	4	-	2	-	2	20
*Students exiting the programme after **securing 84 credits will be awarded UG Diploma** in the relevant Discipline /Subject provided they secure additional 4 credit in skill based vocational courses offered during first year or second year summer term.*							**84**
V	4+4+4+2+2	4	-	-	-	-	20
VI	4+4+4+2+2+2	-	-	-	2	-	20
*Students who want to undertake 3-year UG programme will be awarded **UG Degree** in the relevant Discipline /Subject **upon securing 124 credits***							**124**
VII	4+4+2+2	4+4	-	-	-	-	20
VIII	4+4	-	-	-	12	-	20
*Students will be awarded **UG Degree with Research** in the relevant Discipline /Subject, **provided they secure 164 credits***							**164**
OR							
VII	4+4+2+2	4+4	-	-	-	-	20
VIII	4+4+4	4+4	-	-	-	-	20
*Students will be awarded **UG Degree in Honours** in the relevant Discipline /Subject **provided they secure 164 credits***							**164**

COURSE STRUCTURE FOR EACH SEMESTER for the Academic Year 2023-24

SEMESTER-I							
S.No.	**Category of Course**	**Course Code**	**Course Title**	**Hours**			**Credits**
				L	**T**	**P**	
1	Major	UCHTC10101	Fundamentals of Chemistry-I	3	1	0	4
2	Major	UCHPC10102	Fundamental Inorganic Chemistry Laboratory	0	0	4	2
3	Minor	-	Physics / Mathematics / Life Science / Computer Science	3	1	0	4
4	Minor	-	Physics / Mathematics / Life Science / Computer Science	0	0	4	2
5	Multidisciplinary Course (MDC)	-	Inorganic Chemistry in day-to-day life	2	1	0	3
6	Ability Enhancement Course (AEC)	-	A course on English Language	2	0	0	2
7	Skill Enhancement Course (SEC)	UCHTS10101	Mathematics for Chemists / Green Chemistry / Food Chemistry / Quality Control Chemist	2	0	2	3
8	Value Added Course (VAC)	-	Yoga and Health / Ethics and Human Values / Personal Development	2	0	0	2
Total				14	3	10	**22**

SEMESTER-II							
S.No.	**Category of Course**	**Course Code**	**Course Title**	**Hours**			**Credits**
				L	**T**	**P**	
1	Major	UCHTC20103	Fundamentals of Chemistry-II	3	1	0	4
2	Major	UCHPC20104	Fundamental Organic Chemistry Laboratory	0	0	4	2
3	Minor	-	Physics / Mathematics / Life Science / Computer Science	3	1	0	4
4	Minor	-	Physics / Mathematics / Life Science / Computer Science	0	0	4	2
5	Multidisciplinary Course (MDC)	-	Organic Chemistry in day-to-day life	2	1	0	3

6	Ability Enhancement Course (AEC)	-	A course on English Language	2	0	0	2
7	Skill Enhancement Course (SEC)	UCHTS20102	Mathematics for Chemists / Green Chemistry / Food Chemistry / Quality Control Chemist	2	0	2	3
8	Value Added Course (VAC)	-	Indian Knowledge System / Professional Development / Soft Skills	2	0	0	2
Total				14	3	10	**22**

SEMESTER-III							
S.No.	**Category of Course**	**Course Code**	**Course Title**	**Hours**			**Credits**
				L	**T**	**P**	
1	Major	UCHTC30205	Fundamentals of Chemistry-III	3	1	0	4
2	Major	UCHPC30206	Fundamental Physical Chemistry Laboratory	0	0	4	2
3	Minor	-	Physics / Mathematics / Life Science / Computer Science	3	1	0	4
4	Multidisciplinary Course (MDC)	-	Physical Chemistry in day-to-day life	2	1	0	3
5	Ability Enhancement Course (AEC)	-	A course on Language	2	0	0	2
6	Skill Enhancement Course (SEC)	UCHTS30103	Mathematics for Chemists / Green Chemistry / Food Chemistry/ Quality Control Chemist	2	0	2	3
7	Value Added Course (VAC)	-	Community Engagement / Employability Skills / Entrepreneurship Development	2	0	0	2
Total				14	3	6	**20**

SEMESTER-IV							
S.No.	**Category of Course**	**Course Code**	**Course Title**	**Hours**			**Credits**
				L	**T**	**P**	
1	Major	UCHTC40207	Fundamentals of Chemistry-IV	3	1	0	4
2	Major	UCHPC40208	Analytical Chemistry Laboratory	0	0	4	2
3	Major	UCHTC40209	Inorganic Qualitative Analysis	0	0	4	2
4	Major	UCHTC40210	Analytical Chemistry	2	0	0	2
5	Major	UCHTC40211	Chemistry of Life	2	0	0	2
6	Minor	-	Physics / Mathematics / Life Science / Computer Science	3	1	0	4
7	Ability Enhancement Course (AEC)	-	A course on Language	2	0	0	2
8	Value Added Course (VAC)	-	Community Engagement / Employability Skills / Entrepreneurship Development	2	0	0	2
Total				16	2	4	**20**

SEMESTER-V							
S.No.	**Category of Course**	**Course Code**	**Course Title**	**Hours**			**Credits**
				L	**T**	**P**	
1	Major	UCHTC50312	Inorganic Chemistry-I	3	1	0	4
2	Major	UCHTC50313	Organic Chemistry-I	3	1	0	4
3	Major	UCHTC50314	Physical Chemistry-I	3	1	0	4
4	Major	UCHPC50315	Organic Chemistry Laboratory	0	0	4	2
5	Major	UCHPC50316	Computational Chemistry Laboratory	0	0	4	2
6	Minor	-	Physics / Mathematics / Life Science / Computer Science	3	1	0	4
Total				12	4	8	**20**

SEMESTER-VI							
S.No.	**Category of Course**	**Course Code**	**Course Title**	**Hours**			**Credits**
				L	**T**	**P**	
1	Major	UCHTC60317	Inorganic Chemistry-II	3	1	0	4
2	Major	UCHTC60318	Organic Chemistry-II	3	1	0	4
3	Major	UCHTC60319	Physical Chemistry-II	3	1	0	4
4	Major	UCHPC60320	Inorganic Chemistry Laboratory	0	0	4	2
5	Major	UCHPC60321	Physical Chemistry Laboratory	0	0	4	2
6	Major	UCHTC60322	Bio-inorganic Chemistry	2	0	0	2
7	Internship	UCHTI60301	Chemistry Internship	0	0	4	2
Total				11	3	12	**20**

SEMESTER-VII							
S.No.	**Category of Course**	**Course Code**	**Course Title**	**Hours**			**Credits**
				L	**T**	**P**	
1	Major	UCHTC70423	Molecular Spectroscopy	3	1	0	4
2	Major	UCHTC70424	Chemical Applications of Group Theory	2	0	0	2
3	Major	UCHTC70425	Spectroscopic Identification of Organic Compounds	3	1	0	4
4	Major	UCHPC70426	Instrumentation and Structure Elucidation Laboratory	0	0	4	2
5	Minor	-	Physics / Mathematics / Life Science / Computer Science	3	1	0	4
6	Minor	-	Physics / Mathematics / Life Science / Computer Science	3	1	0	4
Total				14	4	4	**20**

SEMESTER-VIII							
S.No.	**Category of Course**	**Course Code**	**Course Title**	**Hours**			**Credits**
				L	**T**	**P**	
1	Major	UCHTC80427	Organometallic Chemistry	3	1	0	4
2	Major	UCHTC80428	Organic Chemistry-III	3	1	0	4
3	Research Project / Dissertation	UCHRC80401	Research Project	0	0	24	12
Total				6	2	24	**20**

Name of the Academic Program: B.Sc. (Research) in Chemistry/ B.Sc. (Honours) in Chemistry

Program Learning Outcomes (PLOs)

After the completion of the program, the student will be able to:

PLO-1: Systematic and coherent understanding of the fundamental concepts in Physical chemistry, Organic Chemistry, Inorganic Chemistry, Analytical Chemistry and all other related allied chemistry subjects.

PLO-2: Students will be able to use the evidence based comparative chemistry approach to explain the chemical synthesis and analysis, able to understand the characterization of materials and basic principle of equipment, instruments used in the chemistry laboratory.

PLO-3: *S*tudent will be capable of using of advanced instruments and related soft-wares for in-depth characterization of materials/chemical analysis and separation technology.

PLO-4: *Critical thinker and problem solver:* The course curriculum also includes components that can be helpful to graduate students to develop critical thinking ability by way of solving problems/numerical using basic chemistry knowledge and concepts.

PLO-5: *Sense of inquiry:* It is expected that the course curriculum will develop an inquisitive characteristic among the students through appropriate questions, planning and reporting experimental investigation.

PLO-6: *Lifelong learner:* The course curriculum is designed to inculcate a habit of learning continuously through use of ICT technique/books/journals for personal academic growth as well as for increasing employability opportunity.

PLO-7: *Ability Enhancement/Ethical awareness:* Empowers the students to acquire and understand the skil1s crucial to succeed in their professional and personal lives. Allows to develop ethical awareness/reasoning which the course curriculum adequately provide.

PLO-8: *Generic Elective:* Allows students to understand chemistry in day-to-day life with emphasis on Inorganic Chemistry, Organic Chemistry, and Physical chemistry and motivate them to look for inter-disciplinary research.

PLO-9: *Skill Enhancement:* Enable the students to enhance their practical skills in the area of analysis of the chemicals and ability to pursue a vocation as quality control chemist.

PLO-10: *Value Addition:* Enhance employability of the students through preparation of every day in use chemicals, materials, and processes and encourage to become entrepreneur

PLO-11: Demonstrate comprehensive knowledge and skills to pursue research in chosen area of chemistry and allows to pursue Ph.D immediately after the course.

PLO-12: Apply knowledge in qualification of national as well as international competitive examinations, especially UGC-CSIR NET and UPSC Civil Services Examination.

Syllabus of Major Courses offered by Department of Chemistry

SYLLABUS

Semester-I **No. of credits = 22**

SEMESTER-I							
S.No.	**Category of Course**	**Course Code**	**Course Title**	**Hours**			**Credits**
				L	**T**	**P**	
1	Major	UCHTC10101	Fundamentals of Chemistry-I	3	1	0	4
2	Major	UCHPC10102	Fundamental Inorganic Chemistry Laboratory	0	0	4	2
3	Minor		Physics / Mathematics / Life Science/Computer Science	3	1	0	4
4	Minor		Physics / Mathematics / Life Science/Computer Science	0	0	4	2
5	Multidisciplinary Course (MDC)		Inorganic Chemistry in day-to-day life	2	1	0	3
6	Ability Enhancement Course (AEC)		A course on English Language	2	0	0	2
7	Skill Enhancement Course (SEC)	UCHTS10101	Mathematics for Chemists / Green Chemistry / Food Chemistry /Quality Control Chemist	2	0	2	3
8	Value Added Course (VAC)		Yoga and Health / Ethics and Human Values / Personal Development	2	0	0	2
Total				14	3	10	**22**

Semester-I: Fundamentals of Chemistry-I ***Credits: 04***

Code	Type	Title	Credits	Hours	L	T	P
UCHTC10101	Major	Fundamentals of Chemistry-I	4	4	3	1	0

Course Learning Outcomes (CLOs)

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

CLO-1: Understand the Atomic theory and its evolution. Learning scientific theory of atoms, concept of wave function.
CLO-2: Understand the structure, bonding, to predict the atomic structure, chemical bonding, and molecular geometry based on accepted models.
CLO-3: Basic of organic molecules, structure, bonding, reactivity and reaction mechanisms.
CLO-4: Stereochemistry of organic molecules – conformation and configuration, asymmetric molecules and nomenclature.
CLO-5: Mechanism of organic reactions (effect of nucleophile/leaving group, solvent), substitution *vs*. elimination.
CLO-6: Understand introductory Inorganic Chemistry practicals on qualitative analysis.

Detailed Syllabus:

Unit-1: Atomic Structure:

Fundamental particles, Bohr's theory and its limitations, dual behaviour of matter and radiation, de Broglie's relation, Heisenberg Uncertainty principle. Hydrogen atom spectra. *Quantum mechanics*: Time independent Schrodinger equation and meaning of various terms in it. Significance of ψ, Schrödinger equation for hydrogen atom. Radial and angular parts of the hydrogenic wave functions (atomic orbitals) and their variations for 1s, 2s, 2p, 3s, 3p and 3d orbitals (Only graphical representation). Radial and angular nodes and their significance. Radial distribution functions and the concept of the most probable distance. Quantum numbers, the Hund's rule, Pauli's exclusive principle, Aufbau s rule and their limitations, Electronic configurations of the atoms and simple homonuclear diatomic molecules. Stability of half-filled and completely filled orbitals, concept of exchange energy. Relative energies of atomic orbitals, Anomalous electronic configurations. **(15 Hrs)**

Unit-2: Chemical Bonding and Molecular Structure:

Ionic Bonding: General characteristics of ionic bonding. Energy considerations in ionic bonding. polarizing power and polarizability. Fajan's rules, ionic character in covalent compounds, bond moment, dipole moment and percentage ionic character. *Covalent bonding*: VB Approach: Shapes of some inorganic molecules and ions on the basis of VSEPR and hybridization with suitable examples. Concept of resonance and resonating structures in various inorganic and organic compounds. *MO Approach*: Rules for the LCAO method, bonding and antibonding MOs and their characteristics for s-s, s-p and p-p combinations of atomic orbitals, MO treatment of homonuclear diatomic molecules of 1^{st} and 2^{nd} periods (including idea of s-p mixing) and heteronuclear diatomic molecules such as CO, NO and NO^{+}. Comparison of VB and MO approaches. Concept of HOMO and LUMO. **(15 Hrs)**

Unit-3: Fundamentals of Organic Chemistry

Physical Effects, Electronic Displacements: Inductive Effect, Electrometric Effect, Resonance and Hyper conjugation and application in acidity and basicity of organic compounds. Cleavage of Bonds: Homolysis and Heterolysis. Comparative study with emphasis on factors affecting pKa values. Intermediates in reaction: Generation, structure stability and formation of

carbocation, carbanion, non-classical carbocation, free radicals, carbenes and nitrenes. Aromaticity: Criteria of aromatic (Hückel's rule), benzenoid & non benzenoid compounds, antiaromatic & homoaromatic compounds, aromatic ring currents. **(12 Hrs)**

Unit-4: Stereochemistry-I:

Influence of hybridization on structure of organic compounds. Projection formulae and interconversion, enantiomers, diastereomers, geometrical isomerism. Chirality. Configurational notations of simple molecules, DL and RS configurational notations, and E/Z notation. Conformational analysis of acyclic molecules and cyclohexane. **(9 Hrs)**

Unit-5: Alkenes & Alkynes: (Up to 5 Carbons) Preparation: Elimination reactions: Dehydration of alkenes and dehydrohalogenation of alkyl halides (Saytzeff's rule); The trans-addition (bromine), Addition of HX (Markownikoff's and anti-Markownikoff's addition), Hydration, Oxy mecuration- demercuration, Hydroboration-oxidation. Elimination vs substitutions, Conjugated and isolated dienes. Alkynes: (Up to 5 Carbons) Preparation: Acetylene from CaC_2 and conversion into higher alkynes; by dehalogenation of tetra halides and dehydrohalogenation of vicinal-dihalides. Reactions: formation of metal acetylides, addition of bromine and alkaline $KMnO_4$, ozonolysis and oxidation with hot alkaline. $KMnO_4$. **(9 Hrs)**

Suggested Books:

1. Lee, J.D., Concise Inorganic Chemistry, 5th Ed., Blackwell Publishing, 2006.

2. Cotton, F.A., Wilkinson, G., Gaus, P. L., Basic Inorganic Chemistry, 3rd Ed., John Wiley and Sons Press, 1995.

3. Atkins, P., et al., Shriver and Atkins Inorganic Chemistry, 4th Ed., Oxford University Press, 2006.

4. Clayden, J. et al., Organic Chemistry, 2nd Ed., Oxford University Press, 2001.

5. Hornback, J. M., Organic Chemistry, 2nd Ed., Cengage Learning, 2006.

6. Solomons, T. W. G. and Fryhle, C. B., Organic Chemistry, 9th Ed. John Wiley and Sons, 2007.

7. Morrison, R. M. and Boyd, R. N., Organic Chemistry, 6th Ed., Pearson Education, 2008.

8. Sykes, P. A., A guide book to mechanism in organic chemistry, 6th Ed., Pearson India, 2008.

Semester-I: Fundamental Inorganic Chemistry Laboratory Credits: 02

Code	Type	Title	Credits	Hours	L	T	P
UCHPC10102	Major	Fundamental Inorganic Chemistry Laboratory	2	4	0	0	4

Course Learning Outcomes (CLOs)

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

CLO-1: Develop knowledge on working principles of volumetric analysis.
CLO-2: Handle the glassware effectively and appropriately.
CLO-3: Estimate the unknown quantity of the analyte by choosing standard methods
CLO-4: Perform instrument handling, note book entry and calculations
CLO-5: Propose methods to analyze quantitatively commercial and environmental samples.

I. ACIDIMETRY

1. Estimation of Na_2CO_3 and $NaHCO_3$ mixture –Link HCl - standard Na_2CO_3
2. Estimation of HCl– Link NaOH -standard oxalic acid

II. PERMANGANOMETRY

3. Estimation of oxalic acid
4. Estimation of FAS

III. DICHROMETRY

5. Internal indicator method
6. External indicator method

IV. IODOMETRY

7. Estimation of potassium dichromate

V. COMPLEXOMETRY

8. Estimation of Zn^{2+}
9. Hardness of water- temporary and permanent

References:

1. V. Venkateswaran, R.Veerasamy, A.R.Kulandaivelu, Basic principles of practical Chemistry, 2nd Edt, Sultan Chand & sons publisher, 1997.
2. A. I. Vogel, "Quantitative Inorganic Analysis", ELBS, 3rd Edition, 1971

Semester-II No. of credits = 22

SEMESTER-II							
S.No.	Category of Course	Course Code	Course Title	Hours			Credits
				L	T	P	
1	Major	UCHTC20103	Fundamentals of Chemistry-II	3	1	0	4

2	Major	UCHPC20104	Fundamental Organic Chemistry Laboratory	0	0	4	2
3	Minor		Physics / Mathematics / Life Science	3	1	0	4
4	Minor		Physics / Mathematics / Life Science	0	0	4	2
5	Multidisciplinary Course (MDC)		Organic Chemistry in day-to-day life	2	1	0	3
6	Ability Enhancement Course (AEC)		A course on English Language	2	0	0	2
7	Skill Enhancement Course (SEC)	UCHTS20102	Mathematics for Chemists / Green Chemistry / Food Chemistry / Quality Control Chemist	2	0	2	3
8	Value Added Course (VAC)		Indian Knowledge System / Professional Development / Soft Skills	2	0	0	2
Total				14	3	10	**22**

Semester-II: Fundamentals of Chemistry-II ***Credits: 04***

Code	Type	Title	Credits	Hours	L	T	P
UCHTC20103	Major	Fundamentals of Chemistry-II	2	4	3	1	0

Course Learning Outcomes (CLOs)

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

CLO-1: Understand the concept of Thermodynamics.
CLO-2: Understand the Le Chatelier's principle.
CLO-3: Understand the Hard and soft acids and bases
CLO-4: Familiarization about classes of organic compounds and their methods of preparation.
CLO-5: Mechanism of organic reactions (effect of nucleophile/leaving group, solvent), substitution *vs.* elimination.
CLO-6: Understand introductory Organic Chemistry practicals on qualitative analysis.

Detailed Syllabus:

Unit-1: Chemical Energetics

The Laws of Thermodynamics. Thermochemistry. Concept of standard state and standard enthalpies of formations, integral and differential enthalpies of solution and dilution. Calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data. Variation of enthalpy of a reaction with temperature – Kirchhoff's equation. Statement of Third Law of thermodynamics and calculation of absolute entropies of substances. **(10 Hrs)**

Unit-2: Chemical Equilibrium:

Free energy change in a chemical reaction. Thermodynamic derivation of the law of chemical equilibrium. Distinction between ΔG and ΔG^o, Le Chatelier's principle. Relationships between Kp, Kc and Kx for reactions involving ideal gases **(10 Hrs)**

Unit-3: Ionic Equilibria:

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect. Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions. Solubility and solubility product of sparingly soluble salts – applications of solubility product principle. Acids and Bases: super acids, relative strengths of acids; acid-base neutralisation curves and indicators.

(10 Hrs)

Unit-4: Aromatic hydrocarbons: Preparation, Reactions of Benzene, Naphthalene and Anthracene. **(5 Hrs)**

Unit-5: Alkyl & Aryl Halides (Upto 5 Carbons) Preparations, Reactions: Types of Nucleophilic Substitution (SN1, SN2 and SNi) reactions, SET mechanism. With stereochemical considerations, substrate structure, leaving groups, nucleophiles, ambident nucleophilic reactions, role of solvents tests for alkyl halides, organometallic compounds of Mg and Li – use in synthesis of organic chemistry. **Aryl Halides -**Preparation: (Chloro, bromo and iodo-benzene case): from phenol, Sand Meyer & Gattermann reactions. Reactions (Chlorobenzene): Aromatic electrophilic substitution, Reactivity and Relative strength of C-Halogen bond in alkyl, allyl, benzyl, vinyl and aryl halides. **(13Hrs)**

Unit-6: Alcohols, Phenols and Ethers (Up to 5 Carbons)

Alcohols: Preparation of 1^o, 2^o and 3^o alcohols: using Grignard reagent, Ester hydrolysis, Reduction of aldehydes, ketones, carboxylic acid and esters. Reactions: With sodium, HX (Lucas test), esterification, oxidation (with PCC, alk. $KMnO_4$, acidic dichromate, conc. HNO_3). Oppeneauer oxidation Diols: (Up to 6 Carbons) oxidation of diols.

Phenols: (Phenol case) Preparation: Cumene hydro peroxide method, from Diazonium salts. Reactions: Electrophilic substitution: Nitration, halogenation and sulphonation. Reimer-Tiemann reaction, Gattermann-Koch reaction, Houben– Hoesch condensation,

Ethers (aliphatic and aromatic): Preparations and Reactions **(13 Hrs)**

Suggested Books

1. Levine, I., Physical Chemistry, 6th Ed., McGraw Hill, 2009.

2. Atkins, P.W. and de Paula, J., Physical Chemistry, 9th Ed., Oxford Press, 2009.

3. Castellan, G.W., Physical Chemistry, 3rd Ed., Narosa Publishing House, 2004.

4. Puri, B. R, Sharma, L.R, Pathania, M.S., Principles of Physical Chemistry, Vishal Publishing Co., 47th Edition, 2020. 5. Clayden, J. et al., Organic Chemistry, 2nd Ed., Oxford University Press, 2001.

5. Clayden, J. et al., Organic Chemistry, 2nd Ed., Oxford University Press, 2001.

6. Hornback, J. M., Organic Chemistry, 2nd Ed., Cengage Learning, 2006.

7. Morrison, R. M. and Boyd, R. N., Organic Chemistry, 6th Ed., Pearson Education, 2008.

8. Smith, M. B. and March, J., Advanced Organic Chemistry, 6th Ed., John Wiley and Sons, 2007.

9. Carey, F. A, Sundberg, R. J., Advanced Organic Chemistry, Parts A and B, Springer, 2007.

10. Kapoor K. L., A Textbook of Physical Chemistry, Volume 1 to Volume 6, McGraw Hill Education (India) Private Limited, 2015

Semester-II: Fundamental Organic Chemistry Laboratory Credits: 02

Code	Type	Title	Credits	Hours	L	T	P
UCHPC20104	Major	Fundamentals Organic Chemistry Laboratory	2	4	0	0	4

Detailed Syllabus:

Organic Qualitative Analysis

1. Preliminary Tests: Colour, Odour, Solubility and Litmus Test
2. Detection of Elements: Detection of nitrogen, sulphur, halogens
3. Detection of Characteristic functional groups: Test for Aliphatic or aromatic, Test for unsaturation, Tests for Carbohydrates, aromatic amines, amides, aromatic acids, polyhydric phenols, aromatic acids, polyhydric phenols, sugars, aliphatic aldehydes, nitrophenols, aromatic amides, carboxylic acids, alcohols, phenols, salicylic acid, naphthol, aldehyde, ketone, glucose
4. Confirmation of functional groups:

(i)Acid amides containing $–CONH_2$

(ii) Amino compounds containing $–NH_2$ group (aliphatic and aromatic)

(iii) Anilides containing (-NHCOR) group

(iv) Nitro compounds containing $–NO_2$ group.

Confirmatory tests: Fehling's Test, Biuret Test, Sodalime Test

Confirmation of amines (Primary, Secondary and tertiary amines)

(a) Dye Test (b) Carbylamine test

Confirmation of Nitro group

(a) Mulliken and Barker reaction (b) Reduction Test

Functional group test for compounds containing carbon, hydrogen and halogen with or without oxygen---Confirmation of Chloro, Bromo and iodo ---Reaction with Silver nitrate.

Identification of compounds containing carbon, hydrogen and sulfur along with or without oxygen

Test for thiourea and sulphonamide.

Confirmatory tests for Carboxylic acids, Phenols, alcohols, aldehydes, ketones, esters, carbohydrates etc…

5. Preparation of solid derivatives

   Derivatives for carboxylic acid, Phenols, Alcohols, Esters, amides, Urea, Amines, Nitro compounds, aldehydes, ketones, thioureas, halogen compounds, carbohydrates.

Reference Books:

1. Svehla, G. Vogel's *Qualitative Inorganic Analysis*, Pearson Education, **2012**.

2. Mendham, J. Vogel's *Quantitative Chemical Analysis*, Pearson, **2009**.

3. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., *Textbook of Practical Organic Chemistry*, Prentice-Hall, 5th edition, **1996**.

Semester-III No. of credits = 20

SEMESTER-III							
S.No.	**Category of Course**	**Course Code**	**Course Title**	**Hours**			**Credits**
				L	**T**	**P**	
1	Major	UCHTC30205	Fundamentals of Chemistry-III	3	1	0	4
2	Major	UCHPC30206	Fundamental Physical Chemistry Laboratory	0	0	4	2
3	Minor		Physics / Mathematics / Life Science	3	1	0	4

4	Multidisciplinary Course (MDC)		Physical Chemistry in day-to-day life	2	1	0	3
5	Ability Enhancement Course (AEC)		A course on English Language	2	0	0	2
6	Skill Enhancement Course (SEC)	UCHTS30103	Mathematics for Chemists / Green Chemistry / Food Chemistry/ Quality Control Chemist	2	0	2	3
7	Value Added Course (VAC)		Community Engagement / Employability Skills / Entrepreneurship Development	2	0	0	2
Total				14	3	6	**20**

Semester-III: Fundamentals of Chemistry-III ***Credits: 04***

Code	Type	Title	Credits	Hours	L	T	P
UCHTC30205	Major	Fundamentals of Chemistry-III	4	4	3	1	0

Course Learning Outcomes (CLOs)

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

CLO-1: Understand theories/thermodynamics of ideal solutions. Understanding of Nernst distribution law and its applications, solvent extraction.
CLO-2: Understand the Derivation of Clausius – Clapeyron equation and its importance in phase equilibria.
CLO-3: Understand the fundamentals of conductance and it's application.
CLO-4: Understand the fundamentals of Electrochemistry and it's application.
CLO-5: Understand the different fundamental functional group making & transformation reactions.
CLO-6: Understand the introduction to amino acids & peptides.
CLO-7: Understand introductory Physical Chemistry practicals on kinetics, pH, equilibrium, etc..

Detailed Syllabus:

Unit-1: Solutions

Thermodynamics of ideal solutions: Ideal solutions and Raoult's law, deviations from Raoult's law – non-ideal solutions. Vapour pressure-composition and temperature composition curves

of ideal and non-ideal solutions. Distillation of solutions. Lever rule. Azeotropes. Partial miscibility of liquids: Critical solution temperature; effect of impurity on partial miscibility of liquids. Immiscibility of liquids-Principle of steam distillation. Nernst distribution law and its applications, solvent extraction. Colligative properties, binary solutions. **(7 Hrs)**

Unit-2: Phase Equilibrium

Phases, components and degrees of freedom of a system, criteria of phase equilibrium. Gibbs Phase Ruleand its thermodynamic derivation. Derivation of Clausius – Clapeyron equation and its importance in phase equilibria. Phase diagrams of one-component systems (water and Sulphur) and two component systems involving eutectics, congruent and incongruent melting points (lead-silver, $FeCl_3$-H_2O andNa-K only). **(8 Hrs)**

Unit-3: Conductance

Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Kohlrausch law of independent migration of ions. Debye Huckel's theory. Transference number and itsexperimental determination using Hittorf and Moving boundary methods. Ionic mobility. Applications of conductance measurements: determination of degree of ionization of weak electrolyte, solubility andsolubility products of sparingly soluble salts, ionic product of water, hydrolysis constant of a salt. Conductometric titrations (only acid-base). **(7 Hrs)**

Unit-4: Electrochemistry

Reversible and irreversible cells. Concept of EMF of a cell. Measurement of EMF of a cell. Nernst equation and its importance. Types of electrodes. Standard electrode potential. Electrochemical series. Thermodynamics of a reversible cell, calculation of thermodynamic properties: ΔG, ΔH and ΔS from EMF data. Calculation of equilibrium constant from EMF data. Concentration cells with transference and without transference. Liquid junction potential and salt bridge. pH determination using hydrogen electrode and quinhydrone electrode. Potentiometric titrations -qualitative treatment (acid-base and oxidation-reduction only)., redox reactions. **(8 Hrs)**

Unit-5: Aldehydes, Ketones & Carboxylic acids and their derivatives:

(Formaldehyde, acetaldehyde, acetone and benzaldehyde) *Preparation:* from acid chlorides and from nitriles. *Reactions* – Reaction with HCN, ROH, $NaHSO_3$, NH_2-G derivatives. Iodoform test. Clemensen reduction and Wolff Kishner reduction. Meerwein-Pondorff Verley reduction.Aldol Condensation, Cannizzaro's reaction, Wittig reaction, Benzoin condensation. Carboxylic acids (aliphatic and aromatic) *Preparation*: acidic and alkaline hydrolysis of esters *Reactions*: Hell – Volhard Zelinsky reaction Carboxylic acid derivatives (aliphatic): (up to 5 carbons) Preparation: Acid chlorides, anhydrides, Esters and Amides from acids and their interconversion Reactions: comparative study of nucleophilicity of acyl derivatives. Reformatsky reaction, Perkin condensation. **(14 Hrs)**

Unit-6: Amines and Diazonium Salts

Amines (Aliphatic and Aromatic): (Up to 5 carbons) *Preparation*: From alkyl halides, Gabriel's Phthalimide synthesis, and Hofmann Bromamide reaction. Hofmann elimination, Carbylamine test, Hinsberg test, with HNO_2, Schotten – Baumann Reaction. Electrophilic substitution (case aniline): nitration, bromination, sulphonation. Diazonium salts: *Preparation:* from aromatic amines.*Reactions:* conversion to benzene, phenol, dyes. **(6 Hrs)**

Unit-7: Amino Acids and Peptides

Preparation of Amino Acids: Strecker synthesis using Gabriel's phthalimide synthesis. Zwitterion, Isoelectric point and Electrophoresis. *Reactions of Amino acids*: ester of –COOH group, acetylation of $–NH_2$ group, complexation with Cu^{2+} ions,ninhydrin test. Overview of Primary, Secondary, Tertiary and Quaternary Structure of proteins. Determination of Primary structure of Peptides by degradation Edmann degradation (N-terminal) and C–terminal (thiohydantoin and with carboxypeptidase enzyme). Synthesis of simple peptides (upto dipeptides) by N-protection (t-butyloxycarbonyl and phthaloyl) & C-activating groups and Merrifield solid-phase synthesis. **(12 Hrs)**

Suggested Books

1. Puri, B. R, Sharma, L.R, Pathania, M.S., Principles of Physical Chemistry, Vishal Publishing Co., 47th Edition, **2020**
2. Physical chemistry by G. M. Barrow, Mc Graw Hill. NewYork
3. Introduction to Electrochemistry by Samuel Glass stone East West Press Pvt Ltd New Dehli
4. Bard, A.J. and Faulkner, L.R., *Electrochemical Methods: Fundamentals and Applications*, 2nd Ed., John Wiley & Sons, **2001**.
5. Bockris, J.O'M, Reddy, A.K.N, *Modern Electrochemistry Ionics: Volume 1*, 2nd Ed., Plenum Press, **1998**.
6. Clayden, J. et al., Organic Chemistry, 2nd Ed., Oxford University Press, 2001.
7. Smith, M. B. and March, J., Advanced Organic Chemistry, 6th Ed., John Wiley and Sons, 2007.
8. Carey, F. A. and Sundberg, R. J., Advanced Organic Chemistry, Part A and B, Springer, 2007.
9. Berg, J., Tymoczko, J. and Stryer, L., *Biochemistry*, 5th Ed., W. H. Freeman, **2002**.
10. Kapoor K. L., A Textbook of Physical Chemistry, Volume 1 to Volume 6, McGraw Hill Education (India) Private Limited, **2015**
11. Levine, I., Physical Chemistry, 6th Ed., McGraw Hill, 2009.
12. Atkins, P.W. and de Paula, J., Physical Chemistry, 9th Ed., Oxford Press, **2009.**
13. Castellan, G.W., Physical Chemistry, 3rd Ed., Narosa Publishing House, **2004.**

Semester-III: Fundamental Physical Chemistry Laboratory Credits: 02

Code	Type	Title	Credits	Hours	L	T	P
UCHPC30206	Major	Fundamental Physical Chemistry Laboratory	2	4	0	0	4

Detailed Syllabus:

(Any 8-10 experiments will be carried out depending on the availability of resources)

I. Thermochemistry

1. Determination of heat capacity of calorimeter for different volumes.
2. Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
3. Determination of enthalpy of ionization of acetic acid.
4. Determination of integral enthalpy of solution of salts (KNO_3, NH_4Cl).
5. Determination of enthalpy of hydration of copper sulphate.
6. Study of the solubility of benzoic acid in water and determination of ΔH .

II. Ionic equilibria

1. Measurement of pH of different solutions like aerated drinks, fruit juices, shampoos and Soaps (use dilute solutions of soaps and shampoos to prevent damage to the glass Electrode) using pH- meter.
2. Preparation of buffer solutions:

   (i) Sodium acetate-acetic acid

   (ii) Ammonium chloride-ammonium hydroxide

   Measurement of the pH of buffer solutions and comparison of the values with theoretical values.

III. Distribution Law, Phase rule

1. Critical solution temperature of partially miscible liquid system
2. Two component simple eutectic systems
3. Determination of partition coefficient of given system between two immiscible liquids

IV. Conductance and Electrochemistry, Chemical Equilibrium

1. Determination of cell constant of a conductivity cell
2. Determination of molar conductance at infinite dilution for given electrolyte
3. Conductometric titration of given acid vs base
4. Redox titration
5. Determination of standard reduction potential of given electrode
6. Determination of pKa of given acids using pH method
7. Determination of ionic product of water at room temperature using pH metry

Any other suitable experiments from the theory subject taught in Semester 2 and Semester

Reference Books:

1. Svehla, G. Vogel's *Qualitative Inorganic Analysis*, Pearson Education, **2012**.
2. Mendham, J. Vogel's *Quantitative Chemical Analysis*, Pearson, **2009**.

3. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., *Textbook of Practical Organic Chemistry*, Prentice-Hall, 5th edition, **1996**.
4. Viswanathany, B., Raghavan, P.S., Practical Physical Chemistry, Viva Books Private Ltd, 2012
5. Maity, S.K., Ghosh, N.K., Physical Chemistry Practicals, New Central Book Agency Ltd, 2012
6. A.Findlay, Practical Physical Chemistry (Longmans, Green and Co).
7. J.M.Wilson, K.J.Newcombe, A.R.Denko, R.M.W.Richett, Experiments in Physical Chemistry, (Pergamon Press).
8. Garland, C.W., Nibler, J.W., Shoemaker, D.P., Experiments in Physical Chemistry, McGraw-Hill Higher Education, 8th Edition, 2009

Semester-IV — No. of credits = 20

SEMESTER-IV							
S.No.	**Category of Course**	**Course Code**	**Course Title**	**Hours**			**Credits**
				L	**T**	**P**	
1	Major	UCHTC40207	Fundamentals of Chemistry-IV	3	1	0	4
2	Major	UCHPC40208	Analytical Chemistry Laboratory	0	0	4	2
3	Major	UCHPC40209	Inorganic Qualitative Analysis	2	0	0	2
4	Major	UCHTC40210	Analytical Chemistry	2	0	0	2
5	Major	UCHTC40211	Chemistry of Life	2	0	0	2
6	Minor		Physics / Mathematics / Life Science	3	1	0	4
7	Ability Enhancement Course (AEC)		A course on Language	2	0	0	2
8	Value Added Course (VAC)		Community Engagement / Employability Skills / Entrepreneurship Development	2	0	0	2
Total				16	2	4	**20**

Semester-IV: Fundamentals of Chemistry-IV — ***Credits: 04***

Code	Type	Title	Credits	Hours	L	T	P
UCHTC40207	Major	Fundamentals of Chemistry-IV	4	4	3	1	0

Course Learning Outcomes (CLOs)

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

CLO-1: Understand different acid base concept
CLO-2: Understand the general characteristics of alkali and alkaline earth metals
CLO-3: Understand the role of gases and different laws governing them.
CLO-4: Understand the fundamentals of Carbohydrate chemistry and it's utility in Organic Chemistry.
CLO-5: Understand the fundamentals of Polymer chemistry and its application.
CLO-6: Learn fundamental principles of Analytical Chemistry by different techniques like titration methods, purification methods etc..

Detailed Syllabus:

Unit -1: Acid-Base Concept

Arrhenius theory, Bronsted – Lowry theory, Lewis acid base theory, solvent system concept, levelling solvents, Lux flood theory, Usanovich definition, factors influencing relative strengths of acids and bases, HSAB principle and its applications. Physical properties of solvent, types of solvents and their general characteristics, protic solvents like H_2O, reaction in non-aqueous solvents with special reference to liquid NH_3 and liquid HF. **(10 Hrs)**

Unit -2: s- Block Chemistry

Hydrogen and its isotopes, reactive forms of hydrogen, nascent hydrogen, active hydrogen, ortho and parahydrogen. Alkali and alkaline earth metals, General characteristics, electronegativity, ionisation energy, electropositive character, reducing properties, flame colour, hydration energy, lattice energy and solubility of salts. **(10 Hrs)**

Unit-3: Kinetic Theory of Gases

Postulates of Kinetic Theory of Gases and derivation of the kinetic gas equation. Deviation of real gasesfrom ideal behaviour, compressibility factor, causes of deviation. Van der Waals equation of state for real Gases. Boyle temperature (derivation not required). Critical phenomena, critical constants and their calculation from van der Waals equation. Andrews's isotherms of CO_2. Maxwell Boltzmann distribution laws of molecular velocities and molecular energies (graphic representation – derivation not required) and their importance. Temperature dependence of these distributions. Most probable, average and root mean square velocities (no derivation). Collision cross section, collision number, collision frequency, collision diameter and mean free path of molecules. Viscosity of gases and effect of temperature and pressure on coefficient of viscosity (qualitative treatment only).

(10 Hrs)

Unit-4: Liquids

Surface tension and its determination using stalagmometer. Viscosity of a liquid and determination of coefficient of viscosity using Ostwald viscometer. Effect of temperature on surface tension and coefficient of viscosity of a liquid (qualitative treatment only).

(4 Hrs)

Unit-5: Chemical Kinetics

The concept of reaction rates. Effect of temperature, pressure, catalyst and other factors on reaction rates. Order and molecularity of a reaction. Derivation of integrated rate equations for zero, first and second order reactions (both for equal and unequal concentrations of reactants). Half–life of a reaction. General methods for determination of order of a reaction. Concept of activation energy and its calculation from Arrhenius equation. Theories of Reaction Rates: Collision theory and Activated Complex theory of bimolecular reactions. Comparison of the two theories (qualitative treatment only). **(6 Hrs)**

Unit-6: Carbohydrates:

Classification, and General Properties, Glucose and Fructose (open chain and cyclic structure), Determination of configuration of monosaccharides, absolute configuration of Glucose and Fructose, Mutarotation, ascending and descending in monosaccharides. Structure of disaccharides (sucrose, cellobiose, maltose, lactose) and polysaccharides (starch and cellulose) excluding their structure elucidation. **(10 Hrs)**

Unit-7: Polymer chemistry

Introduction, background, nomenclature, classifications, examples of applications, principles of polymerization; synthesis of polymers: step growth, radical, chain polymerization, controlled radical, emulsion polymerization, ionic chain polymerization, coordination polymerization, ring –opening polymerization, copolymerization; determination of frictional properties of polymers in solution, polymer processing, hydrodynamic size. **(10 Hrs)**

Suggested Books

1. Huheey, J. E., Keiter, E. A. and Keiter, R. L., *Inorganic Chemistry-Principles of Structure and Reactivity*, 4th Ed., Harper-Collins, 1993.
2. Douglas, B., McDaniel, D., Alexander, J., *Concepts and Models of Inorganic Chemistry*, 3rd Ed.
3. Wiley India (P.) Ltd., India, 2010.
4. Cotton, F. A. et al., *Advanced Inorganic Chemistry*, 3rd Ed., John Wiley and Sons, 1995.
5. Jolly, W. L., *Modern Inorganic Chemistry*, 2nd Ed., McGraw-Hill, NY, 1991.
6. Shriver, D. F. and Atkins, P. W., *Inorganic Chemistry*, 3rd Ed. Oxford University Press, 1999.
7. Levine, I., *Physical Chemistry*, 6th Ed., McGraw Hill, **2009**.
8. Atkins, P.W. and de Paula, J., *Physical Chemistry*, 9th Ed., Oxford Press, **2009**.
9. Castellan, G.W., *Physical Chemistry*, 3rd Ed., Narosa Publishing House, **2004**.
10. Chemical kinetics by K J Laidler. Harper and Row
11. Solid state physics by C. Kittel, Tata Mc Graw Hill
12. Levine, I., Physical Chemistry, 6th Ed., McGraw Hill, 2009.

13. Puri, B. R, Sharma, L.R, Pathania, M.S., Principles of Physical Chemistry, Vishal Publishing Co., 47th Edition, **2020.**
14. Kapoor K. L., A Textbook of Physical Chemistry, Volume 1 to Volume 6, McGraw Hill Education (India) Private Limited, **2015**

Semester-IV: Analytical Chemistry Laboratory *Credits: 02*

Code	Type	Title	Credits	Hours	L	T	P
UCHPC40208	Major	Analytical Chemistry Laboratory	2	4	0	0	4

(Any 6-8 Practicals will be conducted)

1. **Purification of Solid and Liquids**

(i) Crystallisation (ii) Sublimation (iii) Distillation

(iv) Fractional Distillation (v) Distillation under reduced pressure (vi) Differential extraction

2. **Separation Techniques:**

(i) Thin layer chromatography (ii) Column Chromatography

3. **Surface tension measurement** (use of organic solvents excluded)

(i) Determination of the surface tension of a liquid or a dilute solution using a stalagmometer.

(ii) Study of the variation of surface tension of a detergent solution with concentration

4. **Viscosity measurement (use of organic solvents excluded).**

(i) Determination of the relative and absolute viscosity of a liquid or dilute solution using an Ostwald's viscometer.

(ii) Study of the variation of viscosity of an aqueous solution with concentration of solute.

5. Determination of the concentration of given acids in a mixture of HCl + CH_3COOH conductometrically using the standard (0.5 N) NaOH
6. Determination of solubility of sparingly soluble salt, $BaSO_4$/$PbSO_4$ conductometrically
7. Determination of redox potentials of Fe^{3+}/Fe^{2+} using of $FeSO_4.7H_2O$ solution (≈ 0.1N) by potentiometric titration against the standard solution of $K_2Cr_2O_7$ (0.1 N)
8. Determination of the solubility and solubility product of sparingly soluble salts (AgCl) potentiometrically
9. Determination of the percentage composition of unknown mixture of A and B liquids using
10. Abbe's refractometer by graphical method
11. Determination of pK_a of acetic acid potentiometrically

Semester-IV: **Inorganic** *Qualitative Analysis* *Credits: 02*

Code	Type	Title	Credits	Hours	L	T	P

UCHPC40209	Major	Inorganic Qualitative Analysis	2	4	0	0	4

Inorganic Chemistry - Qualitative Analysis:

A mixture of inorganic salts which contains two cations or two anions will be given. Among them, one of the anion must be an interfering ion. Spot tests for anions and cations are also included.

Acid Radicals like: CO_3^{2-}, S^{2-}, SO_3^{2-}, NO_2^-, Cl^-, Br^-. NO_3^-, SO_4^{2-}, PO_4^{3-} etc

Basic Radicals like: Na^+, K^+, Ca^{2+}, Mg^{2+}, Sr^{2+}, Ba^{2+}, Al^{3+}, Cr^{3+}, Fe^{3+}, Bi^{3+}, Hg^{2+}, Ag^+, Cu^{2+}, Zn^{2+}, Mn^{2+} etc

Reference Books:

1. Svehla, G. Vogel's Qualitative Inorganic Analysis, Pearson Education, 2012.
2. V.V. Ramanujam, Inorganic Semimicro qualitative analysis, National Publishing company, Madras, 1974.
3. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., Textbook of Practical Organic Chemistry, Prentice-Hall, 5th edition, 1996.

Semester-IV: Analytical Chemistry ***Credits: 02***

Code	Type	Title	Credits	Hours	L	T	P
UCHTC40210	Major	Analytical Chemistry	2	2	2	0	0

Course Learning Outcomes (CLOs)

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

CLO-1: Develop knowledge on working principles of various analytical techniques available for chemical analysis in laboratories.
CLO-2: Summarize the advantages and disadvantages of different calorimetry techniques.
CLO-3: Analyze experimental data using various mathematical and statistical models.
CLO-4: Recognize suitable titration method for quantitative analysis of ions/chemicals
CLO-5: Design a suitable method for separation and analysis of chemicals by chromatography.

Detailed Syllabus:

UNIT I: Errors analysis: Accuracy and precision, absolute, relative, determinate and indeterminate errors, statistical treatment of random errors, computation rules for significant

figures, method of least squares, mean deviations, and standard deviation, The Confidence Limit, test of significance, statistics for small data sets, linear least square method, detection limits, use of spreadsheets/softwares in analytical chemistry **(10 Hrs)**

UNIT II: Titrations & Gravimetric analysis: Theory of Acid base equilibria, Acid-base, complexometric, conductometric and potentiometric titrations- theory of acid base indicators, Precipitation reaction & titration, EDTA based titration, Redox titrations, redox indicators, and their use in volumetric analysis, iodometry and iodimetry. Introduction to gravimetric analysis, Thermogravimetry (TGA), Differential Thermal Analysis (DTA), and Differential Scanning Calorimetry (DSC): definition, theoretical basis, instrumentation, factors affecting the data curve, applications, advantages and disadvantages. **(10 Hrs)**

UNIT-III: Separation Techniques: Solvent extraction, distribution coefficient, extraction of metals, thin-layer chromatography (TLC), gas chromatography (GC), liquid chromatography (LC), high performance liquid chromatography (HPLC), ion exchange chromatography, gel permeation chromatography. Chromatography coupled instrumentation.

(10 Hrs)

Reference books:

1. Douglas A. Skoog, Donald M. West, F. James Holler and Stanley R. Crouch, (2013). *Fundamentals of Analytical Chemistry*, 9th Edition, Cengage Learning.
2. James W. Robinson, Eileen M. Skelly Frame, George M. Frame II, (2005). *Undergraduate Instrumental Analysis*, Sixth Edition, Marcel Dekker, New York.
3. Donald L. Pavia, Gary M. Lampman, George S. Kriz, James R. Vyvyan, (2009). *Introduction to Spectroscopy*, Fourth Edition, Brooks/Cole Thomson Learning.
4. Gary D. Christian, Purnendu Das gupta, Kevin Schug, (2013). *Analytical Chemistry*, 7th Edition, Wiley.
5. P.M.S. Monk "Fundamentals of Electroanalytical Chemistry" J. Wiley & Sons, New York, 2002.
6. Skoog, D.A., West, D.M., Holler, F.J., and Crouch, S.R., Fundamentals of Analytical Chemistry, Brooks/Cole (2003) 8th ed.

Semester-IV: Chemistry of Life ***Credits: 02***

Code	Type	Title	Credits	Hours	L	T	P
UCHTC40211	Major	Chemistry of Life	2	2	2	0	0

Course Learning Outcomes (CLOs)

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

CLO-1: Demonstrate the applications of enzyme-kinetics in the identification of types of inhibitors.
CLO-2: Categorize biomolecules based on their biological functions and chemical structures.
CLO-3: Demonstrate the steps involved in the structure elucidation of various natural

products using chemical, analytical and synthetic methods.

Detailed Syllabus:

UNIT I: Biophysical chemistry: Chemistry and biology of water, Chemical forces responsible for stability of biomolecules; hydrogen bonding; electrostatic interactions, hydrophobic interactions; stacking interactions; enzymes, catalysis, and kinetics- Michaelis-Menten equation, and Lineweaver–Burk plot; enzyme inhibition and different types of enzyme inhibition. **(6 Hrs)**

UNIT II: Bioorganic chemistry: Biopolymers-DNA, RNA and Proteins- structures of monomers, bonding, and hierarchy of structural organization. Chemical methods involved in sequencing of DNA and Proteins. Chemical and biochemical synthesis of DNA-Phosphoramidite method and replication. Chemical and biochemical synthesis of peptides/proteins- solution phase and solid phase peptide synthesis methods and ribosomal synthesis of proteins. Applications of PNAS. **(10 Hrs)**

UNIT III: Natural product chemistry: Chemistry of alkaloids - structure determination and synthesis of nicotine, morphine, coniine. Chemistry of terpenes- general methods, classification and special isoprene rule. Characterization of terpenes- Citral, Limonene, Geraniol. Biosynthesis of acyclic and monocyclic terpenes from acetyl CoA. **:** Chemistry of steroids-Structure of common steroids such as cholesterol and steroidal hormones. **(14 Hrs)**

Reference books:

1. C.R. Cantor & P.R. Schimmel, Biophysical Chemistry, W.H.Freeman& Company, 1980
2. David Van Vranken and Gregory A, Introduction to Bioorganic Chemistry and Chemical
   Biology. Garland Science (Taylor & Francis), 2012.
3. R.H. Thomson, Chemistry of Natural Products - Wiley, New York, 1996.
4. I. L. Finar, *Advanced Organic Chemistry*, Vol. 2 ELBS, New Delhi, 1975.
5. Bhat, S. V., Nagasampagi, B.A., Meenakshi, S. (2009). *Natural Product Chemistry & Applications*, Narosa Publishing House, New Delhi.

Semester-V No. of credits = 20

SEMESTER-V							
S.No.	**Category of Course**	**Course Code**	**Course Title**	**Hours**			**Credits**
				L	**T**	**P**	
1	Major	UCHTC50312	Inorganic Chemistry-I	3	1	0	4
2	Major	UCHTC50313	Organic Chemistry-I	3	1	0	4
3	Major	UCHTC50314	Physical Chemistry-I	3	1	0	4
4	Major	UCHPC50315	Organic Chemistry Laboratory	0	0	4	2
5	Major	UCHPC50316	Computational Chemistry Laboratory	0	0	4	2

6	Minor		Physics / Mathematics / Life Science	3	1	0	4
Total				12	4	8	**20**

Semester-V: Inorganic Chemistry-I ***Credits: 04***

Code	Type	Title	Credits	Hours	L	T	P
UCHTC50312	Major	Inorganic Chemistry – I	4	4	3	1	0

Course Learning Outcomes (CLOs)

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

CLO-1: Understand the fundamentals of periodic properties and their applications.
CLO-2: Categorize inorganic solids into different classes based on its structure, chemical property, and applications.
CLO-3: Understand the structure, bonding, and properties of electron-deficient clusters and cages of boron, silicon, and phosphorus compounds.
CLO-4: Apply the knowledge of radioactivity and nuclear reactions into various applications such as radio-dating, reaction mechanisms, and nuclear energy.
CLO-5: Apply basic concepts into other branches of chemistry and other allied subjects.

Detailed Syllabus:

UNIT I- Periodic Table and Bonding: Arrangement of elements in the Periodic Table, periodic properties. Atomic volume and density. Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization energy. Applications of ionization enthalpy. Electron gain enthalpy, trends of electron gain enthalpy. Electronegativity, Pauling's/ Mulliken's/ Allred Rachow's/ and Sanderson's electronegativity scales. Group electronegativity. **(8Hrs)**

UNIT II-Inorganic Solids: Types of forces-cohesive energy, van der Waals forces, hydrogen bonding. Types of solids, covalent, ionic, molecular and metallic solids. Unit cell, density and crystal lattice structures of ionic crystals AX & AX_2 and layered structures. Lattice energy, Born-Lande equations and modifications. Defects (0D, 1D, 2D, 3D) in ionic solids and associated theories. Band theory, semiconductors and its type & superconductors. **(15 Hrs)**

UNIT III-p block elements: Boron hydrides (small boranes and their anions, B1−B4), boron nitride, borazines, carboranes, metalloboranes, metallocarboranes. Diamond, graphite, fullerenes, silicates, silicones, zeolites, organo-silicon compounds. Phosphorus allotropes, Berry's pseudo rotation, phosphorus-nitrogen compounds, organo-phosphorus compounds, hydrides, oxides and oxy acids of nitrogen, phosphorus, sulphur and halogens, sulphur-nitrogen and inter-halogen compounds, pseudohalogens, poly halide anions, noble gas compounds. **(30 Hrs)**

UNIT IV- Nuclear Chemistry Nuclear chemistry: radioactive decay and equilibrium. nuclear reactions, Q value, cross sections, types of reactions, chemical effects of nuclear transformations; fission and fusion, fission products and fission yields; radioactive techniques, tracer technique. **(7 Hrs)**

Reference books:

1. C. E. Housecroft, A. G. Sharpe, *Inorganic Chemistry*, 4th Edn, Pearson, 2012.
2. J. E. Huheey, *Inorganic Chemistry, Principles, Structure and Reactivity*, Harper and Row, 3rd Edn, 1983.
3. N. N. Greenwood, A. Earnshaw, *Chemistry of the Elements*, 2nd Edn., Pergamon Press, 1989.
4. Shriver and Atkins, Inorganic Chemistry by Atkins, Overton, Rourke, Weller, and Armstrong, 5th Edition. South Asia Edition (paperback), Oxford University Press, 2010.
5. G. Wulfsberg, *Inorganic chemistry*, 1st Edn, Viva books Pvt Ltd. 2002.
6. M. Weller, T. Overton, J. Rourke, F. Armstrong, Inorganic Chemistry, 7th Edn, Oxford University Press India, 2018.
7. F. A. Cotton and G. Wilkinson, *Advanced Inorganic Chemistry- A comprehensive Text*, John Wiley, 5th Edn, 1987.
8. A. R. West, *Solid state Chemistry and its Applications*, 2nd Edn, Wiley, 2007.
9. C. Kettel, *Introduction to Solid state Physics*, 8th Edn, Wiley, 2012.
10. H. J. Arnikar, *Essentials of nuclear chemistry*, New Age International Publisher, 4th Edn, 2018.
11. G. Friedlander, J. W. Kennedy, E. S. Macias, J. M. Miller, *Nuclear and Radiochemistry*, 3rd Edn, 1981.

Semester-V: Organic Chemistry-I ***Credits: 04***

Code	Type	Title	Credits	Hours	L	T	P
UCHTC50313	Major	Organic Chemistry – I	4	4	3	1	0

Course Learning Outcomes (CLOs)

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

CLO-1: Analyze the role of reactive intermediates such as carbocations, carbanions, non-classical carbocation in the chemical reactions.
CLO-2: Demonstrate chirality in organic molecules using units such as center, axial, planar , and helicity.
CLO-3: Predict E/Z and R/S configuration in organic molecules by applying concepts of stereochemistry
CLO-4: Illustrate the reaction mechanism aspects in the context of addition, elimination and substitution reactions
CLO-5: Assess the structural effects of organic molecules and functional groups on the

tendency to participate in various types of organic reactions.

Detailed Syllabus:

UNIT-I: Reaction Mechanism: Methods of determining reaction mechanisms- kinetic and non-kinetic, isotope effects, and reaction profile diagram, Hammet and Taft equations. substituent constants and reaction constants. A (1,2) and A (1,3) strain, Captodative effect, Hammond's postulate, Curtin-Hammett principle, cross over experiment and thermodynamic and kinetic control of reactions. **(14 Hrs)**

UNIT-II: Stereochemistry-II: Elements of symmetry, chirality, Chirality involving atoms other than carbon. Optical activity in the absence of chiral centre: Axial and planar chirality and helicity. Racemic mixture and their resolution. Topicity: Enantiotopic and diastereotopic atoms, ligands and faces. Conformational analysis of mono-substituted and disubstituted cyclohexanes. Decalins. Asymmetric synthesis: Chiral auxiliaries, methods of asymmetric induction – substrate, reagent and catalyst-controlled reactions; determination of enantiomeric and diastereomeric excess; enantio-discrimination. Stereoelectronic and steric principles in reactions. Importance of stereochemistry in real life: some examples **(24 Hrs)**

UNIT-III: Substitution and allied reactions: Neighbouring group participation, SE2 and SE1 mechanism S_NAr, benzyne and S_N1 mechanism Arenium ion mechanism, ipso attack, orientation in other ring systems, nucleophilic substitution, Benzyne Mechanism; Baldwin Rules for ring closure on saturated and unsaturated carbons. **(08 Hrs)**

UNIT-IV: Elimination and addition reactions: The E2, E1 and E1cB mechanisms, Hoffman and Saytzeff modes of elimination, stereochemical aspect of elimination reaction, orientation of the double bond, reactivity effects of substrate structures, attacking base, the leaving group and the medium, pyrolytic elimination; Mechanistic and stereochemical aspects of addition reactions involving electrophiles, nucleophiles, regio- and chemo selectivity orientation and reactivity; Reactivity of carbonyl group, nucleophilic addition of hetero-atoms (N, O), conjugate addition reactions. **(14 Hrs)**

Reference books:

1. Carey B. F. A., Sundberg R.J., (2007). *Advanced Organic Chemistry Part A and Part B, Springer, 5th edition*.
2. Kalsi, P.S., (2010). *Stereochemistry: Conformation and Mechanism*, New Age International (p) Ltd. New Delhi.
3. Morrison, R.T., Boyd, R.N. (2011). *Organic Chemistry*, Prentice- Hall of India, 6th edition, New Delhi.
4. Smith, M. B., March J., (Latest Ed.). *March's Advanced Organic Chemistry*, John Wiley and Sons, 6th edition, New York.
5. Sykes, P., (1997). *A Guide Book to Mechanism in Organic Chemistry*, Prentice Hall, 6th edition.

6. Eliel, E. L.; Wilen, S. H. (2008). *Stereochemistry of carbon compounds*. Wiley, Student edition.
7. Clayden, J.; Greeves, N.; Warren, S., (2012). *Organic Chemistry*, Oxford University press, 2nd edition.
8. Bruice Paula, Y., (2015). *Organic Chemistry*, 7th Edition, Pearson Edition.
9. Nasipuri, D. (Latest edition). *Stereochemistry of Organic Compounds: Principles & Applications*, New Age International Publishers.

Semester-V: Physical Chemistry-I ***Credits: 04***

Code	Type	Title	Credits	Hours	L	T	P
UCHTC50314	Major	Physical Chemistry – I	4	4	3	1	0

Course Learning Outcomes (CLOs)

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

CLO-1: Understand the fundamentals of quantum chemistry, classical and statistical thermodynamics
CLO-2: Develop problem-solving ability in quantum chemistry and thermodynamics
CLO-3: Recognize the role of multidisciplinary streams especially basic physics & mathematics knowledge in the development of quantum chemistry & thermodynamics
CLO-4: Apply the fundamental knowledge in quantum chemistry & thermodynamics to an existing and emerging problem in basic science
CLO-5: Demonstrate the ability to do some independent calculation and use some computational resources at the end of the course

Detailed Syllabus:

UNIT I-Equilibrium Thermodynamics: Concept of work and heat, first law of thermodynamics, enthalpy and heat capacities- concept of entropy, second law of thermodynamics, third law of thermodynamics-residual entropy. Calculation of entropy, enthalpy, internal energy, Combination of first and second law, Helmholtz Energy, Gibbs Free energy, Maxwell Relationship, Gibbs-Helmholtz equation **(12 Hrs)**

UNIT II-Statistical Thermodynamics: BE, FD, MB statistics and distribution, partition functions and molecular partition functions, ensembles, entropy of monoatomic gas, Sackur–Tetrode equation, thermodynamic properties from partition function, mean energy, Residual entropy, heat capacity of mono and diatomic gases, chemical equilibrium, Einstein and Debye theories of heat capacity of solids. Non-equilibrium thermodynamics, Postulates and methodologies, linear laws, Gibbs equation, Onsager reciprocal theory. **(18 Hrs)**

UNIT III-Quantum Chemistry I: Introduction, Black body radiation, photoelectric effect, Classical mechanics, Lagrange & Hamiltonian equation, Inadequacy & need for quantum mechanics, postulates, operators & operator algebra, Linear, Hermitian and non-Hermitian

operators, Commuting and non-commuting operators, eigen values, eigen vectors & commutation relation, orthogonality, The Schrodinger equation, Discussion of Solution of Schrodinger equation to few model system e. g particles in 1D, 2D & 3D box, harmonic oscillator, rigid rotor, hydrogen atom etc.. **(15 Hrs)**

UNIT IV-Quantum Chemistry II: Approximation methods, viz variation method, perturbation method, Application of variation method and perturbation theory to the Helium atom, Electron spin & Zeeman effect, spin-orbit coupling, introduction to the methods of self-consistent field, the viral theorem. Hartree and Hartree-Fock self-consistent field model, Electronic configuration of atoms, addition of angular momenta, spectroscopic term symbols, spin-orbit coupling, selection rules for atomic spectra, Electronic configuration of atoms, addition of angular momenta, spectroscopic term symbols, selection rules for atomic spectra. **(15 Hrs)**

Reference books:

1. P. W. Atkins, Physical Chemistry, 9thEdtion Oxford University Press, 2010.
2. L.A. Woodward, Molecular Statistics, Oxford University Press.
3. Y. V.C. Rao, An Introduction to Thermodynamics, Wiley Eastern, 1993.
4. Physical Chemistry, R.S.Berry, S.A.Rice and J.Ross, Oxford, 2001.
5. M. Ladd, Introduction to Physical Chemistry, Cambridge, 1998.
6. J. Rajaram & J.C. Kuriacose, Chemical Thermodynamics: Classical, Statistical and Irreversible. Pearson, 2013
7. D. A. McQuarrie and J. D. Simon Physical Chemistry, A molecular Approach, Viva, 1998.
8. F. W. Sears & G. L. Salinger, Thermodynamics, Kinetic Theory & Statistical Thermodynamics, Narosa, 1986.
9. D. A. McQuairrie: Quantum Chemistry, Oxford University press, Oxford, 1982.
10. Ira N. Levine, Quantum Chemistry 7th Ed, Pearson Education India, 2016.
11. A.K.Chandra, Introductory Quantum Chemistry, 4th Ed, McGraw Hill Education, 2017.
12. Donald A McQuarrie, Statistical Mechanics, Viva Books, 2018
13. David Chandler, Introduction to Modern Statistical Mechanics, OUP USA, 1987

Semester-V: Organic Chemistry Laboratory-I ***Credits: 02***

Code	Type	Title	Credits	Hours	L	T	P
UCHPC50315	Major	Organic Chemistry Laboratory	2	4	0	0	4

Course Learning Outcomes (CLOs)

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

CLO-1: Demonstrate purification of organic liquids using Fractional & Vacuum distillations.

CLO-2: Separate the organic solids and their qualitative analysis and identification of functional groups.
CLO-3: Synthesize the biologically important molecules having carbonyl functionality.
CLO-4: Verify the purity of organic compounds by employing a thin layer chromatography
CLO-5: Apply photo-chemical reaction conditions in organic synthesis.

Detailed Syllabus:

S.No	Practical (Any 8-10 Experiments will be conducted)
1	Vacuum Distillations & Anhydrous solvent. Ex. Hexane, Ethyl Acetate, DMF, DMSO
2	Separation and Qualitative analysis of an organic mixture containing two components. At least one experiments to be performed
3	Thin Layer Chromatography (TLC) experiment
4	Separation of compounds using Column Chromatography/ Medium Pressure Liquid Chromatography (MPLC)
5	Synthesis of Dibenzalpropanone from benzaldehyde and acetone
6	Synthesis of a Chalcones *via* Claisen-Schmidt condensation by grinding method.
7	Nitration of Salicylic acid using Calcium nitrate.
8	Preparation Aspirin by acetylation-Protection Chemistry
9	Bromination of Acetanilide: Green Approach
10	Photoreduction of benzophenone to benzopinacol
11	Synthesis of benzopinacol from benzophenone using Photoreduction
12	Heterocyclic compound synthesis
13	Two step synthesis reaction
14	Any one Name reaction (Diel's-Alder/ Baylis-Hillman/Biginelli Reaction etc.)

Reference books:

1. Vogel, A.I. (1996). *Text book of practical organic chemistry*, Pearson, 5th edition, UK.
2. Adams, R.; Johnson, J.R.; Wilcox, C.F. (1970). *Laboratory Experiments in Organic Chemistry*, The Macmillan Limited, London.
3. Mann and Saunders. (2009). *Practical organic chemistry*, Pearson, 4th edition, UK.
4. Pasto, D.P., Johnson, C., Miller, M. (1992). *Experiments and Techniques in Organic Chemistry*, Prentice Hall, 1st edition, US.
5. Roberts, R.M.; Gilbert, J.C.; Rodewald, L.B.; Wingrove, A.S. (1969). *An introduction to Modern Experimental Organic Chemistry*, Ranehart and Winston Inc., New York.

6. Williamson, K.L., Health, D.C. (1999). *Macroscale and Microscale Organic Experiments, Heath, D.C.* and Co., Lexington, MA.

Semester-V: Computational Chemistry Laboratory-I Credits: 02

Code	Type	Title	Credits	Hours	L	T	P
UCHPC50316	Major	Computational Chemistry Laboratory	2	4	0	0	4

Course Learning Outcomes (CLOs)

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

CLO-1: Apply computational tools to understand the fundamentals of atoms, molecules and solids.
CLO-2: Practice the Linux operating system and Linux commands to operate the Quantum Expresso software.
CLO-3: Develop skills to analyze compounds using various analytical techniques.
CLO-4: Illustrate experimental skills to operate various computational software and analytical instruments.

Detailed Syllabus:

S.No	Practical
1	Determination of internal coordinates of organic molecules and metal complexes in the crystal structures retrieved from CCDC using Mercury software.
2	Plotting atomic orbitals and hybrid orbitals using Origin software.
3	Conformational analysis of cyclohexane using Materials Science platform of Schrödinger software.
4	Indexing an XRD pattern-Determination of density by X-ray method.
5	Morse's potential plot of oxygen molecule by density functional theory using Quantum ESPRESSO software.
6	Computational drug design through protein-ligand docking using Glide tool of Schrodinger software.

Reference books:

1. A. Findary, T. A. Kitchner , Practical physical chemistry, (Longmans, Green and Co.)

2. J. M. Wilson, K. J. Newcombe, A. R. Denko, R. M. W. Richett, Experiments in Physical Chemistry, (Pergamon Press)
3. F. Jensen, Introduction to Computational Chemistry (John Wiley and Sons Ltd.)

Semester-VI No. of credits = 20

SEMESTER-VI							
S.No.	Category of Course	Course Code	Course Title	Hours			Credits
				L	T	P	
1	Major	UCHTC60317	Inorganic Chemistry-II	3	1	0	4
2	Major	UCHTC60318	Organic Chemistry-II	3	1	0	4
3	Major	UCHTC60319	Physical Chemistry-II	3	1	0	4
4	Major	UCHPC60320	Inorganic Chemistry Laboratory	0	0	4	2
5	Major	UCHPC60321	Physical Chemistry Laboratory	0	0	4	2
6	Major	UCHTC60322	Bio-inorganic Chemistry	2	0	0	4
7	Internship	UCHTI60301	Chemistry Internship	0	0	4	2
Total				11	3	12	**20**

Semester-VI: Inorganic Chemistry-II *Credits: 04*

Code	Type	Title	Credits	Hours	L	T	P
UCHTC60317	Major	Inorganic Chemistry – II	4	4	3	1	0

Course Learning Outcomes (CLOs)

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

CLO-1: Understand the basics of coordination chemistry including coordination numbers, geometry, and chelate effect.
CLO-2: Describe the bonding theories VBT, CFT, and MOT in turn describe CFSE, High and low spin complexes, magnetic moment of coordination compounds
CLO-3: Interpret the electronic spectra of coordination compounds explaining color, allowed and forbidden transitions through Orgel and Tanabe-Sugano diagrams.
CLO-4: Design reaction mechanism pathways like associative/dissociative, inner and outer sphere mechanism including electron transfer pathways.
CLO-5: Demonstrate the basics, spectral and magnetic properties of Lanthanides and Actinides

Detailed Syllabus:

UNIT I-Introduction to transition metal complexes: A brief history of coordination chemistry, nomenclature, coordination numbers, geometry and isomerism, chelate effect and stability constants. (**10 Hrs)**

UNIT II-Theories of transition metal complexes: Valence bond theory, Crystal field theory, crystal field splitting, application of d-orbital splitting to explain magnetic properties, low spin and high spin complexes, crystal field stabilization energy, spectrochemical series, weak and strong field complexes, thermodynamic and related aspects of crystal fields, ionic radii, heats of ligation, lattice energies, site preference energies. Molecular Orbital theory of complexes (quantitative principles involved in complexes without pi and with pi bonding), ligand field theory. **(18 Hrs)**

UNIT III-Electronic spectra and Magnetism of transition metal complexes: Atomic terms, states and microstates, Electronic spectra of transition metal complexes, selection rules, correlation diagram, Orgel and Tanabe-Sugano diagrams and Lever plot, charge transfer and d-d transitions, Jahn-Teller effect, nephelauxetic series. Dia-, para-, ferro- and antiferromagnetism, quenching of orbital angular moment, spin-orbit coupling. (**17 Hrs)**

UNIT IV-Inorganic reaction mechanisms: Inert and labile compounds, substitution reactions of octahedral complexes, dissociative, associative, anation, aquation, conjugate base mechanism; substitution reactions of square planar complexes, trans effect, trans effect series, theories of trans effect; electron transfer reactions. **(10 Hrs)**

UNIT V-Lanthanides and Actinides: Chemistry of lanthanides and actinides: lanthanide contraction, oxidation states, spectral and magnetic properties, use of lanthanide compounds as shift reagents. (**5 Hrs)**

Reference books:

1. J. E. Huheey, *Inorganic Chemistry*, 3rd Edition. Harper International, 1983.
2. B. Douglas, D. McDaniel, J. Alexander, *Concepts and Models of Inorganic Chemistry*, 3rd Edition. John Wiley. 1994.
3. W. L. Jolly, *Modern Inorganic Chemistry*, 2nd Edition. McGraw-Hill.
4. C. Housecroft and A. G. Sharpe, *Inorganic Chemistry*, 5th Edition, Pearson. 2018.
5. B. N. Figgis, M. A. Hitchman, *Ligand field theory and its applications*, Wiley-VCH, 2000.
6. A. P. B. Lever, *Inorganic electronic spectroscopy*, Elsevier, 1984.
7. F.A. Cotton, *Chemical applications of Group theory*, 3rd Edn, John Wiley & Sons, 1990.
8. K. F. Purcell, J. C. Kotz, *Inorganic chemistry*, 1st Edn, W.B. Saunders company, 1977.
9. M. Weller, T. Overton, J. Rourke, F. Armstrong, *Inorganic Chemistry*, 7th Edn, Oxford University Press India, 2018.

Semester-VI: Organic Chemistry-II ***Credits: 04***

Code	Type	Title	Credits	Hours	L	T	P
UCHTC60318	Major	Organic Chemistry – II	4	4	3	1	0

Course Learning Outcomes (CLOs)

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

CLO-1: Apply the basic oxidation and reduction reactions on organic molecules.
CLO-2: Apply reagents in the stereoselective reactions using mild reagents.
CLO-3: Plan to synthesize molecules using popularly named reactions.
CLO-4: Categorize the pericyclic reactions and construct various cyclic molecules.
CLO-5: Apply oxidations, reductions, photochemical reactions in the organic synthesis.

Detailed Syllabus:

UNIT-I: Oxidations and reductions in organic synthesis: Mechanism, selectivity, stereochemistry and applications of selenium dioxide, Cr and Mn reagents, periodic acid, Osmium tetroxide, Swern oxidations, Baeyer-Villiger oxidation, epoxidations using peracids. Sharpless epoxidation, asymmetric dihydroxylation. Mechanism, selectivity, stereochemistry and applications of catalytic hydrogenations using Pd, Pt and Ni catalysts, metal hydride reductions using $NaBH_4$, $LiAlH_4$, DIBAL, K-selectride, Sodium cyanoborohydride. Asymmetric reductions of prochiral carbonyl compounds and olefins. **(16 Hrs)**

UNIT-II: Reagents in organic synthesis: Lithium diisopropylamide (LDA), Dicyclohexyl Carbodiimide (DCC), Trimethylsilyl iodide, Gilman's reagent, DDQ, Prevost Hydroxylation, Phase transfer catalysts, Phosphorous and Sulphur ylides, Merrifield resin, Lawson reagents, IBX, Ceric ammonium nitrate, Tebbe reagent. **(14 Hrs)**

UNIT-III: Named Reactions & Rearrangements in organic synthesis: Pinacol-pinacolone, Wagner-Meerwein, Demjanov, Benzil-Benzillic acid, Favorskii, Neber, Beckmann, Hofmann, Curtius, Schimidt rearrangements, Arndt-Eister syntheses, Mukaiyama aldol reaction, Mitsunobu reaction, Shapiro reaction, Vilsmeier–Haack reaction, Baylis-Hillman reaction, Biginelli reaction. **(14 Hrs)**

UNIT-IV: Pericyclic reactions: Thermal and photochemical pericyclic reactions, Conrotation and disrotation; Electrocyclic closure and opening in 4n and 4n+2 systems. Woodward-Hoffmann selection rules for electrocyclic reactions. Explanation for the mechanism of electrocyclic reactions and examples. Cycloaddition reactions: Suprafacial and antarafacial interactions. $\pi^2 + \pi^2$ and $\pi^4 + \pi^2$ cycloadditions. Diels-Alder reaction, Woodward-Hoffmann selection rules for cycloaddition reactions and examples. Mechanism by orbital symmetry correlation diagrams, Fukui Frontier Molecular Orbital (FMO) theory. Endo-exo selectivity in

Diels-Alder reaction and its explanation by FMO theory. Sigmatropic reactions: mechanism of sigmatropic reactions, Cope and Claisen rearrangements. **(16 Hrs)**

Reference books:

1. Carey B. F. A., Sundberg R.J., (2007). *Advanced Organic Chemistry Part A and Part B, Springer, 5th edition*.
2. Jie Jack Li, (2009). *Name Reactions: A collection of Detailed Reaction Mechanism*, Publisher: Springer-verlag.
3. McMurry J., *Organic Chemistry***,** Asian Book Pvt. Ltd, 8th edition, New Delhi.
4. Smith, M. B., March J., (Latest Ed.) *March's Advanced Organic Chemistry*, John Wiley and Sons, 6th edition, New York.
5. Clayden, J.; Greeves, N.; Warren, S., (2012) *Organic Chemistry*, Oxford University press, 2nd edition.
6. Sankaraman, S. (2005). *Pericyclic reactions: Reactions, Applications and Theory*, Wiley-VCH.
7. Kurti, L., Czako, B. (2005). *Strategic Applications of Named Reactions in Organic Synthesis*, Elsevier Publications.

Semester-VI: Physical Chemistry-II ***Credits: 04***

Code	Type	Title	Credits	Hours	L	T	P
UCHTC60319	Major	Physical Chemistry – II	4	4	3	1	0

Course Learning Outcomes (CLOs)

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

CLO-1: Understand the fundamentals of electrochemistry, chemical kinetics, and colloid & surface chemistry
CLO-2: Develop problem-solving ability in electrochemistry, kinetics, and surface chemistry
CLO-3: Recognize the role of multidisciplinary streams especially basic physics & mathematics along with the role of colloid & surface science knowledge in the development of chemistry
CLO-4: Apply the fundamental knowledge in electrochemistry, kinetics, and surface and colloid chemistry to existing and emerging problem in basic science
CLO-5: Demonstrate the ability to do some independent calculation and use some computational resources at the end of the course

Detailed Syllabus:

UNIT I-Kinetics-I: Basic Chemical Kinetics Molecularity, order and rate of reactions, Arrhenius theory - Complex reactions: reversible, pre-equilibrium, consecutive, chain and photochemical, oscillatory reactions, enzyme kinetics - Lindenmann's theory of uni-molecular

reactions - laser flash photolysis, femto second spectroscopy, flow techniques and relaxation methods. (**12 Hrs)**

UNIT II-Kinetics-II: Molecular reaction dynamics collision and activated complex theory, comparison of results with Eyring and Arrhenius equations - reactive collisions, molecular beam experiments, introduction to potential energy surfaces: treatment of H_2 + H reaction – ionic reactions, salt effect. (**12 Hrs)**

UNIT III-Surface & Colloid Chemistry: Surface phenomena Growth and structure of surface, surface defects, kinetics of surface adsorption: Langmuir and BET isotherms. Surface & interfaces, Surface characterisation techniques, colloid chemistry, Surfactants, Micelles, emulsion & gels, macromolecular films, surface films and surface Gibbs energy and isotherm, surface engineering and catalysis **(8 Hrs)**

UNIT IV-Electrochemistry-I: Equilibrium electrochemistry, Activities in electrolytic solutions, mean activity coefficient, Debye-Huckel treatment of dilute electrolyte solutions, origin of electrode potential, half-cell potential, electrochemical cell, Galvanic & electrolytic cells, Electrolysis, Nernst equation, thermodynamics of electrochemical cell**. (12 Hrs)**

UNIT V-Electrochemistry-II: Dynamic electrochemistry, Electrical double layer - electrode kinetics: rate of charge transfer, current density, Tafel equation, Butler-Volmer equation - introduction to polarography, Introduction to electrochemical techniques such as pulse, linear, differential voltammetery, cyclic voltammetry etc, Introduction to convective mass transfer system. Applied electrochemistry & energy science with introduction to batteries, fuel cells, electrochemical capacitors & solar cells. Introduction to corrosion. Inhibition of corrosion **(16 Hrs)**

Reference books:

1. K. J. Laidler, Chemical Kinetics, 3rd Edn., Harper International, 1987.
2. G. D. Billing & K. V. Mikkelson, Molecular dynamics and chemical kinetics, JohnWiley, 1996.
3. J. I. Sheinfield, J. S. Francisco, W. L. Hasse, Chemical kinetics & dynamics, Prentice Hall, 1998.
4. A. J. Bard & L. R. Faulkner, Electrochemical Methods, Fundamental and Applications, JohnWiley, 1980.
5. Bockris & Reddy, Electrochemistry, Vol. 1& 2, Plenum, 1973
6. H. V. Keer, Solid State Chemistry, Wiley Eastern, 1993.
7. A. K. Cheetam & P. Day, Solid State Chemistry Techniques, Oxford, 1987.
8. Arthur W. Adamson, Physical Chemistry of Surfaces, 6th Edition, Wiley India Pvt Ltd, 2011
9. Southampton Electrochemistry Group, Instrumental Methods in Electrochemistry, Woodhead Publishing, 2001

Semester-VI: Inorganic Chemistry laboratory Credits: 02

Code	Type	Title	Credits	Hours	L	T	P
UCHPC60320	Major	Inorganic Chemistry Laboratory	2	4	0	0	4

Course Learning Outcomes (CLOs)

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

CLO-1: Understand the safety and precautionary measures in handling chemicals.
CLO-2: Demonstrate the rudimentary principle related to inorganic synthesis
CLO-3: Synthesize the given list of compounds using standard procedure in a pure form.
CLO-4: Analyze compounds using various analytical techniques and arrive at the conclusion of the correct chemical structure.
CLO-5: Design and synthesize either the same compound by different synthetic strategy or a new compound.

S.No	Practical (Any 8-10 of the following experiments will be conducted)
1	Preparation of cobalt ammine complexes $[Co(NH_3)_6]Cl_3$, $[Co(NH_3)_5Cl]Cl_2$, $[Co(NH_3)_4Cl_2]Cl$.
2	Preparation of *cis* and *trans* –bis(glycinato) copper (II) monohydrate Determination of percentage weight of copper in $[Cu(glycinato)_2].H_2O$.
3	Preparation of tris(ethylenediamine)cobalt(III) chloride, $[Co(en)_3]Cl_3$.
4	Preparation of tris(ethylenediamine)nickel(II)chloride dihydrate$[Ni(en)_3]Cl_2$. $2H_2O$ and Dichlorobis(ethylenediamine)nickel(II) dihydrate$[Ni(en)_2Cl_2]$. $2H_2O$ from $[Ni(en)_3]Cl_2$. $2H_2O$.
5	Preparation of lanthanum hexacyanoferrate (III) pentahydrate, $La[Fe(CN)_6].5H_2O$. Calculating the percentage of $[Fe(CN)_6]^{3-}$
6	Estimation of iodine in iodised common salt using Iodometry.
7	Colorimetry: Simultaneous determination of chromium and manganese in a solution by visible spectroscopy.
8	Analysis of Brass (Gravimetric and Volumetric).
9-12	Qualitative analysis of binary mixture (Group analysis of Cations and Anions along with less common metals).

13	Preparation of Silicon based linear and cyclic polysiloxane polymers and its characterization by Infrared spectra.
14	Preparation and characterization of Ferrocene
15	Preparation and characterization of tris(acetylacetonato) aluminum(III)

Reference books:

1. Text book of Quantitative Analysis, A.I. Vogel 4thedn (1992)
2. Electronic Spectroscopy by A.B. P. Lever.
3. Inorganic Synthesis (Vol. Series)

Semester-VI: Physical Chemistry laboratory ***Credits: 02***

Code	Type	Title	Credits	Hours	L	T	P
UCHPC60321	Major	Physical Chemistry Laboratory	2	4	0	0	4

Course Learning Outcomes (CLOs)

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

CLO-1: Understand the fundamentals of doing experimental physical chemistry
CLO-2: Develop problem-solving & troubleshooting ability in experimental physical chemistry
CLO-3: Recognize the role of multidisciplinary streams starting with basic science to understanding the key role of instruments in doing experimental physical chemistry
CLO-4: Apply the fundamental knowledge in experimental physical chemistry to existing and emerging problem in basic science
CLO-5: Demonstrate the ability to do some independent calculation and use some computational resources at the end of the course

Detailed Syllabus:

(Any 8-10 of the following experiments will be conducted)

S.No	Practical
I	**Potentiometric Titration (Electrodics)** 1. Determination of standard redox potential of standard redox couple. 2. Potentiometric titration of Zn^{2+} or Cd^{2+} or Pb^{2+} with potassium ferrocyanide

	and determination of composition of Zn(II) or Cd(II) or Pb(II) -ferrocyanide complex (three different experiments as the metal ion only changed). 3. Potentiometric titration of mixture of halides. 4. Determination of standard reduction potential of quinhydrone electrode. 5. Potentiometric titration of mixture of acids (strong & weak) with strong base. 6. Redox-titration: Determination of concentration of reductant or oxidant by potentiometric method.
II.	**Conductometric Titration (Ionics)** 1. Solubility product of sparingly soluble salt by conductance measurements. 2. Determination of Equilibrium constant & equivalent conductance at infinite dilution of a weak electrolyte. 3. Determination of equivalent conductance at infinite dilution of strong electrolyte. 4. Verification of Ostwald's dilution law. 5. Conductometric determination of mixture of acids using strong electrolyte. 6. Conductometric determination of critical micelle concentration of any given surfactant. 7. Verification of Kohlrausch Law
III	**Chemical Kinetics** 1. Saponification of ethyl or methyl acetate using conductometric methods a) Determination of rate constant & order of reaction with respect to reactants b) Influence of ionic strength on the rate constant (Salt effect) c) Effect of Temperature on rate constant (Arrhenius Equation) (This practical is equivalent to three different experiments). 2. Kinetics of iodination of acetone by spectrophotometry or by colorimetry method a)Acetone effect; b)Iodine effect; c)Acid effect (This practical is also can be split into at least two separate experiments). 3. Kinetics of alkaline hydrolysis of dye such as crystal violet or similar such compounds by spectrophotometry or colorimetry method. 4. Determination of rate constant of Inversion of sucrose by polarimeter & verification of the effect of catalyst on the rate constant. 5. Kinetics of catalytic decomposition of hydrogen peroxide.
IV	**Thermodynamics, Phase rule, Surface & Colloid Chemistry** 1. Vapour pressure measurements and enthalpy of vaporisation of solvent such as water. 2. Heat of neutralisation of a strong acid by a strong base. 3. Adsorption of acetic acid or iodine on charcoal. 4. Critical micelle concentration of given surfactant by surface tension measurements. 5. Three component liquid system (acetic acid, benzene, water). 6. Two component simple eutectic system (Examples: o-nitrophenol & naphthalene, acetamide & Benzoic acid, p-nitrotoluene & diphenylamine etc.). Determination of dimerization constant of benzoic acid in organic medium.

V	**Miscellaneous experiments (pH, Colorimetry etc.)** 1. Determination of Composition & stability constant of given complex such as Fe (III)- Salicylic acid complex by Job's method using colorimetry. 2. Verification of Beer-Lambert's law & determination of concentration of unknown solution. 3. Determination of ionic product of water by pH metric method. 4. Determination of hydrolytic constant of given salts such as ammonium chloride by pH metric method. 5. Determination of pKa of dibasic or tribasic acids by pH-metric methods. 6. Determination of strength of individual acids (E.g. HCl & acetic acid) in a mixture by pH metric method.

Reference books:

1. Viswanathany, B., Raghavan, P.S., Practical Physical Chemistry, Viva Books Private Ltd, 2012
2. Maity, S.K., Ghosh, N.K., Physical Chemistry Practicals, New Central Book Agency Ltd, 2012
3. A.Findlay, Practical Physical Chemistry (Longmans, Green and Co).
4. J.M.Wilson, K.J.Newcombe, A.R.Denko, R.M.W.Richett, Experiments in Physical Chemistry, (Pergamon Press).
5. Garland, C.W., Nibler, J.W., Shoemaker, D.P., Experiments in Physical Chemistry, McGraw-Hill Higher Education, 8th Edition, 2009

Semester-VI:* Bio-inorganic *Chemistry ***Credits: 02***

Code	Type	Title	Credits	Hours	L	T	P
UCHTC60322	Major	Bio-inorganic Chemistry	2	2	2	0	0

Course Learning Outcomes (CLOs)

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

CLO-1: Explain the role of metal ions in biological systems and biochemical reactions.
CLO-2: Outline the effects of functional groups of biomolecules on metal-mediated biological reactions.

Detailed Syllabus:

UNIT I: Bioinorganic chemistry I: Occurrence of elements, specific ligands, and coordination sites in biomolecules. Metal homeostasis in biology: Transport and storage of K^+,

Ca^{2+} Iron and copper. Dioxygen transport and storage: haemoglobin, myoglobin, hemerythrin and hemocyanine and their electronic structural properties. Synthetic oxygen carrier and model systems. Electron Transfer protein and photosynthesis: Cytochromes, Fe-S Clusters and blue-copper, metal in photosystems I and II. Enzymes and its classifications. The role of metallo enzymes: peroxidase, catalse and cytochrome P-450, superoxide dismutase and carboxypeptidase A, carbonic anhydrase, vitamin B12 and nitrogenase. Medicinal bioinorganic chemistry. **(30 Hrs)**

Reference books:

1. S. J. Lippard, J. M. Berg, *Principles of Bioinorganic Chemistry*, University Science Books. 1994.
2. I. Bertini, H. B. Gray, S. J. Lippard, J. A. Valentine, *Bioinorganic Chemistry,* University Science Books. 1994.
3. A. K. Das, *Bioinorganic Chemistry*, Books & Allied Limited. 2013.
4. W. Kaim.; *Bioinorgnic Chemistry*, 2nd Edition, John Wiley. 2013.
5. R. M. Roat-Malone, *Bioinorganic Chemistry*, John Wiley, 2002.

Semester-VII — No. of credits = 20

SEMESTER-VII							
S.No.	**Category of Course**	**Course Code**	**Course Title**	**Hours**			**Credits**
				L	**T**	**P**	
1	Major	UCHTC70423	Molecular Spectroscopy	3	1	0	4
2	Major	UCHTC70424	Chemical Applications of Group Theory	2	0	0	2
3	Major	UCHTC70425	Spectroscopic Identification of Organic Compounds	3	1	0	4
4	Major	UCHPC70426	Instrumentation and Structure Elucidation Laboratory	0	0	4	2
5	Minor		Physics / Mathematics / Life Science	3	1	0	4
6	Minor		Physics / Mathematics / Life Science	3	1	0	4
Total				14	4	4	**20**

Semester-VII: Molecular Spectroscopy ***Credits: 04***

Code	Type	Title	Credits	Hours	L	T	P
UCHTC70423	Major	Molecular Spectroscopy	4	4	3	1	0

Course Learning Outcomes (CLOs)

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

CLO-1: Understand the basic principles of light-matter interactions and learn quantum mechanical methods to analyze the interactions
CLO-2: Apply selection rules in microwave, infrared, Raman, UV-Vis spectroscopy/ Rotational, Vibrational & Electronic spectroscopy
CLO-3: Describe the principles of ESCA, PES, AUGER, NMR, EPR, Mossbauer spectroscopy and NQR.
CLO-4: Differentiate various resonance techniques used in the analysis of molecules.
CLO-5: Apply the fundamental knowledge of molecular spectroscopy to existing and an emerging problem in basic science

Detailed Syllabus:

UNIT I-Rotational, Vibrational & Electronic spectroscopy: Electromagnetic radiation, interaction of electromagnetic radiation with matter, quantum mechanical approach - transition probabilities: Einstein coefficients - pure vibrational and rotational spectra, selection rules, vibrational and rotational spectra of polyatomic molecules, normal modes, anharmonicity, selection rules – Raman effect: classical and quantum theory of Raman effect, rotational and vibrational Raman spectra. Franck-Condon principle, Electronic Spectra of atoms/molecules, Born- Oppenheimer Approximation, Rotational fine structures Fortrat Diagram, Pre-dissociation, Transition moments, assignment of electronic transitions of N2, H2O and formaldehyde using group theory, solvent effect, ESCA, PES, AUGER techniques. **(30 Hrs)**

UNIT II-Introduction to NMR:-Origin of magnetic moments in matter, electronic and nuclear moments, interaction with magnetic field, Larmor equation - conditions for magnetic resonance absorption, relaxation times, line widths and line shapes, ring currents, diamagnetic anisotropy, spin-spin splitting, high resolution NMR spectra of simple molecules, first and second order treatment of AB systems - FT techniques. **(15 Hrs)**

UNIT III-Other Resonance Spectroscopy Methods:- NMR of ^{1}H, ^{11}B, ^{19}F, ^{31}P and other active nuclei. NMR of simple molecules and metal complexes. NMR of paramagnetic complexes- Contact shifts. Electron paramagnetic resonance (EPR): Hyperfine splitting, g value, ESR of organic free radicals, zero-field splitting and Kramer's degeneracy, Line widths in Solid state EPR. The principles of Mossbauer spectroscopy. Origin of isomer shifts, quadrupole splitting and h. f. s. Nuclear quadrapole resonance (NQR). **(15 Hrs)**

Reference books:

1. P. W. Atkins, *Physical Chemistry*, Oxford, London, 7th edition, 2006.

2. D. L. Pavia, G. M. Lampman and G. S. Kriz, *Introduction to Spectroscopy*, 2nd Edn, Saunders
3. C. N. Banwell, *Fundamentals of Molecular Spectroscopy*, 4th Edition Tata McGraw Hill, 2016.
4. Carrington and Machlachlon, *Magnetic Resonance*, Harper & Row, 1967.
5. G. M. Barrow, *Introduction to Molecular Spectroscopy*, McGraw Hill, 1964.
6. D. H. Williams and I. Fleming, *Spectroscopic methods in organic chemistry*, Tata McGraw Hill, 1998.
7. J. Micheal Hollas, *Modern Spectroscopy*, 4th Edition, Wiley India Pvt Ltd, 2010
8. Harald Gunther, *NMR Spectroscopy: Basic Principles, Concepts and Applications in Chemistry*, 2nd Edition, Wiley India Pvt Ltd, 2010
9. R. S. Drago, Physical methods in Inorganic chemistry, 1st Edition. Affiliated East-West Press, 2012.
10. M. T. Weller, N. A. Young. *Characterization methods in inorganic chemistry*, Oxford University press, 2017.
11. J.Micheal Hollas, Basic Atomic and Molecular Spectroscopy: (Tutorial Chemistry Texts), Royal Society of Chemistry, 2002
12. D.N.Sathyanarayana, Vibrational Spectroscopy: Theory and Applications, New Age International, 2005

Semester-VII: Chemical applications of Group Theory Credits: 02

Code	Type	Title	Credits	Hours	L	T	P
UCHTC70424	Major	Chemical applications of Group Theory	2	2	2	0	0

Course Learning Outcomes (CLOs)

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

CLO-1: Understand the basic concepts of symmetry and its mathematical expression.
CLO-2: Apply these mathematical notations into objects and molecules.
CLO-3: Analyze infrared, Raman, and electronic spectra of simple molecules.
CLO-4: Understand orbital symmetry and energy levels and in the conjugated alkenes.
CLO-5: Apply the knowledge of group theory into different fields such as asymmetric synthesis, spectroscopy, photochemistry, crystallography, and even to other branches of science like physics and biology.

Detailed Syllabus:

UNIT-I: Group Theory: Groups, sub-groups, classes and their properties, postulates of group, construction of group multiplication table, symmetry elements and operations, general relations among symmetry elements and operations, molecular symmetry and point groups, matrix representation of symmetry elements, representation of groups, character, reducible and

irreducible representations, Great Orthogonality theorem, properties of irreducible representations, Mulliken's symbols for irreducible representations, character tables. **(15 Hrs)**

UNIT- II: Applications of Group Theory:

Group theory & quantum mechanics, wave functions as basis for irreducible representations, direct products, time dependent perturbation theory; Symmetry-adapted linear combinations (SALC); linear combination of atomic orbitals (LCAO), application of LCAO in conjugated system and MO diagram of octahedral and tetrahedral molecules.

Vibrational and electronic spectroscopy for Inorganic compounds: Normal Mode analyses *and its applications in* IR and Raman spectroscopy. Selection rules, spectral transition probability, vibronic coupling, electronic spectra of metal complexes. **(15 Hrs)**

Reference books:

1. F. A. Cotton. *Chemical applications of group theory*, 3rd edition, Wiley India edition, 2003.
2. R. L. Carter, Molecular Symmetry and Group Theory, Wiley India, 2004.
3. K. Veera Reddy, *Symmetry and spectroscopy of molecules*, 2nd edition, New Age International Publishers, 2009.
4. B. S. Garg, *Chemical applications of molecular symmetry and group theory*, 1st edition, Macmillan Publishers Indian Ltd , 2012.
5. Mark Ladd, Symmetry of Crystals and Molecules, Oxford University Press, 2014
6. L. H. Hall, Group Theory and Symmetry in Chemistry, McGraw Hill Book Company, 1969

Semester-VII: Spectroscopic Identification of Organic Compounds Credits: 04

Code	Type	Title	Credits	Hours	L	T	P
UCHTC70425	Major	Spectroscopic Identification of Organic Compounds	4	4	3	1	0

Course Learning Outcomes (CLOs)

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

CLO-1: Describe the applications of UV-Visible spectroscopy in the identification of conjugation in organic compounds

CLO-2: Apply IR spectroscopy to identify the various functional groups in organic molecules

CLO-3: Evaluate the structure of organic compounds using ^{1}H, ^{13}C, and 2D-NMR spectroscopy

CLO-4: Describe the basic principles and applications of organic-mass spectrometry.

CLO-5: Apply UV-Visible, IR, NMR, and mass spectrometry in structure elucidation of organic compounds.

Detailed Syllabus:

UNIT-I: Introduction to spectroscopic techniques: Structure elucidation. Application of UV – Visible and IR spectroscopy to organic structure elucidation. Electromagnetic spectrum, absorption of energy by organic compounds, types of spectroscopic methods to organic structure elucidation. Woodward – Fisher rules, Octant rule, Application of ORD – CD to stereochemical assignments. Organic functional group identification through IR spectroscopy. **(16 Hrs)**

UNIT-II: Application of NMR Spectroscopy. Basic principles. Introduction to NMR techniques. CW and FT NMR techniques. ^{1}H NMR Spectral parameters – intensity, chemical shift, multiplicity, coupling constant. Analysis of first order and second - order spectra. Structure determination of organic compounds by ^{1}H NMR spectra. **(16 Hrs)**

UNIT-III: Multinuclear ^{1}H NMR &^{13}C NMR: Proton coupled, off resonance decoupled, proton noise decoupled ^{13}C NMR spectra. Assignment of chemical shifts, additively effect, characteristic chemical shifts of common organic compounds and functional groups, DEPT & SEFT spectra. 2D NMR techniques ^{1}H – ^{1}H COSY, ^{1}H – ^{13}C COSY – HMBC, and NOESY. **(12 Hrs)**

UNIT-IV: Application of mass spectrometry: Basic principles, mass analyzers, ionization methods: EI, PI, CI, FAB, MALDI, ES. Liquid chromatography and mass spectrometry, types of ions and fragmentations, even electron rule, nitrogen rule, isotope abundance, McLafferty rearrangement.

Organic structure elucidation, techniques of ion production, ion and daughter ions, molecular ion and isotope abundance. Nitrogen rule energetics of fragmentation, metastable ions, common fragmentation pathways, fragmentation pattern of common chemical classes. Illustrative examples from macromolecules and supramolecules. **(20 Hrs)**

Reference books:

1. R. M. Silverstein and F. X. Webster, Spectrometric identification of organic compounds, 6thEdn, Wiley.
2. W. Kemp, Organic Spectroscopy, 3rdEdn., MacMillon, 1994.
3. Pavia, Lampman and Kriz, Introduction to Spectroscopy, 3rdEdn., Brooks/Cole.
4. D. H Williams and Ian Fleming, Spectroscopic methods in organic chemistry, Tata McGraw Hill,1998.
5. W. Kemp, Introduction to multinuclear NMR.
6. P. S. Kalsi, Spectroscopy of Organic Compounds, 6th edition, New age international, 2004.

Semester-VII: Instrumentation and Structure Elucidation Laboratory Credits: 02

Code	Type	Title	Credits	Hours	L	T	P
UCHPC70426	Major	Instrumentation and Structure Elucidation Laboratory	2	4	0	0	4

Course Learning Outcomes (CLOs)

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

CLO-1: Employ sophisticated instruments to study the chemical compounds
CLO-2: Develop critical thinking and orientation towards research projects.
CLO-3: Develop skills to interpret spectroscopic data & confirm the structure of molecule

Unit-I: Instrumentation: Hands-on experience of advanced instruments such as UV-visible Spectrophotometer, FT-IR Spectrometer, polarimeter, RP-HPLC, MPLC, Electrochemical work-station, Raman spectrometer, Lyophilizer, Fluorescence Spectrometer, Photochemical reactor. basic instruments such as rotary evaporator, pH meter, Melting-point apparatus, Vacuum oven and Furnace.

Unit-II: Combined Spectroscopy Spectral elucidation: Students will be trained for the structure elucidation of molecules based on IR, NMR, ^{13}C NMR, Mass spectrum data. 2D NMR data interpretation in solving the structures also will be trained.

Semester-VIII — No. of credits = 20

SEMESTER-VIII							
S.No.	**Category of Course**	**Course Code**	**Course Title**	**Hours**			**Credits**
				L	**T**	**P**	
1	Major	UCHTC80427	Organometallic Chemistry	3	1	0	4
2	Major	UCHTC80428	Organic Chemistry-III	3	1	0	4
3	Research Project / Dissertation	UCHRC80401	Research Project	0	0	24	12
Total				6	2	24	**20**

Semester-VIII: Organometallic Chemistry ***Credits: 04***

Code	Type	Title	Credits	Hours	L	T	P
UCHTC80427	Major	Organometallic Chemistry	4	4	3	1	0

Course Learning Outcomes (CLOs)

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

CLO-1: Understand the basics of Organometallic (OM) chemistry. Illustrate organometallic complexes with phosphines, carbenes, alkyl, alkene, and alkyne as ligands.
CLO-2: Evaluate Pi-Conjugated systems as ligands, synthesis, and reactivity of metallocenes,fluxionality and dynamic NMR.
CLO-3: Explain the structure, bonding, reactivity, and spectral study of metal carbonyls, carbonyl clusters and isolobal analogy.
CLO-4: Devise special reactions of organometallic chemistry: Oxidative addition, reductive elimination and migratory insertion.
CLO-5: Design the catalytic cycles, mechanistic studies and apply metal-catalyzed reactions for industrial applications.

Detailed Syllabus:

UNIT I-Organometallic Chemistry 1: Introduction, history, classification of ligands, 18-electron rule, metal carbonyls: synthesis, structure, π- bonding and infrared spectroscopy and reactions of metal carbonyls. Organometallic complexes (OMCs) with alkyl group, alkene and alkyne as ligands, synthesis, reactions and bonding models. OMC of neutral spectator ligands: phosphines, multidentate phosphines, chiral phosphines and NHCs. **(20Hrs)**

UNIT II-Organometallic Chemistry 2: Brief about organometallic compounds of ***s***-and ***p***-block elements. Complexes containing η^5- cyclopentadienyl ligands: ferrocene and other metallocenes: structure, bonding and reactions. OMCs containing η^{4-}- η^6- η^7- and η^8 ligands. Multinuclear carbonyl clusters, metal-metal bond, Mingo's rules, isolobal analogy. Hydride, dihydrogen complexes and fluxionality. (**15 Hrs**)

UNIT III-Unique reactions of Organometallic Complexes: Oxidative addition, reductive elimination, β- hydride elimination, α- hydrogen abstraction and migratory insertion. **(5 Hrs)**

UNIT IV-Catalysis: Homogeneous and Heterogeneous catalysis. Olefin hydrogenation: Wilkinson catalyst, iridium and ruthenium-based catalysts, directing effects in hydrogenation and asymmetric hydrogenation. hydrocyanation and hydrosilylation of alkenes. Hydroformylation: cobalt catalysts, rhodium-phosphine catalysts, *n*/*iso* ratio of products, enantioselective hydroformylation. Monsanto acetic acid process, Cativa and Wacker processes. metathesis: Grubb's and Schrock Catalysts, ring opening metathesis (ROM), ring closing metathesis (RCM), enyne metathesis (EM). Olefin polymerization: Ziegler-Natta and metallocene based catalysts. Coupling reactions: Industrial applications, different catalysts for coupling. Suzuki-Miyaura, Heck, Sonogashira, Stille, Kumada, Negishi, Hiyama and Buchwald-Hartwig C-N cross coupling reactions. **(20 Hrs)**

Reference Books:

1. R. H. Crabtree, *The organometallic chemistry of transition metals*, 7th Edn. Wiley, 2019.
2. Ch.Elsenbroich, A. Salzar, *Organanometallics*, 2nd Edn, VCH Publishers Inc, NY, 1992.
3. B. D. Gupta, A. J. Elias, *Basic Organometallic chemistry*, 2nd Edn, University Press, 2013.
4. J. E. Huheey, E. A. Keiter & R. L. Keiter, *Inorganic Chemistry: Principles of Structure and Reactivity*, Pearson Education, 4th Edn. 1992.
5. R. Whyman, *Applied organometallic chemistry and catalysis*, Oxford University Press, 2001.
6. C. E. Housecraft and A. G. Sharpe, *Inorganic Chemistry*, Pearson, 5th Edn. 2018.
7. J. P. Collman, L.S. Hegedus, J. R. Norton, R. G. Finke, P*rinciples and applications of organotransition metal chemistry*, University Science Books, 1987.
8. K. F. Purcell and J. C. Kotz, *Inorganic chemistry*, W.B. Saunders Company,1977.

Semester-VIII: Organic Chemistry ***Credits: 04***

Code	Type	Title	Credits	Hours	L	T	P
UCHTC80428	Major	Organic Chemistry-III	4	4	3	1	0

Course Learning Outcomes (CLOs)

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

CLO-1: Summarize photochemical intermediates involved in organic reactions.
CLO-2: Develop organic synthetic strategies using the disconnection approach.
CLO-3: Assess the reactivity patterns of enolates and their mechanisms
CLO-4: Synthesis of heterocyclic compounds with mono and di heteroatoms.
CLO-5: Write the synthetic schemes based on photochemistry, enolates, and heterocyclics.

UNIT-I: Photochemistry: Franck-Condon principle, Jablonski diagram, fluorescence and phosphorescence, Singlet and triplet states, Photosensitization, Quantum efficiency, Photochemistry of carbonyl compounds, Norrish type-I and type-II cleavages, Paterno-Buchi reaction, Photoreduction, Photochemistry of enones and para-benzoquinones, Di π – methane rearrangement, Photodynamic therapy, Photochemical [4+2] cycloaddition using singlet Oxygen; Barton reaction. **(16 Hrs)**

UNIT-II: Synthetic strategies: Synthon, Synthetic equivalent, Functional group interconversion (FGI), Functional group addition, Functional group elimination. Criteria for selection of target; Linear and convergent synthesis; Retrosynthetic analysis and synthesis involving chemo selectivity, regioselectivity, reversal of polarity and cyclizations; Criteria for disconnection of strategic bonds; One group and two group C-X disconnections in 1,2-, 1,3-, 1,4- difunctional compounds. Protection and deprotection of functional groups in synthetic

strategy: Protection of alcohols by silyl ethers and ester formations and their deprotection; Protection of 1, 2 diols- by acetal, ketal and their deprotection. **(18 Hrs)**

UNIT-III: Enolate of carbonyl compounds: Kinetic and thermodynamic control, Potential energy diagrams, methods of determining mechanisms, isotopes effects, region and stereo-selective reactions. Enolates: Regio- and stereo-selectivity in enolate generation. "O" versus "C" alkylation, Effect of solvent, Counter cation and Electrophiles; Symbiotic effect; Thermodynamically and kinetically controlled enolate formations; Various transition state models to explain stereoselective enolate formation; Enamines; Regioselectivity in generation, Application in controlling the selectivity of alkylation. **(12 Hrs)**

UNIT-IV: Heterocycles in Chemistry: Introduction to heterocycles; Nomenclature; Single heteroatom heterocycles Furan, pyrrole, thiophene, indole, pyridine, quinoline, isoquinoline synthesis, reactivities and application. Synthesis and reaction of five membered heterocycles containing two heteroatoms, imidazole, oxazole, thiazole; Benzo-fused five-membered and six membered heterocycles. **(14 Hrs)**

Reference books:

1. Finar, I.L. (2006). *Organic Chemistry: Stereochemistry and the Chemistry of Natural Products.* Dorling Kindersley Pvt. Ltd., 6th edition, India.
2. McMurry J., *Organic Chemistry***,** Asian Book Pvt. Ltd, 8th edition, New Delhi.
3. Morrison, R.T., Boyd, R.N. (2011). *Organic Chemistry*, Prentice- Hall of India, 6th edition, New Delhi.
4. Clayden,J.;Greeves,N.;Warren,S., (2012). *Organic Chemistry*, Oxford University press, 2nd edition.
5. Warren S.; Wyatt, P. (2008). *Organic Synthesis The Disconnection Approach*, Wiley 2nd edition.
6. Coyle, J. D. (1991), *Introduction to organic photochemistry*, Wiley.
7. Halton, B.; Coxon J. M. (2011), *Organic Photochemistry*, Cambridge University Press.
8. Smith, M. B.; March, J. (2007), *March's Advanced Organic Chemistry*, Wiley 6th edition.

Semester-VIII: Research Project ***Credits: 12***

Code	Type	Title	Credits	Hours	L	T	P
UCHRC80401	Research Project/ Dissertation	Research Project	12	24	0	0	24

Detailed Syllabus:

Individual faculty members will float a stipulated number of projects. Students have to consult respective faculty members and select projects. More than one student can work under a single

project based on the nature of the project. Guide allotment for the MSc project will be based on choice cum merit.

Once guide allotment (either single or more than one guide) is declared, the student has to submit a research proposal either individually or one member from the group. Students will be periodically assessed for their project work by the individual faculty member or group of faculty members and 40% internal marks will be credited for this continuous assessment.

The final submission of the research project i.e. small thesis, presentation, and comprehensive viva carries 60% marks.

Note:

1. Student should submit 3 copies of the final research project copy in hard binding format with all declarations and signatures.
2. For referencing any ACS journal pattern should be followed.

Syllabus of Minor Courses offered by Department of Chemistry to Other Departments

SYLLABUS

Semester-I

SEMESTER-I							
S.No.	Category of Course	Course Code	Course Title	Hours			Credits
				L	T	P	
1	Minor	UCHTM20101	Introduction of Chemistry-I	3	1	0	4
2	Minor	UCHPM20102	Introduction to Inorganic Chemistry Laboratory	0	0	4	2

Semester-I: Introduction of Chemistry-I Credits: 04

Code	Type	Title	Credits	Hours	L	T	P
UCHTM10101	Minor	Introduction of Chemistry-I	4	4	3	1	0

Course Learning Outcomes (CLOs)

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

CLO-1: Understand the Atomic theory and its evolution. Learning scientific theory of atoms, concept of wave function.
CLO-2: Understand the structure, bonding, to predict the atomic structure, chemical bonding, and molecular geometry based on accepted models.
CLO-3: Basic of organic molecules, structure, bonding, reactivity and reaction mechanisms.
CLO-4: Stereochemistry of organic molecules – conformation and configuration, asymmetric molecules and nomenclature.
CLO-5: Mechanism of organic reactions (effect of nucleophile/leaving group, solvent), substitution *vs*. elimination.
CLO-6: Understand introductory Inorganic Chemistry practicals on qualitative analysis.

Detailed Syllabus:

Unit-1: Atomic Structure:

Fundamental particles, Bohr's theory and its limitations, dual behaviour of matter and radiation, de Broglie's relation, Heisenberg Uncertainty principle. Hydrogen atom spectra. *Quantum mechanics*: Time independent Schrodinger equation and meaning of various terms in it. Significance of ψ, Schrödinger equation for hydrogen atom. Radial and angular parts of the hydrogenic wave functions (atomic orbitals) and their variations for 1s, 2s, 2p, 3s, 3p and 3d orbitals (Only graphical representation). Radial and angular nodes and their significance. Radial distribution functions and the concept of the most probable distance. Quantum numbers,

the Hund's rule, Pauli's exclusive principle, Aufbau s rule and their limitations, Electronic configurations of the atoms and simple homonuclear diatomic molecules. Stability of half-filled and completely filled orbitals, concept of exchange energy. Relative energies of atomic orbitals, Anomalous electronic configurations. **(15 Hrs)**

Unit-2: Chemical Bonding and Molecular Structure:

Ionic Bonding: General characteristics of ionic bonding. Energy considerations in ionic bonding. polarizing power and polarizability. Fajan's rules, ionic character in covalent compounds, bond moment, dipole moment and percentage ionic character. *Covalent bonding*: VB Approach: Shapes of some inorganic molecules and ions on the basis of VSEPR and hybridization with suitable examples. Concept of resonance and resonating structures in various inorganic and organic compounds. *MO Approach*: Rules for the LCAO method, bonding and antibonding MOs and their characteristics for s-s, s-p and p-p combinations of atomic orbitals, MO treatment of homonuclear diatomic molecules of 1^{st} and 2^{nd} periods (including idea of s-p mixing) and heteronuclear diatomic molecules such as CO, NO and NO^{+}. Comparison of VB and MO approaches. Concept of HOMO and LUMO. **(15 Hrs)**

Unit-3: Fundamentals of Organic Chemistry

Physical Effects, Electronic Displacements: Inductive Effect, Electrometric Effect, Resonance and Hyper conjugation and application in acidity and basicity of organic compounds. Cleavage of Bonds: Homolysis and Heterolysis. Comparative study with emphasis on factors affecting pKa values. Intermediates in reaction: Generation, structure stability and formation of carbocation, carbanion, non-classical carbocation, free radicals, carbenes and nitrenes. Aromaticity: Criteria of aromatic (Hückel's rule), benzenoid & non benzenoid compounds, antiaromatic & homoaromatic compounds, aromatic ring currents. **(12 Hrs)**

Unit-4: Stereochemistry-I:

Influence of hybridization on structure of organic compounds. Projection formulae and interconversion, enantiomers, diastereomers, geometrical isomerism. Chirality. Configurational notations of simple molecules, DL and RS configurational notations, and E/Z notation. Conformational analysis of acyclic molecules and cyclohexane. **(9 Hrs)**

Unit-5: Alkenes & Alkynes: (Up to 5 Carbons) Preparation: Elimination reactions: Dehydration of alkenes and dehydrohalogenation of alkyl halides (Saytzeff's rule); The trans-addition (bromine), Addition of HX (Markownikoff's and anti-Markownikoff's addition), Hydration, Oxy mecuration- demercuration, Hydroboration-oxidation. Elimination vs substitutions, Conjugated and isolated dienes. Alkynes: (Up to 5 Carbons) Preparation: Acetylene from CaC_2 and conversion into higher alkynes; by dehalogenation of tetra halides and dehydrohalogenation of vicinal-dihalides. Reactions: formation of metal acetylides, addition of bromine and alkaline $KMnO_4$, ozonolysis and oxidation with hot alkaline. $KMnO_4$. **(9 Hrs)**

Suggested Books:

1. Lee, J.D., Concise Inorganic Chemistry, 5^{th} Ed., Blackwell Publishing, 2006.

2. Cotton, F.A., Wilkinson, G., Gaus, P. L., Basic Inorganic Chemistry, 3rd Ed., John Wiley and Sons Press, 1995.
3. Atkins, P., et al., Shriver and Atkins Inorganic Chemistry, 4th Ed., Oxford University Press, 2006.
4. Clayden, J. et al., Organic Chemistry, 2nd Ed., Oxford University Press, 2001.
5. Hornback, J. M., Organic Chemistry, 2nd Ed., Cengage Learning, 2006.
6. Solomons, T. W. G. and Fryhle, C. B., Organic Chemistry, 9th Ed. John Wiley and Sons, 2007.
7. Morrison, R. M. and Boyd, R. N., Organic Chemistry, 6th Ed., Pearson Education, 2008.
8. Sykes, P. A., A guide book to mechanism in organic chemistry, 6th Ed., Pearson India, 2008.

Semester-I: Introduction to Inorganic Chemistry Laboratory Credits: 02

Code	Type	Title	Credits	Hours	L	T	P
UCHPM10102	Minor	Introduction to Inorganic Chemistry Laboratory	2	4	0	0	4

Course Learning Outcomes (CLOs)

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

CLO-1: Develop knowledge on working principles of volumetric analysis.
CLO-2: Handle the glassware effectively and appropriately.
CLO-3: Estimate the unknown quantity of the analyte by choosing standard methods
CLO-4: Perform instrument handling, note book entry and calculations
CLO-5: Propose methods to analyze quantitatively commercial and environmental samples.

I. ACIDIMETRY

1. Estimation of Na_2CO_3 and $NaHCO_3$ mixture –Link HCl - standard Na_2CO_3
2. Estimation of HCl– Link NaOH -standard oxalic acid

II. PERMANGANOMETRY

3. Estimation of oxalic acid
4. Estimation of FAS

III. DICHROMETRY

5. Internal indicator method
6. External indicator method

IV. IODOMETRY

7. Estimation of potassium dichromate

V. COMPLEXOMETRY

8. Estimation of Zn^{2+}

9. Hardness of water- temporary and permanent

References:

1. V. Venkateswaran, R.Veerasamy, A.R.Kulandaivelu, Basic principles of practical Chemistry, 2nd Edt, Sultan Chand & sons publisher, 1997.
2. A. I. Vogel, "Quantitative Inorganic Analysis", ELBS, 3rd Edition, 1971

Semester-II

SEMESTER-II							
S.No.	**Category of Course**	**Course Code**	**Course Title**	**Hours**			**Credits**
				L	**T**	**P**	
1	Minor	UCHTM20103	Introduction of Chemistry-II	3	1	0	4
2	Minor	UCHPM20104	Introduction to Organic Chemistry Laboratory	0	0	4	2

Semester-II: Introduction of Chemistry-II ***Credits: 04***

Code	Type	Title	Credits	Hours	L	T	P
UCHTM20103	Minor	Introduction of Chemistry-II	4	4	3	1	0

Course Learning Outcomes (CLOs)

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

CLO-1: Understand the concept of Thermodynamics.
CLO-2: Understand the Le Chatelier's principle.
CLO-3: Understand the Hard and soft acids and bases
CLO-4: Familiarization about classes of organic compounds and their methods of preparation.
CLO-5: Mechanism of organic reactions (effect of nucleophile/leaving group, solvent), substitution *vs*. elimination.
CLO-6: Understand introductory Organic Chemistry practicals on qualitative analysis.

Detailed Syllabus:

Unit-1: Chemical Energetics

The Laws of Thermodynamics. Thermochemistry. Concept of standard state and standard enthalpies of formations, integral and differential enthalpies of solution and dilution. Calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data. Variation of enthalpy of a reaction with temperature – Kirchhoff's equation. Statement of Third Law of thermodynamics and calculation of absolute entropies of substances. **(10 Hrs)**

Unit-2: Chemical Equilibrium:

Free energy change in a chemical reaction. Thermodynamic derivation of the law of chemical equilibrium. Distinction between ΔG and ΔGo, Le Chatelier's principle. Relationships between Kp, Kc and Kx for reactions involving ideal gases **(10 Hrs)**

Unit-3: Ionic Equilibria:

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect. Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions. Solubility and solubility product of sparingly soluble salts – applications of solubility product principle. Acids and Bases: super acids, relative strengths of acids; acid-base neutralisation curves and indicators.

(10 Hrs)

Unit-4: Aromatic hydrocarbons: Preparation, Reactions of Benzene, Naphthalene and Anthracene. **(5 Hrs)**

Unit-5: Alkyl Halides (Upto 5 Carbons) Preparations, Reactions: Types of Nucleophilic Substitution (SN1, SN2 and SNi) reactions, SET mechanism. With stereochemical considerations, substrate structure, leaving groups, nucleophiles, ambident nucleophilic reactions, role of solvents tests for alkyl halides, organometallic compounds of Mg and Li – use in synthesis of organic chemistry.

Unit-6: Aryl Halides -Preparation: (Chloro, bromo and iodo-benzene case): from phenol, Sand Meyer & Gattermann reactions. Reactions (Chlorobenzene): Aromatic nucleophilic substitution (replacement by –OH group) and effect of nitro substituent. Benzyne Mechanism: KNH_2/NH_3 (or $NaNH_2/NH_3$). Reactivity and Relative strength of C-Halogen bond in alkyl, allyl, benzyl, vinyl and aryl halides. **(9 Hrs)**

Unit-7: Alcohols, Phenols and Ethers (Up to 5 Carbons)

Alcohols: Preparation: Preparation of 1^o, 2^o and 3^o alcohols: using Grignard reagent, Ester hydrolysis, Reduction of aldehydes, ketones, carboxylic acid and esters. Reactions: With sodium, HX (Lucas test), esterification, oxidation (with PCC, alk. $KMnO_4$, acidic dichromate, conc. HNO_3). Oppeneauer oxidation Diols: (Up to 6 Carbons) oxidation of diols.

Phenols: (Phenol case) Preparation: Cumene hydro peroxide method, from Diazonium salts. Reactions: Electrophilic substitution: Nitration, halogenation and sulphonation. Reimer-

Tiemann reaction, Gattermann-Koch reaction, Houben– Hoesch condensation, Schotten – Baumann reaction.

Ethers (aliphatic and aromatic): Preparations and Reactions **(16 Hrs)**

Suggested Books

1. Levine, I., Physical Chemistry, 6th Ed., McGraw Hill, 2009.
2. Atkins, P.W. and de Paula, J., Physical Chemistry, 9th Ed., Oxford Press, 2009.
3. Castellan, G.W., Physical Chemistry, 3rd Ed., Narosa Publishing House, 2004.
4. Puri, B. R, Sharma, L.R, Pathania, M.S., Principles of Physical Chemistry, Vishal Publishing Co., 47th Edition, 2020. 5. Clayden, J. et al., Organic Chemistry, 2nd Ed., Oxford University Press, 2001.
5. Clayden, J. et al., Organic Chemistry, 2nd Ed., Oxford University Press, 2001.
6. Hornback, J. M., Organic Chemistry, 2nd Ed., Cengage Learning, 2006.
7. Morrison, R. M. and Boyd, R. N., Organic Chemistry, 6th Ed., Pearson Education, 2008.
8. Smith, M. B. and March, J., Advanced Organic Chemistry, 6th Ed., John Wiley and Sons, 2007.
9. Carey, F. A, Sundberg, R. J., Advanced Organic Chemistry, Parts A and B, Springer, 2007.
10. Kapoor K. L., A Textbook of Physical Chemistry, Volume 1 to Volume 6, McGraw Hill Education (India) Private Limited, 2015

Semester-II: Introduction to Organic Chemistry Laboratory Credits: 02

Code	Type	Title	Credits	Hours	L	T	P
UCHPM20104	Minor	Introduction to Organic Chemistry Laboratory	2	4	0	0	4

Detailed Syllabus:

Organic Qualitative Analysis

1. Preliminary Tests: Colour, Odour, Solubility and Litmus Test
2. Detection of Elements: Detection of nitrogen, sulphur, halogens
3. Detection of Characteristic functional groups: Test for Aliphatic or aromatic, Test for unsaturation, Tests for Carbohydrates, aromatic amines, amides, aromatic acids, polyhydric phenols, aromatic acids, polyhydric phenols, sugars, aliphatic aldehydes, nitrophenols, aromatic amides, carboxylic acids, alcohols, phenols, salicylic acid, naphthol, aldehyde, ketone, glucose
4. Confirmation of functional groups:

(i)Acid amides containing $–CONH_2$

(ii) Amino compounds containing $–NH_2$ group (aliphatic and aromatic)

(iii) Anilides containing (-NHCOR) group

(iv) Nitro compounds containing $–NO_2$ group.

Confirmatory tests: Fehling's Test, Biuret Test, Sodalime Test

Confirmation of amines (Primary, Secondary and tertiary amines)

(a) Dye Test (b) Carbylamine test

Confirmation of Nitro group

(a) Mulliken and Barker reaction (b) Reduction Test

Functional group test for compounds containing carbon, hydrogen and halogen with or without oxygen---Confirmation of Chloro, Bromo and iodo ---Reaction with Silver nitrate.

Identification of compounds containing carbon, hydrogen and sulfur along with or without oxygen

Test for thiourea and sulphonamide.

Confirmatory tests for Carboxylic acids, Phenols, alcohols, aldehydes, ketones, esters, carbohydrates etc…

5. Preparation of solid derivatives

   Derivatives for carboxylic acid, Phenols, Alcohols, Esters, amides, Urea, Amines, Nitro compounds, aldehydes, ketones, thioureas, halogen compounds, carbohydrates.

Reference Books:

1. Svehla, G. Vogel's *Qualitative Inorganic Analysis*, Pearson Education, **2012**.
2. Mendham, J. Vogel's *Quantitative Chemical Analysis*, Pearson, **2009**.
3. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., *Textbook of Practical Organic Chemistry*, Prentice-Hall, 5th edition, **1996**.

Semester-III

SEMESTER-III							
S.No.	**Category of Course**	**Course Code**	**Course Title**	**Hours**			**Credits**
				L	**T**	**P**	
1	UCHTM30205	Minor	Introduction of Chemistry-III	3	1	0	4
2	UCHPM30206	Minor	Introduction to Physical Chemistry Laboratory	0	0	4	2

Semester-III: Introduction of Chemistry-III Credits: 04

Code	Type	Title	Credits	Hours	L	T	P
UCHTM30205	Minor	Introduction of Chemistry-III	4	4	3	1	0

Course Learning Outcomes (CLOs)

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

CLO-1: Understand theories/thermodynamics of ideal solutions. Understanding of Nernst distribution law and its applications, solvent extraction.
CLO-2: Understand the Derivation of Clausius – Clapeyron equation and its importance in phase equilibria.
CLO-3: Understand the fundamentals of conductance and it's application.
CLO-4: Understand the fundamentals of Electrochemistry and it's application.
CLO-5: Understand the different fundamental functional group making & transformation reactions.
CLO-6: Understand the introduction to amino acids & peptides.
CLO-7: Understand introductory Physical Chemistry practicals on kinetics, pH, equilibrium, etc..

Detailed Syllabus:

Unit-1: Solutions

Thermodynamics of ideal solutions: Ideal solutions and Raoult's law, deviations from Raoult's law – non-ideal solutions. Vapour pressure-composition and temperature composition curves of ideal and non-ideal solutions. Distillation of solutions. Lever rule. Azeotropes. Partial miscibility of liquids: Critical solution temperature; effect of impurity on partial miscibility of liquids. Immiscibility of liquids-Principle of steam distillation. Nernst distribution law and its applications, solvent extraction. Colligative properties, binary solutions. **(7 Hrs)**

Unit-2: Phase Equilibrium

Phases, components and degrees of freedom of a system, criteria of phase equilibrium. Gibbs Phase Ruleand its thermodynamic derivation. Derivation of Clausius – Clapeyron equation and its importance in phase equilibria. Phase diagrams of one-component systems (water and Sulphur) and two component systems involving eutectics, congruent and incongruent melting points (lead-silver, $FeCl_3$-H_2O andNa-K only). **(8 Hrs)**

Unit-3: Conductance

Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Kohlrausch law of independent migration of ions. Debye Huckel's theory. Transference number and itsexperimental determination using Hittorf and Moving boundary

methods. Ionic mobility. Applications of conductance measurements: determination of degree of ionization of weak electrolyte, solubility andsolubility products of sparingly soluble salts, ionic product of water, hydrolysis constant of a salt. Conductometric titrations (only acid-base). **(7 Hrs)**

Unit-4: Electrochemistry

Reversible and irreversible cells. Concept of EMF of a cell. Measurement of EMF of a cell. Nernst equation and its importance. Types of electrodes. Standard electrode potential. Electrochemical series. Thermodynamics of a reversible cell, calculation of thermodynamic properties: ΔG, ΔH and ΔS from EMF data. Calculation of equilibrium constant from EMF data. Concentration cells with transference and without transference. Liquid junction potential and salt bridge. pH determination using hydrogen electrode and quinhydrone electrode. Potentiometric titrations -qualitative treatment (acid-base and oxidation-reduction only)., redox reactions. **(8 Hrs)**

Unit-5: Aldehydes, Ketones & Carboxylic acids and their derivatives:

Carboxylic acids (aliphatic and aromatic) *Preparation*: acidic and alkaline hydrolysis of esters *Reactions*: Hell – Volhard Zelinsky reaction Carboxylic acid derivatives (aliphatic): (up to 5 carbons) Preparation: Acid chlorides, anhydrides, Esters and Amides from acids and their interconversion Reactions: comparative study of nucleophilicity of acyl derivatives. Reformatsky reaction, Perkin condensation **(14 Hrs)**

Unit-6: Amines and Diazonium Salts

Amines (Aliphatic and Aromatic): (Up to 5 carbons) *Preparation*: From alkyl halides, Gabriel's Phthalimide synthesis, and Hofmann Bromamide reaction. Hofmann elimination, Carbylamine test, Hinsberg test, with HNO_2, Schotten – Baumann Reaction. Electrophilic substitution (case aniline): nitration, bromination, sulphonation. Diazonium salts: *Preparation:* from aromatic amines.*Reactions:* conversion to benzene, phenol, dyes. **(6 Hrs)**

Unit-7: Amino Acids and Peptides

Preparation of Amino Acids: Strecker synthesis using Gabriel's phthalimide synthesis. Zwitterion, Isoelectric point and Electrophoresis. *Reactions of Amino acids*: ester of –COOH group, acetylation of $–NH_2$ group, complexation with Cu^{2+} ions,ninhydrin test. Overview of Primary, Secondary, Tertiary and Quaternary Structure of proteins. Determination of Primary structure of Peptides by degradation Edmann degradation (N-terminal) and C–terminal (thiohydantoin and with carboxypeptidase enzyme). Synthesis of simple peptides (upto dipeptides) by N-protection (t-butyloxycarbonyl and phthaloyl) & C-activating groups and Merrifield solid-phase synthesis. **(12 Hrs)**

Suggested Books

1. Puri, B. R, Sharma, L.R, Pathania, M.S., Principles of Physical Chemistry, Vishal Publishing Co., 47th Edition, **2020**
2. Physical chemistry by G. M. Barrow, Mc Graw Hill. NewYork
3. Introduction to Electrochemistry by Samuel Glass stone East West Press Pvt Ltd New Dehli

4. Bard, A.J. and Faulkner, L.R., *Electrochemical Methods: Fundamentals and Applications*, 2nd Ed., John Wiley & Sons, **2001**.
5. Bockris, J.O'M, Reddy, A.K.N, *Modern Electrochemistry Ionics: Volume 1*, 2nd Ed., Plenum Press, **1998**.
6. Clayden, J. et al., Organic Chemistry, 2nd Ed., Oxford University Press, 2001.
7. Smith, M. B. and March, J., Advanced Organic Chemistry, 6th Ed., John Wiley and Sons, 2007.
8. Carey, F. A. and Sundberg, R. J., Advanced Organic Chemistry, Part A and B, Springer, 2007.
9. Berg, J., Tymoczko, J. and Stryer, L., *Biochemistry*, 5th Ed., W. H. Freeman, **2002**.
10. Kapoor K. L., A Textbook of Physical Chemistry, Volume 1 to Volume 6, McGraw Hill Education (India) Private Limited, **2015**
11. Levine, I., Physical Chemistry, 6th Ed., McGraw Hill, 2009.
12. Atkins, P.W. and de Paula, J., Physical Chemistry, 9th Ed., Oxford Press, **2009.**
13. Castellan, G.W., Physical Chemistry, 3rd Ed., Narosa Publishing House, **2004.**

Semester-III: Introduction to Physical Chemistry Laboratory Credits: 02

Code	Type	Title	Credits	Hours	L	T	P
UCHPM30206	Minor	Introduction to Physical Chemistry Laboratory	2	4	0	0	4

Detailed Syllabus:

(Any 8-10 experiments will be carried out depending on the availability of resources)

I. Thermochemistry

1. Determination of heat capacity of calorimeter for different volumes.
2. Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
3. Determination of enthalpy of ionization of acetic acid.
4. Determination of integral enthalpy of solution of salts (KNO_3, NH_4Cl).
5. Determination of enthalpy of hydration of copper sulphate.
6. Study of the solubility of benzoic acid in water and determination of ΔH .

II. Ionic equilibria

1. Measurement of pH of different solutions like aerated drinks, fruit juices, shampoos and Soaps (use dilute solutions of soaps and shampoos to prevent damage to the glass Electrode) using pH- meter.
2. Preparation of buffer solutions:

   (i) Sodium acetate-acetic acid

   (ii) Ammonium chloride-ammonium hydroxide

   Measurement of the pH of buffer solutions and comparison of the values with theoretical values.

III. Distribution Law, Phase rule

4. Critical solution temperature of partially miscible liquid system
5. Two component simple eutectic systems
6. Determination of partition coefficient of given system between two immiscible liquids

IV. Conductance and Electrochemistry, Chemical Equilibrium

8. Determination of cell constant of a conductivity cell
9. Determination of molar conductance at infinite dilution for given electrolyte
10. Conductometric titration of given acid vs base
11. Redox titration
12. Determination of standard reduction potential of given electrode
13. Determination of pKa of given acids using pH method
14. Determination of ionic product of water at room temperature using pH metry

Any other suitable experiments from the theory subject taught in Semester 2 and Semester 3

Reference Books:

1. Svehla, G. Vogel's *Qualitative Inorganic Analysis*, Pearson Education, **2012**.
2. Mendham, J. Vogel's *Quantitative Chemical Analysis*, Pearson, **2009**.
3. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., *Textbook of Practical Organic Chemistry*, Prentice-Hall, 5th edition, **1996**.
4. Viswanathany, B., Raghavan, P.S., Practical Physical Chemistry, Viva Books Private Ltd, 2012
5. Maity, S.K., Ghosh, N.K., Physical Chemistry Practicals, New Central Book Agency Ltd, 2012
6. A.Findlay, Practical Physical Chemistry (Longmans, Green and Co).
7. J.M.Wilson, K.J.Newcombe, A.R.Denko, R.M.W.Richett, Experiments in Physical Chemistry, (Pergamon Press).
8. Garland, C.W., Nibler, J.W., Shoemaker, D.P., Experiments in Physical Chemistry, McGraw-Hill Higher Education, 8th Edition, 2009

Semester-IV — No. of credits = 20

SEMESTER-IV							
S.No.	**Category of Course**	**Course Code**	**Course Title**	**Hours**			**Credits**
				L	**T**	**P**	
1	Minor	UCHTM40207	Introduction to Chemistry-IV	3	1	0	4
2	Minor	UCHPM40208	Analytical Chemistry Laboratory	0	0	4	2
3	Minor	UCHPM40209	Inorganic Qualitative Analysis	2	0	0	2

4	Minor	UCHTM40210	Analytical Chemistry	2	0	0	2
5	Minor	UCHTM40211	Chemistry of Life	2	0	0	2

Semester-IV: Introduction to Chemistry-IV Credits: 04

Code	Type	Title	Credits	Hours	L	T	P
UCHTM40207	Minor	Introduction to Chemistry-IV	4	4	3	1	0

Course Learning Outcomes (CLOs)

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

CLO-1: Understand different acid base concept
CLO-2: Understand the general characteristics of alkali and alkaline earth metals
CLO-3: Understand the role of gases and different laws governing them.
CLO-4: Understand the fundamentals of Carbohydrate chemistry and it's utility in Organic Chemistry.
CLO-5: Understand the fundamentals of Polymer chemistry and its application.
CLO-6: Learn fundamental principles of Analytical Chemistry by different techniques like titration methods, purification methods etc..

Detailed Syllabus:

Unit -1: Acid-Base Concept

Arrhenius theory, Bronsted – Lowry theory, Lewis acid base theory, solvent system concept, levelling solvents, Lux flood theory, Usanovich definition, factors influencing relative strengths of acids and bases, HSAB principle and its applications. Physical properties of solvent, types of solvents and their general characteristics, protic solvents like H_2O, reaction in non-aqueous solvents with special reference to liquid NH_3 and liquid HF. **(10 Hrs)**

Unit -2: s- Block Chemistry

Hydrogen and its isotopes, reactive forms of hydrogen, nascent hydrogen, active hydrogen, ortho and parahydrogen. Alkali and alkaline earth metals, General characteristics, electronegativity, ionisation energy, electropositive character, reducing properties, flame colour, hydration energy, lattice energy and solubility of salts. **(10 Hrs)**

Unit-3: Kinetic Theory of Gases

Postulates of Kinetic Theory of Gases and derivation of the kinetic gas equation. Deviation of real gasesfrom ideal behaviour, compressibility factor, causes of deviation. Van der Waals equation of state for real Gases. Boyle temperature (derivation not required). Critical phenomena, critical constants and their calculation from van der Waals equation. Andrews's isotherms of CO_2. Maxwell Boltzmann distribution laws of molecular velocities and

molecular energies (graphic representation – derivation not required) and their importance. Temperature dependence of these distributions. Most probable, average and root mean square velocities (no derivation). Collision cross section, collision number, collision frequency, collision diameter and mean free path of molecules. Viscosity of gases and effect of temperature and pressure on coefficient of viscosity (qualitative treatment only).

(10 Hrs)

Unit-4: Liquids

Surface tension and its determination using stalagmometer. Viscosity of a liquid and determination of coefficient of viscosity using Ostwald viscometer. Effect of temperature on surface tension and coefficient of viscosity of a liquid (qualitative treatment only).

(4 Hrs)

Unit-5: Chemical Kinetics

The concept of reaction rates. Effect of temperature, pressure, catalyst and other factors on reaction rates. Order and molecularity of a reaction. Derivation of integrated rate equations for zero, first and second order reactions (both for equal and unequal concentrations of reactants). Half–life of a reaction. General methods for determination of order of a reaction. Concept of activation energy and its calculation from Arrhenius equation. Theories of Reaction Rates: Collision theory and Activated Complex theory of bimolecular reactions. Comparison of the two theories (qualitative treatment only). **(6 Hrs)**

Unit-6: Carbohydrates:

Classification, and General Properties, Glucose and Fructose (open chain and cyclic structure), Determination of configuration of monosaccharides, absolute configuration of Glucose and Fructose, Mutarotation, ascending and descending in monosaccharides. Structure of disaccharides (sucrose, cellobiose, maltose, lactose) and polysaccharides (starch and cellulose) excluding their structure elucidation. **(10 Hrs)**

Unit-7: Polymer chemistry

Introduction, background, nomenclature, classifications, examples of applications, principles of polymerization; synthesis of polymers: step growth, radical, chain polymerization, controlled radical, emulsion polymerization, ionic chain polymerization, coordination polymerization, ring –opening polymerization, copolymerization; determination of frictional properties of polymers in solution, polymer processing, hydrodynamic size. **(10 Hrs)**

Suggested Books

1. Huheey, J. E., Keiter, E. A. and Keiter, R. L., *Inorganic Chemistry-Principles of Structure and Reactivity*, 4th Ed., Harper-Collins, 1993.
2. Douglas, B., McDaniel, D., Alexander, J., *Concepts and Models of Inorganic Chemistry*, 3rd Ed.
3. Wiley India (P.) Ltd., India, 2010.
4. Cotton, F. A. et al., *Advanced Inorganic Chemistry*, 3rd Ed., John Wiley and Sons, 1995.
5. Jolly, W. L., *Modern Inorganic Chemistry*, 2nd Ed., McGraw-Hill, NY, 1991.
6. Shriver, D. F. and Atkins, P. W., *Inorganic Chemistry*, 3rd Ed. Oxford University Press, 1999.

7. Levine, I., *Physical Chemistry*, 6th Ed., McGraw Hill, **2009**.
8. Atkins, P.W. and de Paula, J., *Physical Chemistry*, 9th Ed., Oxford Press, **2009**.
9. Castellan, G.W., *Physical Chemistry*, 3rd Ed., Narosa Publishing House, **2004**.
10. Chemical kinetics by K J Laidler. Harper and Row
11. Solid state physics by C. Kittel, Tata Mc Graw Hill
12. Levine, I., Physical Chemistry, 6th Ed., McGraw Hill, 2009.
13. Puri, B. R, Sharma, L.R, Pathania, M.S., Principles of Physical Chemistry, Vishal Publishing Co., 47th Edition, **2020.**
14. Kapoor K. L., A Textbook of Physical Chemistry, Volume 1 to Volume 6, McGraw Hill Education (India) Private Limited, **2015**

Semester-IV: Analytical Chemistry Laboratory ***Credits: 02***

Code	Type	Title	Credits	Hours	L	T	P
UCHPM40208	Minor	Analytical Chemistry Laboratory	2	4	0	0	4

(Any 6-8 Practicals will be conducted)

3. Purification of Solid and Liquids

(j) Crystallisation (ii) Sublimation (iii) Distillation

(iv) Fractional Distillation (v) Distillation under reduced pressure (vi) Differential extraction

4. Separation Techniques:

(j) Thin layer chromatography (ii) Column Chromatography

12. **Surface tension measurement** (use of organic solvents excluded)
(i) Determination of the surface tension of a liquid or a dilute solution using a stalagmometer.
(ii) Study of the variation of surface tension of a detergent solution with concentration

13. **Viscosity measurement (use of organic solvents excluded).**
(i) Determination of the relative and absolute viscosity of a liquid or dilute solution using an Ostwald's viscometer.
(ii) Study of the variation of viscosity of an aqueous solution with concentration of solute.

14. Determination of the concentration of given acids in a mixture of HCl + CH_3COOH conductometrically using the standard (0.5 N) NaOH

15. Determination of solubility of sparingly soluble salt, $BaSO_4$/$PbSO_4$ conductometrically

16. Determination of redox potentials of Fe^{3+}/Fe^{2+} using of $FeSO_4.7H_2O$ solution (≈ 0.1N) by potentiometric titration against the standard solution of $K_2Cr_2O_7$ (0.1 N)

17. Determination of the solubility and solubility product of sparingly soluble salts (AgCl) potentiometrically

18. Determination of the percentage composition of unknown mixture of A and B liquids using

19. Abbe's refractometer by graphical method

20. Determination of pK_a of acetic acid potentiometrically

Semester-IV:* Inorganic *Qualitative Analysis ***Credits: 02***

Code	Type	Title	Credits	Hours	L	T	P
UCHPM40209	Minor	Inorganic Qualitative Analysis	2	4	0	0	4

Inorganic Chemistry - Qualitative Analysis:

A mixture of inorganic salts which contains two cations or two anions will be given. Among them, one of the anion must be an interfering ion. Spot tests for anions and cations are also included.

Acid Radicals like: CO_3^{2-}, S^{2-}, SO_3^{2-}, NO_2^-, Cl^-, Br^-. NO_3^-, SO_4^{2-}, PO_4^{3-} etc

Basic Radicals like: Na^+, K^+, Ca^{2+}, Mg^{2+}, Sr^{2+}, Ba^{2+}, Al^{3+}, Cr^{3+}, Fe^{3+}, Bi^{3+}, Hg^{2+}, Ag^+, Cu^{2+}, Zn^{2+}, Mn^{2+} etc

Reference Books:

1. Svehla, G. Vogel's Qualitative Inorganic Analysis, Pearson Education, 2012.
2. V.V. Ramanujam, Inorganic Semimicro qualitative analysis, National Publishing company, Madras, 1974.
3. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., Textbook of Practical Organic Chemistry, Prentice-Hall, 5th edition, 1996.

Semester-IV: Analytical Chemistry ***Credits: 02***

Code	Type	Title	Credits	Hours	L	T	P
UCHTM40210	Minor	Analytical Chemistry	2	2	2	0	0

Course Learning Outcomes (CLOs)

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

CLO-1: Develop knowledge on working principles of various analytical techniques available for chemical analysis in laboratories.
CLO-2: Summarize the advantages and disadvantages of different calorimetry techniques.
CLO-3: Analyze experimental data using various mathematical and statistical models.

CLO-4: Recognize suitable titration method for quantitative analysis of ions/chemicals
CLO-5: Design a suitable method for separation and analysis of chemicals by chromatography.

Detailed Syllabus:

UNIT I: Errors analysis: Accuracy and precision, absolute, relative, determinate and indeterminate errors, statistical treatment of random errors, computation rules for significant figures, method of least squares, mean deviations, and standard deviation, The Confidence Limit, test of significance, statistics for small data sets, linear least square method, detection limits, use of spreadsheets/softwares in analytical chemistry **(10 Hrs)**

UNIT II: Titrations & Gravimetric analysis: Theory of Acid base equilibria, Acid-base, complexometric, conductometric and potentiometric titrations- theory of acid base indicators, Precipitation reaction & titration, EDTA based titration, Redox titrations, redox indicators, and their use in volumetric analysis, iodometry and iodimetry. Introduction to gravimetric analysis, Thermogravimetry (TGA), Differential Thermal Analysis (DTA), and Differential Scanning Calorimetry (DSC): definition, theoretical basis, instrumentation, factors affecting the data curve, applications, advantages and disadvantages. **(10 Hrs)**

UNIT-III: Separation Techniques: Solvent extraction, distribution coefficient, extraction of metals, thin-layer chromatography (TLC), gas chromatography (GC), liquid chromatography (LC), high performance liquid chromatography (HPLC), ion exchange chromatography, gel permeation chromatography. Chromatography coupled instrumentation.

(10 Hrs)

Reference books:

1. Douglas A. Skoog, Donald M. West, F. James Holler and Stanley R. Crouch, (2013). *Fundamentals of Analytical Chemistry*, 9th Edition, Cengage Learning.
2. James W. Robinson, Eileen M. Skelly Frame, George M. Frame II, (2005). *Undergraduate Instrumental Analysis*, Sixth Edition, Marcel Dekker, New York.
3. Donald L. Pavia, Gary M. Lampman, George S. Kriz, James R. Vyvyan, (2009). *Introduction to Spectroscopy*, Fourth Edition, Brooks/Cole Thomson Learning.
4. Gary D. Christian, Purnendu Das gupta, Kevin Schug, (2013). *Analytical Chemistry*, 7th Edition, Wiley.
5. P.M.S. Monk "Fundamentals of Electroanalytical Chemistry" J. Wiley & Sons, New York, 2002.
6. Skoog, D.A., West, D.M., Holler, F.J., and Crouch, S.R., Fundamentals of Analytical Chemistry, Brooks/Cole (2003) 8th ed.

Semester-IV: Chemistry of Life ***Credits: 02***

Code	Type	Title	Credits	Hours	L	T	P
UCHTM40211	Minor	Chemistry of Life	2	2	2	0	0

Course Learning Outcomes (CLOs)

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

CLO-1: Demonstrate the applications of enzyme-kinetics in the identification of types of inhibitors.
CLO-2: Categorize biomolecules based on their biological functions and chemical structures.
CLO-3: Demonstrate the steps involved in the structure elucidation of various natural products using chemical, analytical and synthetic methods.

Detailed Syllabus:

UNIT I: Biophysical chemistry: Chemistry and biology of water, Chemical forces responsible for stability of biomolecules; hydrogen bonding; electrostatic interactions, hydrophobic interactions; stacking interactions; enzymes, catalysis, and kinetics- Michaelis-Menten equation, and Lineweaver–Burk plot; enzyme inhibition and different types of enzyme inhibition. **(6 Hrs)**

UNIT II: Bioorganic chemistry: Biopolymers-DNA, RNA and Proteins- structures of monomers, bonding, and hierarchy of structural organization. Chemical methods involved in sequencing of DNA and Proteins. Chemical and biochemical synthesis of DNA- Phosphoramidite method and replication. Chemical and biochemical synthesis of peptides/proteins- solution phase and solid phase peptide synthesis methods and ribosomal synthesis of proteins. Applications of PNAS. **(10 Hrs)**

UNIT III: Natural product chemistry: Chemistry of alkaloids - structure determination and synthesis of nicotine, morphine, coniine. Chemistry of terpenes- general methods, classification and special isoprene rule. Characterization of terpenes- Citral, Limonene, Geraniol. Biosynthesis of acyclic and monocyclic terpenes from acetyl CoA. **:** Chemistry of steroids-Structure of common steroids such as cholesterol and steroidal hormones. **(14 Hrs)**

Reference books:

1. C.R. Cantor & P.R. Schimmel, Biophysical Chemistry, W.H.Freeman& Company, 1980
2. David Van Vranken and Gregory A, Introduction to Bioorganic Chemistry and Chemical Biology. Garland Science (Taylor & Francis), 2012.
3. R.H. Thomson, Chemistry of Natural Products - Wiley, New York, 1996.
4. I. L. Finar, *Advanced Organic Chemistry*, Vol. 2 ELBS, New Delhi, 1975.
5. Bhat, S. V., Nagasampagi, B.A., Meenakshi, S. (2009). *Natural Product Chemistry & Applications*, Narosa Publishing House, New Delhi.

Semester-V No. of credits = 20

SEMESTER-V							
S.No.	Category of Course	Course Code	Course Title	Hours			Credits
				L	T	P	
1	Minor	UCHTM50312	Inorganic Chemistry-I	3	1	0	4
2	Minor	UCHTM50313	Organic Chemistry-I	3	1	0	4
3	Minor	UCHTM50314	Physical Chemistry-I	3	1	0	4
4	Minor	UCHPM50315	Organic Chemistry Laboratory	0	0	4	2
5	Minor	UCHPM50316	Computational Chemistry Laboratory	0	0	4	2

Semester-V: Inorganic Chemistry-I *Credits: 04*

Code	Type	Title	Credits	Hours	L	T	P
UCHTM50312	Minor	Inorganic Chemistry – I	4	4	3	1	0

Course Learning Outcomes (CLOs)

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

CLO-1: Understand the fundamentals of periodic properties and their applications.
CLO-2: Categorize inorganic solids into different classes based on its structure, chemical property, and applications.
CLO-3: Understand the structure, bonding, and properties of electron-deficient clusters and cages of boron, silicon, and phosphorus compounds.
CLO-4: Apply the knowledge of radioactivity and nuclear reactions into various applications such as radio-dating, reaction mechanisms, and nuclear energy.
CLO-5: Apply basic concepts into other branches of chemistry and other allied subjects.

Detailed Syllabus:

UNIT I- Periodic Table and Bonding: Arrangement of elements in the Periodic Table, periodic properties. Atomic volume and density. Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization energy. Applications of ionization enthalpy. Electron gain enthalpy, trends of electron gain enthalpy. Electronegativity, Pauling's/ Mulliken's/ Allred Rachow's/ and Sanderson's electronegativity scales. Group electronegativity. **(8Hrs)**

UNIT II-Inorganic Solids: Types of forces-cohesive energy, van der Waals forces, hydrogen bonding. Types of solids, covalent, ionic, molecular and metallic solids. Unit cell, density and

crystal lattice structures of ionic crystals AX & AX_2 and layered structures. Lattice energy, Born-Lande equations and modifications. Defects (0D, 1D, 2D, 3D) in ionic solids and associated theories. Band theory, semiconductors and its type & superconductors. **(15 Hrs)**

UNIT III-p block elements: Boron hydrides (small boranes and their anions, B1−B4), boron nitride, borazines, carboranes, metalloboranes, metallocarboranes. Diamond, graphite, fullerenes, silicates, silicones, zeolites, organo-silicon compounds. Phosphorus allotropes, Berry's pseudo rotation, phosphorus-nitrogen compounds, organo-phosphorus compounds, hydrides, oxides and oxy acids of nitrogen, phosphorus, sulphur and halogens, sulphur-nitrogen and inter-halogen compounds, pseudohalogens, poly halide anions, noble gas compounds. **(30 Hrs)**

UNIT IV- Nuclear Chemistry Nuclear chemistry: radioactive decay and equilibrium. nuclear reactions, Q value, cross sections, types of reactions, chemical effects of nuclear transformations; fission and fusion, fission products and fission yields; radioactive techniques, tracer technique. **(7 Hrs)**

Reference books:

1. C. E. Housecroft, A. G. Sharpe, *Inorganic Chemistry*, 4th Edn, Pearson, 2012.
2. J. E. Huheey, *Inorganic Chemistry, Principles, Structure and Reactivity*, Harper and Row, 3rd Edn, 1983.
3. N. N. Greenwood, A. Earnshaw, *Chemistry of the Elements*, 2nd Edn., Pergamon Press, 1989.
4. Shriver and Atkins, Inorganic Chemistry by Atkins, Overton, Rourke, Weller, and Armstrong, 5th Edition. South Asia Edition (paperback), Oxford University Press, 2010.
5. G. Wulfsberg, *Inorganic chemistry*, 1st Edn, Viva books Pvt Ltd. 2002.
6. M. Weller, T. Overton, J. Rourke, F. Armstrong, Inorganic Chemistry, 7th Edn, Oxford University Press India, 2018.
7. F. A. Cotton and G. Wilkinson, *Advanced Inorganic Chemistry- A comprehensive Text*, John Wiley, 5th Edn, 1987.
8. A. R. West, *Solid state Chemistry and its Applications*, 2nd Edn, Wiley, 2007.
9. C. Kettel, *Introduction to Solid state Physics*, 8th Edn, Wiley, 2012.
10. H. J. Arnikar, *Essentials of nuclear chemistry*, New Age International Publisher, 4th Edn, 2018.
11. G. Friedlander, J. W. Kennedy, E. S. Macias, J. M. Miller, *Nuclear and Radiochemistry*, 3rd Edn, 1981.

Semester-V: Organic Chemistry-I ***Credits: 04***

Code	Type	Title	Credits	Hours	L	T	P
UCHTM50313	Minor	Organic Chemistry – I	4	4	3	1	0

Course Learning Outcomes (CLOs)

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

CLO-1: Analyze the role of reactive intermediates such as carbocations, carbanions, non-classical carbocation in the chemical reactions.
CLO-2: Demonstrate chirality in organic molecules using units such as center, axial, planar , and helicity.
CLO-3: Predict E/Z and R/S configuration in organic molecules by applying concepts of stereochemistry
CLO-4: Illustrate the reaction mechanism aspects in the context of addition, elimination and substitution reactions
CLO-5: Assess the structural effects of organic molecules and functional groups on the tendency to participate in various types of organic reactions.

Detailed Syllabus:

UNIT-I: Reaction Mechanism: Methods of determining reaction mechanisms- kinetic and non-kinetic, isotope effects, and reaction profile diagram, Hammet and Taft equations. substituent constants and reaction constants. A (1,2) and A (1,3) strain, Captodative effect, Hammond's postulate, Curtin-Hammett principle, cross over experiment and thermodynamic and kinetic control of reactions. **(14 Hrs)**

UNIT-II: Stereochemistry-II: Elements of symmetry, chirality, Chirality involving atoms other than carbon. Optical activity in the absence of chiral centre: Axial and planar chirality and helicity. Racemic mixture and their resolution. Topicity: Enantiotopic and diastereotopic atoms, ligands and faces. Conformational analysis of mono-substituted and disubstituted cyclohexanes. Decalins. Asymmetric synthesis: Chiral auxiliaries, methods of asymmetric induction – substrate, reagent and catalyst-controlled reactions; determination of enantiomeric and diastereomeric excess; enantio-discrimination. Stereoelectronic and steric principles in reactions. Importance of stereochemistry in real life: some examples **(24 Hrs)**

UNIT-III: Substitution and allied reactions: Neighbouring group participation, S_NAr, Arenium ion mechanism, ipso attack, orientation in other ring systems; Baldwin Rules for ring closure on saturated and unsaturated carbons. **(08 Hrs)**

UNIT-IV: Elimination and addition reactions: The E2, E1 and E1cB mechanisms, Hoffman and Saytzeff modes of elimination, stereochemical aspect of elimination reaction, orientation of the double bond, reactivity effects of substrate structures, attacking base, the leaving group and the medium, pyrolytic elimination; Mechanistic and stereochemical aspects of addition reactions involving electrophiles, nucleophiles, regio- and chemo selectivity orientation and reactivity; Reactivity of carbonyl group, nucleophilic addition of hetero-atoms (N, O), conjugate addition reactions. **(14 Hrs)**

Reference books:

1. Carey B. F. A., Sundberg R.J., (2007). *Advanced Organic Chemistry Part A and Part B, Springer, 5th edition*.
2. Kalsi, P.S., (2010). *Stereochemistry: Conformation and Mechanism*, New Age International (p) Ltd. New Delhi.
3. Morrison, R.T., Boyd, R.N. (2011). *Organic Chemistry*, Prentice- Hall of India, 6th edition, New Delhi.
4. Smith, M. B., March J., (Latest Ed.). *March's Advanced Organic Chemistry*, John Wiley and Sons, 6th edition, New York.
5. Sykes, P., (1997). *A Guide Book to Mechanism in Organic Chemistry*, Prentice Hall, 6th edition.
6. Eliel, E. L.; Wilen, S. H. (2008). *Stereochemistry of carbon compounds*. Wiley, Student edition.
7. Clayden, J.; Greeves, N.; Warren, S., (2012). *Organic Chemistry*, Oxford University press, 2nd edition.
8. Bruice Paula, Y., (2015). *Organic Chemistry*, 7th Edition, Pearson Edition.
9. Nasipuri, D. (Latest edition). *Stereochemistry of Organic Compounds: Principles & Applications*, New Age International Publishers.

Semester-V: Physical Chemistry-I ***Credits: 04***

Code	Type	Title	Credits	Hours	L	T	P
UCHTM50314	Minor	Physical Chemistry – I	4	4	3	1	0

Course Learning Outcomes (CLOs)

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

CLO-1: Understand the fundamentals of quantum chemistry, classical and statistical thermodynamics
CLO-2: Develop problem-solving ability in quantum chemistry and thermodynamics
CLO-3: Recognize the role of multidisciplinary streams especially basic physics & mathematics knowledge in the development of quantum chemistry & thermodynamics
CLO-4: Apply the fundamental knowledge in quantum chemistry & thermodynamics to an existing and emerging problem in basic science
CLO-5: Demonstrate the ability to do some independent calculation and use some computational resources at the end of the course

Detailed Syllabus:

UNIT I-Equilibrium Thermodynamics: Concept of work and heat, first law of thermodynamics, enthalpy and heat capacities- concept of entropy, second law of thermodynamics, third law of thermodynamics-residual entropy. Calculation of entropy, enthalpy, internal energy, Combination of first and second law, Helmholtz Energy, Gibbs Free energy, Maxwell Relationship, Gibbs-Helmholtz equation **(12 Hrs)**

UNIT II-Statistical Thermodynamics: BE, FD, MB statistics and distribution, partition functions and molecular partition functions, ensembles, entropy of monoatomic gas, Sackur–Tetrode equation, thermodynamic properties from partition function, mean energy, Residual entropy, heat capacity of mono and diatomic gases, chemical equilibrium, Einstein and Debye theories of heat capacity of solids. Non-equilibrium thermodynamics, Postulates and methodologies, linear laws, Gibbs equation, Onsager reciprocal theory. **(18 Hrs)**

UNIT III-Quantum Chemistry I: Introduction, Black body radiation, photoelectric effect, Classical mechanics, Lagrange & Hamiltonian equation, Inadequacy & need for quantum mechanics, postulates, operators & operator algebra, Linear, Hermitian and non-Hermitian operators, Commuting and non-commuting operators, eigen values, eigen vectors & commutation relation, orthogonality, The Schrodinger equation, Discussion of Solution of Schrodinger equation to few model system e. g particles in 1D, 2D & 3D box, harmonic oscillator, rigid rotor, hydrogen atom etc.. **(15 Hrs)**

UNIT IV-Quantum Chemistry II: Approximation methods, viz variation method, perturbation method, Application of variation method and perturbation theory to the Helium atom, Electron spin & Zeeman effect, spin-orbit coupling, introduction to the methods of self-consistent field, the viral theorem. Hartree and Hartree-Fock self-consistent field model, Electronic configuration of atoms, addition of angular momenta, spectroscopic term symbols, spin-orbit coupling, selection rules for atomic spectra, Electronic configuration of atoms, addition of angular momenta, spectroscopic term symbols, selection rules for atomic spectra. **(15 Hrs)**

Reference books:

1. P. W. Atkins, Physical Chemistry, 9thEdtion Oxford University Press, 2010.
2. L.A. Woodward, Molecular Statistics, Oxford University Press.
3. Y. V.C. Rao, An Introduction to Thermodynamics, Wiley Eastern, 1993.
4. Physical Chemistry, R.S.Berry, S.A.Rice and J.Ross, Oxford, 2001.
5. M. Ladd, Introduction to Physical Chemistry, Cambridge, 1998.
6. J. Rajaram & J.C. Kuriacose, Chemical Thermodynamics: Classical, Statistical and Irreversible. Pearson, 2013
7. D. A. McQuarrie and J. D. Simon Physical Chemistry, A molecular Approach, Viva, 1998.
8. F. W. Sears & G. L. Salinger, Thermodynamics, Kinetic Theory & Statistical Thermodynamics, Narosa, 1986.
9. D. A. McQuairrie: Quantum Chemistry, Oxford University press, Oxford, 1982.
10. Ira N. Levine, Quantum Chemistry 7th Ed, Pearson Education India, 2016.
11. A.K.Chandra, Introductory Quantum Chemistry, 4th Ed, McGraw Hill Education, 2017.
12. Donald A McQuarrie, Statistical Mechanics, Viva Books, 2018
13. David Chandler, Introduction to Modern Statistical Mechanics, OUP USA, 1987

Semester-V: Organic Chemistry Laboratory-I ***Credits: 02***

Code	Type	Title	Credits	Hours	L	T	P
UCHPM50315	Minor	Organic Chemistry Laboratory	2	4	0	0	4

Course Learning Outcomes (CLOs)

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

CLO-1: Demonstrate purification of organic liquids using Fractional & Vacuum distillations.
CLO-2: Separate the organic solids and their qualitative analysis and identification of functional groups.
CLO-3: Synthesize the biologically important molecules having carbonyl functionality.
CLO-4: Verify the purity of organic compounds by employing a thin layer chromatography
CLO-5: Apply photo-chemical reaction conditions in organic synthesis.

Detailed Syllabus:

S.No	Practical (Any 8-10 Experiments will be conducted)
1	Vacuum Distillations & Anhydrous solvent. Ex. Hexane, Ethyl Acetate, DMF, DMSO
2	Separation and Qualitative analysis of an organic mixture containing two components. At least one experiments to be performed
3	Thin Layer Chromatography (TLC) experiment
4	Separation of compounds using Column Chromatography/ Medium Pressure Liquid Chromatography (MPLC)
5	Synthesis of Dibenzalpropanone from benzaldehyde and acetone
6	Synthesis of a Chalcones *via* Claisen-Schmidt condensation by grinding method.
7	Nitration of Salicylic acid using Calcium nitrate.
8	Preparation Aspirin by acetylation-Protection Chemistry
9	Bromination of Acetanilide: Green Approach
10	Photoreduction of benzophenone to benzopinacol
11	Synthesis of benzopinacol from benzophenone using Photoreduction
12	Heterocyclic compound synthesis
13	Two step synthesis reaction
14	Any one Name reaction (Diel's-Alder/ Baylis-Hillman/Biginelli Reaction etc.)

Reference books:

1. Vogel, A.I. (1996). *Text book of practical organic chemistry*, Pearson, 5th edition, UK.
2. Adams, R.; Johnson, J.R.; Wilcox, C.F. (1970). *Laboratory Experiments in Organic Chemistry*, The Macmillan Limited, London.
3. Mann and Saunders. (2009). *Practical organic chemistry*, Pearson, 4th edition, UK.
4. Pasto, D.P., Johnson, C., Miller, M. (1992). *Experiments and Techniques in Organic Chemistry*, Prentice Hall, 1st edition, US.
5. Roberts, R.M.; Gilbert, J.C.; Rodewald, L.B.; Wingrove, A.S. (1969). *An introduction to Modern Experimental Organic Chemistry*, Ranehart and Winston Inc., New York.
6. Williamson, K.L., Health, D.C. (1999). *Macroscale and Microscale Organic Experiments, Heath, D.C.* and Co., Lexington, MA.

Semester-V: Computational Chemistry Laboratory-I Credits: 02

Code	Type	Title	Credits	Hours	L	T	P
UCHPM50316	Minor	Computational Chemistry Laboratory	2	4	0	0	4

Course Learning Outcomes (CLOs)

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

CLO-1: Apply computational tools to understand the fundamentals of atoms, molecules and solids.
CLO-2: Practice the Linux operating system and Linux commands to operate the Quantum Expresso software.
CLO-3: Develop skills to analyze compounds using various analytical techniques.
CLO-4: Illustrate experimental skills to operate various computational software and analytical instruments.

Detailed Syllabus:

S.No	Practical
1	Determination of internal coordinates of organic molecules and metal complexes in the crystal structures retrieved from CCDC using Mercury software.
2	Plotting atomic orbitals and hybrid orbitals using Origin software.
3	Conformational analysis of cyclohexane using Materials Science platform of Schrödinger software.
4	Indexing an XRD pattern-Determination of density by X-ray method.
5	Morse's potential plot of oxygen molecule by density functional theory using Quantum ESPRESSO software.

6	Computational drug design through protein-ligand docking using Glide tool of Schrodinger software.

Reference books:

1. A. Findary, T. A. Kitchner , Practical physical chemistry, (Longmans, Green and Co.)
2. J. M. Wilson, K. J. Newcombe, A. R. Denko, R. M. W. Richett, Experiments in Physical Chemistry, (Pergamon Press)
3. F. Jensen, Introduction to Computational Chemistry (John Wiley and Sons Ltd.)

Semester-VI No. of credits = 20

SEMESTER-VI							
S.No.	Category of Course	Course Code	Course Title	Hours			Credits
				L	T	P	
1	Minor	UCHTM60317	Inorganic Chemistry-II	3	1	0	4
2	Minor	UCHTM60318	Organic Chemistry-II	3	1	0	4
3	Minor	UCHTM60319	Physical Chemistry-II	3	1	0	4
4	Minor	UCHPM60320	Inorganic Chemistry Laboratory	0	0	4	2
5	Minor	UCHPM60321	Physical Chemistry Laboratory	0	0	4	2
6	Minor	UCHTM60322	Bio-inorganic Chemistry	2	0	0	4

Semester-VI: Inorganic Chemistry-II ***Credits: 04***

Code	Type	Title	Credits	Hours	L	T	P
UCHTM60317	Minor	Inorganic Chemistry – II	4	4	3	1	0

Course Learning Outcomes (CLOs)

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

CLO-1: Understand the basics of coordination chemistry including coordination numbers, geometry, and chelate effect.
CLO-2: Describe the bonding theories VBT, CFT, and MOT in turn describe CFSE, High and low spin complexes, magnetic moment of coordination compounds
CLO-3: Interpret the electronic spectra of coordination compounds explaining color, allowed and forbidden transitions through Orgel and Tanabe-Sugano diagrams.
CLO-4: Design reaction mechanism pathways like associative/dissociative, inner and outer sphere mechanism including electron transfer pathways.

CLO-5: Demonstrate the basics, spectral and magnetic properties of Lanthanides and Actinides

Detailed Syllabus:

UNIT I-Introduction to transition metal complexes: A brief history of coordination chemistry, nomenclature, coordination numbers, geometry and isomerism, chelate effect and stability constants. (**10 Hrs)**

UNIT II-Theories of transition metal complexes: Valence bond theory, Crystal field theory, crystal field splitting, application of d-orbital splitting to explain magnetic properties, low spin and high spin complexes, crystal field stabilization energy, spectrochemical series, weak and strong field complexes, thermodynamic and related aspects of crystal fields, ionic radii, heats of ligation, lattice energies, site preference energies. Molecular Orbital theory of complexes (quantitative principles involved in complexes without pi and with pi bonding), ligand field theory. **(18 Hrs)**

UNIT III-Electronic spectra and Magnetism of transition metal complexes: Atomic terms, states and microstates, Electronic spectra of transition metal complexes, selection rules, correlation diagram, Orgel and Tanabe-Sugano diagrams and Lever plot, charge transfer and d-d transitions, Jahn-Teller effect, nephelauxetic series. Dia-, para-, ferro- and antiferromagnetism, quenching of orbital angular moment, spin-orbit coupling. (**17 Hrs)**

UNIT IV-Inorganic reaction mechanisms: Inert and labile compounds, substitution reactions of octahedral complexes, dissociative, associative, anation, aquation, conjugate base mechanism; substitution reactions of square planar complexes, trans effect, trans effect series, theories of trans effect; electron transfer reactions. **(10 Hrs)**

UNIT V-Lanthanides and Actinides: Chemistry of lanthanides and actinides: lanthanide contraction, oxidation states, spectral and magnetic properties, use of lanthanide compounds as shift reagents. (**4 Hrs)**

Reference books:

1. J. E. Huheey, *Inorganic Chemistry*, 3rd Edition. Harper International, 1983.
2. B. Douglas, D. McDaniel, J. Alexander, *Concepts and Models of Inorganic Chemistry*, 3rd Edition. John Wiley. 1994.
3. W. L. Jolly, *Modern Inorganic Chemistry*, 2nd Edition. McGraw-Hill.
4. C. Housecroft and A. G. Sharpe, *Inorganic Chemistry*, 5th Edition, Pearson. 2018.
5. B. N. Figgis, M. A. Hitchman, *Ligand field theory and its applications*, Wiley-VCH, 2000.
6. A. P. B. Lever, *Inorganic electronic spectroscopy*, Elsevier, 1984.
7. F.A. Cotton, *Chemical applications of Group theory*, 3rd Edn, John Wiley & Sons, 1990.
8. K. F. Purcell, J. C. Kotz, *Inorganic chemistry*, 1st Edn, W.B. Saunders company, 1977.

9. M. Weller, T. Overton, J. Rourke, F. Armstrong, *Inorganic Chemistry*, 7th Edn, Oxford University Press India, 2018.

Semester-VI: Organic Chemistry-II ***Credits: 04***

Code	Type	Title	Credits	Hours	L	T	P
UCHTM60318	Minor	Organic Chemistry – II	4	4	3	1	0

Course Learning Outcomes (CLOs)

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

CLO-1: Apply the basic oxidation and reduction reactions on organic molecules.
CLO-2: Apply reagents in the stereoselective reactions using mild reagents.
CLO-3: Plan to synthesize molecules using popularly named reactions.
CLO-4: Categorize the pericyclic reactions and construct various cyclic molecules.
CLO-5: Apply oxidations, reductions, photochemical reactions in the organic synthesis.

Detailed Syllabus:

UNIT-I: Oxidations and reductions in organic synthesis: Mechanism, selectivity, stereochemistry and applications of selenium dioxide, Cr and Mn reagents, periodic acid, Osmium tetroxide, Swern oxidations, Baeyer-Villiger oxidation, epoxidations using peracids. Sharpless epoxidation, asymmetric dihydroxylation. Mechanism, selectivity, stereochemistry and applications of catalytic hydrogenations using Pd, Pt and Ni catalysts, metal hydride reductions using $NaBH_4$, $LiAlH_4$, DIBAL, K-selectride, Sodium cyanoborohydride. Asymmetric reductions of prochiral carbonyl compounds and olefins. **(16 Hrs)**

UNIT-II: Reagents in organic synthesis: Lithium diisopropylamide (LDA), Dicyclohexyl Carbodiimide (DCC), Trimethylsilyl iodide, Gilman's reagent, DDQ, Prevost Hydroxylation, Phase transfer catalysts, Phosphorous and Sulphur ylides, Merrifield resin, Lawson reagents, IBX, Ceric ammonium nitrate, Tebbe reagent. **(14 Hrs)**

UNIT-III: Named Reactions & Rearrangements in organic synthesis: Pinacol-pinacolone, Wagner-Meerwein, Demjanov, Benzil-Benzillic acid, Favorskii, Neber, Beckmann, Hofmann, Curtius, Schimidt rearrangements, Arndt-Eister syntheses, Mukaiyama aldol reaction, Mitsunobu reaction, Shapiro reaction, Vilsmeier–Haack reaction, Baylis-Hillman reaction, Biginelli reaction. **(14 Hrs)**

UNIT-IV: Pericyclic reactions: Thermal and photochemical pericyclic reactions, Conrotation and disrotation; Electrocyclic closure and opening in 4n and 4n+2 systems. Woodward-Hoffmann selection rules for electrocyclic reactions. Explanation for the mechanism of

electrocyclic reactions and examples. Cycloaddition reactions: Suprafacial and antarafacial interactions. $\pi^2 + \pi^2$ and $\pi^4 + \pi^2$ cycloadditions. Diels-Alder reaction, Woodward-Hoffmann selection rules for cycloaddition reactions and examples. Mechanism by orbital symmetry correlation diagrams, Fukui Frontier Molecular Orbital (FMO) theory. Endo-exo selectivity in Diels-Alder reaction and its explanation by FMO theory. Sigmatropic reactions: mechanism of sigmatropic reactions, Cope and Claisen rearrangements. **(16 Hrs)**

Reference books:

1. Carey B. F. A., Sundberg R.J., (2007). *Advanced Organic Chemistry Part A and Part B, Springer, 5th edition*.
2. Jie Jack Li, (2009). *Name Reactions: A collection of Detailed Reaction Mechanism*, Publisher: Springer-verlag.
3. McMurry J., *Organic Chemistry***,** Asian Book Pvt. Ltd, 8th edition, New Delhi.
4. Smith, M. B., March J., (Latest Ed.) *March's Advanced Organic Chemistry*, John Wiley and Sons, 6th edition, New York.
5. Clayden, J.; Greeves, N.; Warren, S., (2012) *Organic Chemistry*, Oxford University press, 2nd edition.
6. Sankaraman, S. (2005). *Pericyclic reactions: Reactions, Applications and Theory*, Wiley-VCH.
7. Kurti, L., Czako, B. (2005). *Strategic Applications of Named Reactions in Organic Synthesis*, Elsevier Publications.

Semester-VI: Physical Chemistry-II ***Credits: 04***

Code	Type	Title	Credits	Hours	L	T	P
UCHTM60319	Minor	Physical Chemistry – II	4	4	3	1	0

Course Learning Outcomes (CLOs)

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

CLO-1: Understand the fundamentals of electrochemistry, chemical kinetics, and colloid & surface chemistry
CLO-2: Develop problem-solving ability in electrochemistry, kinetics, and surface chemistry
CLO-3: Recognize the role of multidisciplinary streams especially basic physics & mathematics along with the role of colloid & surface science knowledge in the development of chemistry
CLO-4: Apply the fundamental knowledge in electrochemistry, kinetics, and surface chemistry to existing and emerging problem in basic science
CLO-5: Demonstrate the ability to do some independent calculation and use some computational resources at the end of the course

Detailed Syllabus:

UNIT I-Kinetics-I: Basic Chemical Kinetics Molecularity, order and rate of reactions, Arrhenius theory - Complex reactions: reversible, pre-equilibrium, consecutive, chain and photochemical, oscillatory reactions, enzyme kinetics - Lindenmann's theory of uni-molecular reactions - laser flash photolysis, femto second spectroscopy, flow techniques and relaxation methods. (**12 Hrs)**

UNIT II-Kinetics-II: Molecular reaction dynamics collision and activated complex theory, comparison of results with Eyring and Arrhenius equations - reactive collisions, molecular beam experiments, introduction to potential energy surfaces: treatment of H_2 + H reaction – ionic reactions, salt effect. (**12 Hrs)**

UNIT III-Surface & Colloid Chemistry: Surface phenomena Growth and structure of surface, surface defects, kinetics of surface adsorption: Langmuir and BET isotherms. Surface & interfaces, Surface characterisation techniques, colloid chemistry, Surfactants, Micelles, emulsion & gels, macromolecular films, surface films and surface Gibbs energy and isotherm, surface engineering and catalysis **(8 Hrs)**

UNIT IV-Electrochemistry-I: Equilibrium electrochemistry, Activities in electrolytic solutions, mean activity coefficient, Debye-Huckel treatment of dilute electrolyte solutions, origin of electrode potential, half-cell potential, electrochemical cell, Galvanic & electrolytic cells, Electrolysis, Nernst equation, thermodynamics of electrochemical cell**. (12 Hrs)**

UNIT V-Electrochemistry-II: Dynamic electrochemistry, Electrical double layer - electrode kinetics: rate of charge transfer, current density, Tafel equation, Butler-Volmer equation - introduction to polarography, Introduction to electrochemical techniques such as pulse, linear, differential voltammetery, cyclic voltammetry etc, Introduction to convective mass transfer system. Applied electrochemistry & energy science with introduction to batteries, fuel cells, electrochemical capacitors & solar cells. Introduction to corrosion. Inhibition of corrosion **(16 Hrs)**

Reference books:

1. K. J. Laidler, Chemical Kinetics, 3rd Edn., Harper International, 1987.
2. G. D. Billing & K. V. Mikkelson, Molecular dynamics and chemical kinetics, JohnWiley, 1996.
3. J. I. Sheinfield, J. S. Francisco, W. L. Hasse, Chemical kinetics & dynamics, Prentice Hall, 1998.
4. A. J. Bard & L. R. Faulkner, Electrochemical Methods, Fundamental and Applications, JohnWiley, 1980.
5. Bockris & Reddy, Electrochemistry, Vol. 1& 2, Plenum, 1973
6. H. V. Keer, Solid State Chemistry, Wiley Eastern, 1993.
7. A. K. Cheetam & P. Day, Solid State Chemistry Techniques, Oxford, 1987.
8. Arthur W. Adamson, Physical Chemistry of Surfaces, 6th Edition, Wiley India Pvt Ltd, 2011

9. Southampton Electrochemistry Group, Instrumental Methods in Electrochemistry, Woodhead Publishing, 2001

Semester-VI: Inorganic Chemistry laboratory ***Credits: 02***

Code	Type	Title	Credits	Hours	L	T	P
UCHPM60320	Minor	Inorganic Chemistry Laboratory	2	4	0	0	4

Course Learning Outcomes (CLOs)

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

CLO-1: Understand the safety and precautionary measures in handling chemicals.
CLO-2: Demonstrate the rudimentary principle related to inorganic synthesis
CLO-3: Synthesize the given list of compounds using standard procedure in a pure form.
CLO-4: Analyze compounds using various analytical techniques and arrive at the conclusion of the correct chemical structure.
CLO-5: Design and synthesize either the same compound by different synthetic strategy or a new compound.

S.No	Practical (Any 8-10 of the following experiments will be conducted)
1	Preparation of cobalt ammine complexes $[Co(NH_3)_6]Cl_3$, $[Co(NH_3)_5Cl]Cl_2$, $[Co(NH_3)_4Cl_2]Cl$.
2	Preparation of *cis* and *trans* –bis(glycinato) copper (II) monohydrate Determination of percentage weight of copper in $[Cu(glycinato)_2].H_2O$.
3	Preparation of tris(ethylenediamine)cobalt(III) chloride, $[Co(en)_3]Cl_3$.
4	Preparation of tris(ethylenediamine)nickel(II)chloride dihydrate$[Ni(en)_3]Cl_2.2H_2O$ and Dichlorobis(ethylenediamine)nickel(II) dihydrate$[Ni(en)_2Cl_2].2H_2O$ from $[Ni(en)_3]Cl_2.2H_2O$.
5	Preparation of lanthanum hexacyanoferrate (III) pentahydrate, $La[Fe(CN)_6].5H_2O$. Calculating the percentage of $[Fe(CN)_6]^{3-}$
6	Estimation of iodine in iodised common salt using Iodometry.

7	Colorimetry: Simultaneous determination of chromium and manganese in a solution by visible spectroscopy.
8	Analysis of Brass (Gravimetric and Volumetric).
9-12	Qualitative analysis of binary mixture (Group analysis of Cations and Anions along with less common metals).
13	Preparation of Silicon based linear and cyclic polysiloxane polymers and its characterization by Infrared spectra.
14	Preparation and characterization of Ferrocene
15	Preparation and characterization of tris(acetylacetonato) aluminum(III)

Reference books:

1. Text book of Quantitative Analysis, A.I. Vogel 4thedn (1992)
2. Electronic Spectroscopy by A.B. P. Lever.
3. Inorganic Synthesis (Vol. Series)

Semester-VI: Physical Chemistry laboratory ***Credits: 02***

Code	Type	Title	Credits	Hours	L	T	P
UCHPM60321	Minor	Physical Chemistry Laboratory	2	4	0	0	4

Course Learning Outcomes (CLOs)

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

CLO-1: Understand the fundamentals of doing experimental physical chemistry
CLO-2: Develop problem-solving & troubleshooting ability in experimental physical chemistry
CLO-3: Recognize the role of multidisciplinary streams starting with basic science to understanding the key role of instruments in doing experimental physical chemistry
CLO-4: Apply the fundamental knowledge in experimental physical chemistry to existing and emerging problem in basic science
CLO-5: Demonstrate the ability to do some independent calculation and use some computational resources at the end of the course

Detailed Syllabus:

(Any 8-10 of the following experiments will be conducted)

S.No	Practical
I	**Potentiometric Titration (Electrodics)** 7. Determination of standard redox potential of standard redox couple. 8. Potentiometric titration of Zn^{2+} or Cd^{2+} or Pb^{2+} with potassium ferrocyanide and determination of composition of Zn(II) or Cd(II) or Pb(II) -ferrocyanide complex (three different experiments as the metal ion only changed). 9. Potentiometric titration of mixture of halides. 10. Determination of standard reduction potential of quinhydrone electrode. 11. Potentiometric titration of mixture of acids (strong & weak) with strong base. 12. Redox-titration: Determination of concentration of reductant or oxidant by potentiometric method.
II.	**Conductometric Titration (Ionics)** 8. Solubility product of sparingly soluble salt by conductance measurements. 9. Determination of Equilibrium constant & equivalent conductance at infinite dilution of a weak electrolyte. 10. Determination of equivalent conductance at infinite dilution of strong electrolyte. 11. Verification of Ostwald's dilution law. 12. Conductometric determination of mixture of acids using strong electrolyte. 13. Conductometric determination of critical micelle concentration of any given surfactant. 14. Verification of Kohlrausch Law
III	**Chemical Kinetics** 6. Saponification of ethyl or methyl acetate using conductometric methods a) Determination of rate constant & order of reaction with respect to reactants b) Influence of ionic strength on the rate constant (Salt effect) c) Effect of Temperature on rate constant (Arrhenius Equation) (This practical is equivalent to three different experiments). 7. Kinetics of iodination of acetone by spectrophotometry or by colorimetry method a)Acetone effect; b)Iodine effect; c)Acid effect (This practical is also can be split into at least two separate experiments). 8. Kinetics of alkaline hydrolysis of dye such as crystal violet or similar such compounds by spectrophotometry or colorimetry method. 9. Determination of rate constant of Inversion of sucrose by polarimeter & verification of the effect of catalyst on the rate constant. 10. Kinetics of catalytic decomposition of hydrogen peroxide.
IV	**Thermodynamics, Phase rule, Surface & Colloid Chemistry** 7. Vapour pressure measurements and enthalpy of vaporisation of solvent such as water. 8. Heat of neutralisation of a strong acid by a strong base. 9. Adsorption of acetic acid or iodine on charcoal. 10. Critical micelle concentration of given surfactant by surface tension measurements.

	11. Three component liquid system (acetic acid, benzene, water). 12. Two component simple eutectic system (Examples: o-nitrophenol & naphthalene, acetamide & Benzoic acid, p-nitrotoluene & diphenylamine etc.). Determination of dimerization constant of benzoic acid in organic medium.
V	**Miscellaneous experiments (pH, Colorimetry etc.)** 7. Determination of Composition & stability constant of given complex such as Fe (III)- Salicylic acid complex by Job's method using colorimetry. 8. Verification of Beer-Lambert's law & determination of concentration of unknown solution. 9. Determination of ionic product of water by pH metric method. 10. Determination of hydrolytic constant of given salts such as ammonium chloride by pH metric method. 11. Determination of pKa of dibasic or tribasic acids by pH-metric methods. 12. Determination of strength of individual acids (E.g. HCl & acetic acid) in a mixture by pH metric method.

Reference books:

1. Viswanathany, B., Raghavan, P.S., Practical Physical Chemistry, Viva Books Private Ltd, 2012
2. Maity, S.K., Ghosh, N.K., Physical Chemistry Practicals, New Central Book Agency Ltd, 2012
3. A.Findlay, Practical Physical Chemistry (Longmans, Green and Co).
4. J.M.Wilson, K.J.Newcombe, A.R.Denko, R.M.W.Richett, Experiments in Physical Chemistry, (Pergamon Press).
5. Garland, C.W., Nibler, J.W., Shoemaker, D.P., Experiments in Physical Chemistry, McGraw-Hill Higher Education, 8th Edition, 2009

Semester-VI:* Bio-inorganic *Chemistry ***Credits: 02***

Code	Type	Title	Credits	Hours	L	T	P
UCHTM60322	Minor	Bio-inorganic Chemistry	2	2	2	0	0

Course Learning Outcomes (CLOs)

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

CLO-1: Explain the role of metal ions in biological systems and biochemical reactions.
CLO-2: Outline the effects of functional groups of biomolecules on metal-mediated biological reactions.

Detailed Syllabus:

UNIT I: Bioinorganic Chemistry I: Occurrence of elements, specific ligands, and coordination sites in biomolecules. Metal homeostasis in biology: Transport and storage of K^+, Ca^{2+} Iron and copper. Dioxygen transport and storage: haemoglobin, myoglobin, hemerythrin and hemocyanine and their electronic structural properties. Synthetic oxygen carrier and model systems. Electron Transfer protein and photosynthesis: Cytochromes, Fe-S Clusters and blue-copper, metal in photosystems I and II. Enzymes and its classifications. The role of metallo enzymes: peroxidase, catalse and cytochrome P-450, superoxide dismutase and carboxypeptidase A, carbonic anhydrase, vitamin B12 and nitrogenase. Medicinal bioinorganic chemistry. **(30 Hrs)**

Reference books:

1. S. J. Lippard, J. M. Berg, *Principles of Bioinorganic Chemistry*, University Science Books. 1994.
2. I. Bertini, H. B. Gray, S. J. Lippard, J. A. Valentine, *Bioinorganic Chemistry*, University Science Books. 1994.
3. A. K. Das, *Bioinorganic Chemistry*, Books & Allied Limited. 2013.
4. W. Kaim.; *Bioinorgnic Chemistry*, 2nd Edition, John Wiley. 2013.
5. R. M. Roat-Malone, *Bioinorganic Chemistry*, John Wiley, 2002.

Semester-VII

SEMESTER-VII							
S.No.	**Category of Course**	**Course Code**	**Course Title**	**Hours**			**Credits**
				L	**T**	**P**	
1	Minor	UCHTM70423	Molecular Spectroscopy	3	1	0	4
2	Minor	UCHTM70424	Chemical Applications of Group Theory	2	0	0	2
3	Minor	UCHTM70425	Spectroscopic Identification of Organic Compounds	3	1	0	4
4	Minor	UCHPM70426	Instrumentation and Structure Elucidation Laboratory	0	0	4	2

Semester-VII: Molecular Spectroscopy ***Credits: 04***

Code	Type	Title	Credits	Hours	L	T	P
UCHTM70423	Minor	Molecular Spectroscopy	4	4	3	1	0

Course Learning Outcomes (CLOs)

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

CLO-1: Understand the basic principles of light-matter interactions and learn quantum mechanical methods to analyze the interactions
CLO-2: Apply selection rules in microwave, infrared, Raman, UV-Vis spectroscopy/ Rotational, Vibrational & Electronic spectroscopy
CLO-3: Describe the principles of ESCA, PES, AUGER, NMR, EPR, Mossbauer spectroscopy and NQR.
CLO-4: Differentiate various resonance techniques used in the analysis of molecules.
CLO-5: Apply the fundamental knowledge of molecular spectroscopy to existing and an emerging problem in basic science

Detailed Syllabus:

UNIT I-Rotational, Vibrational & Electronic spectroscopy: Electromagnetic radiation, interaction of electromagnetic radiation with matter, quantum mechanical approach - transition probabilities: Einstein coefficients - pure vibrational and rotational spectra, selection rules, vibrational and rotational spectra of polyatomic molecules, normal modes, anharmonicity, selection rules – Raman effect: classical and quantum theory of Raman effect, rotational and vibrational Raman spectra. Franck-Condon principle, Electronic Spectra of atoms/molecules, Born- Oppenheimer Approximation, Rotational fine structures Fortrat Diagram, Pre-dissociation, Transition moments, assignment of electronic transitions of N2, H2O and formaldehyde using group theory, solvent effect, ESCA, PES, AUGER techniques. **(30 Hrs)**

UNIT II-Introduction to NMR:-Origin of magnetic moments in matter, electronic and nuclear moments, interaction with magnetic field, Larmor equation - conditions for magnetic resonance absorption, relaxation times, line widths and line shapes, ring currents, diamagnetic anisotropy, spin-spin splitting, high resolution NMR spectra of simple molecules, first and second order treatment of AB systems - FT techniques. **(15 Hrs)**

UNIT III-Other Resonance Spectroscopy Methods :- NMR of ^{1}H, ^{11}B, ^{19}F, ^{31}P and other active nuclei. NMR of simple molecules and metal complexes. NMR of paramagnetic complexes- Contact shifts. Electron paramagnetic resonance (EPR): Hyperfine splitting, g value, ESR of organic free radicals, zero-field splitting and Kramer's degeneracy, Line widths in Solid state EPR. The principles of Mossbauer spectroscopy. Origin of isomer shifts, quadrupole splitting and h. f. s. Nuclear quadrapole resonance (NQR). **(15 Hrs)**

Reference books:

1. P. W. Atkins, *Physical Chemistry*, Oxford, London, 7th edition, 2006.

2. D. L. Pavia, G. M. Lampman and G. S. Kriz, *Introduction to Spectroscopy*, 2nd Edn, Saunders
3. C. N. Banwell, *Fundamentals of Molecular Spectroscopy*, 4th Edition Tata McGraw Hill, 2016.
4. Carrington and Machlachlon, *Magnetic Resonance*, Harper & Row, 1967.
5. G. M. Barrow, *Introduction to Molecular Spectroscopy*, McGraw Hill, 1964.
6. D. H. Williams and I. Fleming, *Spectroscopic methods in organic chemistry*, Tata McGraw Hill, 1998.
7. J. Micheal Hollas, *Modern Spectroscopy*, 4th Edition, Wiley India Pvt Ltd, 2010
8. Harald Gunther, *NMR Spectroscopy: Basic Principles, Concepts and Applications in Chemistry*, 2nd Edition, Wiley India Pvt Ltd, 2010
9. R. S. Drago, Physical methods in Inorganic chemistry, 1st Edition. Affiliated East-West Press, 2012.
10. M. T. Weller, N. A. Young. *Characterization methods in inorganic chemistry*, Oxford University press, 2017.
11. J.Micheal Hollas, Basic Atomic and Molecular Spectroscopy: (Tutorial Chemistry Texts), Royal Society of Chemistry, 2002
12. D.N.Sathyanarayana, Vibrational Spectroscopy: Theory and Applications, New Age International, 2005

Semester-VII: Chemical applications of Group Theory Credits: 02

Code	Type	Title	Credits	Hours	L	T	P
UCHTM70424	Minor	Chemical applications of Group Theory	2	2	2	0	0

Course Learning Outcomes (CLOs)

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

CLO-1: Understand the basic concepts of symmetry and its mathematical expression.
CLO-2: Apply these mathematical notations into objects and molecules.
CLO-3: Analyze infrared, Raman, and electronic spectra of simple molecules.
CLO-4: Understand orbital symmetry and energy levels and in the conjugated alkenes.
CLO-5: Apply the knowledge of group theory into different fields such as asymmetric synthesis, spectroscopy, photochemistry, crystallography, and even to other branches of science like physics and biology.

Detailed Syllabus:

UNIT-I: Group Theory: Groups, sub-groups, classes and their properties, postulates of group, construction of group multiplication table, symmetry elements and operations, general relations among symmetry elements and operations, molecular symmetry and point groups, matrix representation of symmetry elements, representation of groups, character, reducible and

irreducible representations, Great Orthogonality theorem, properties of irreducible representations, Mulliken's symbols for irreducible representations, character tables. **(15 Hrs)**

UNIT- II: Applications of Group Theory:

Group theory & quantum mechanics, wave functions as basis for irreducible representations, direct products, time dependent perturbation theory; Symmetry-adapted linear combinations (SALC); linear combination of atomic orbitals (LCAO), application of LCAO in conjugated system and MO diagram of octahedral and tetrahedral molecules.

Vibrational and electronic spectroscopy for Inorganic compounds: Normal Mode analyses *and its applications in* IR and Raman spectroscopy. Selection rules, spectral transition probability, vibronic coupling, electronic spectra of metal complexes. **(15 Hrs)**

Reference books:

1. F. A. Cotton. *Chemical applications of group theory*, 3rd edition, Wiley India edition, 2003.
2. R. L. Carter, Molecular Symmetry and Group Theory, Wiley India, 2004.
3. K. Veera Reddy, *Symmetry and spectroscopy of molecules*, 2nd edition, New Age International Publishers, 2009.
4. B. S. Garg, *Chemical applications of molecular symmetry and group theory*, 1st edition, Macmillan Publishers Indian Ltd , 2012.
5. Mark Ladd, Symmetry of Crystals and Molecules, Oxford University Press, 2014
6. L. H. Hall, Group Theory and Symmetry in Chemistry, McGraw Hill Book Company, 1969

Semester-VII: Spectroscopic Identification of Organic Compounds Credits: 04

Code	Type	Title	Credits	Hours	L	T	P
UCHTM70425	Minor	Spectroscopic Identification of Organic Compounds	4	4	3	1	0

Course Learning Outcomes (CLOs)

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

CLO-1: Describe the applications of UV-Visible spectroscopy in the identification of conjugation in organic compounds
CLO-2: Apply IR spectroscopy to identify the various functional groups in organic molecules
CLO-3: Evaluate the structure of organic compounds using ^{1}H, ^{13}C, and 2D-NMR spectroscopy
CLO-4: Describe the basic principles and applications of organic-mass spectrometry.
CLO-5: Apply UV-Visible, IR, NMR, and mass spectrometry in structure elucidation of organic compounds.

Detailed Syllabus:

UNIT-I: Introduction to spectroscopic techniques: Structure elucidation. Application of UV – Visible and IR spectroscopy to organic structure elucidation. Electromagnetic spectrum, absorption of energy by organic compounds, types of spectroscopic methods to organic structure elucidation. Woodward – Fisher rules, Octant rule, Application of ORD – CD to stereochemical assignments. Organic functional group identification through IR spectroscopy. **(16 Hrs)**

UNIT-II: Application of NMR Spectroscopy. Basic principles. Introduction to NMR techniques. CW and FT NMR techniques. ^{1}H NMR Spectral parameters – intensity, chemical shift, multiplicity, coupling constant. Analysis of first order and second - order spectra. Structure determination of organic compounds by ^{1}H NMR spectra. **(16 Hrs)**

UNIT-III: Multinuclear ^{1}H NMR &^{13}C NMR: Proton coupled, off resonance decoupled, proton noise decoupled ^{13}C NMR spectra. Assignment of chemical shifts, additively effect, characteristic chemical shifts of common organic compounds and functional groups, DEPT & SEFT spectra. 2D NMR techniques ^{1}H – ^{1}H COSY, ^{1}H – ^{13}C COSY – HMBC, and NOESY. **(12 Hrs)**

UNIT-IV: Application of mass spectrometry: Basic principles, mass analyzers, ionization methods: EI, PI, CI, FAB, MALDI, ES. Liquid chromatography and mass spectrometry, types of ions and fragmentations, even electron rule, nitrogen rule, isotope abundance, McLafferty rearrangement.

Organic structure elucidation, techniques of ion production, ion and daughter ions, molecular ion and isotope abundance. Nitrogen rule energetics of fragmentation, metastable ions, common fragmentation pathways, fragmentation pattern of common chemical classes. Illustrative examples from macromolecules and supramolecules. **(20 Hrs)**

Reference books:

1. R. M. Silverstein and F. X. Webster, Spectrometric identification of organic compounds, 6thEdn, Wiley.
2. W. Kemp, Organic Spectroscopy, 3rdEdn., MacMillon, 1994.
3. Pavia, Lampman and Kriz, Introduction to Spectroscopy, 3rdEdn., Brooks/Cole.
4. D. H Williams and Ian Fleming, Spectroscopic methods in organic chemistry, Tata McGraw Hill,1998.
5. W. Kemp, Introduction to multinuclear NMR.
6. P. S. Kalsi, Spectroscopy of Organic Compounds, 6th edition, New age international, 2004.

Semester-VII: Instrumentation and Structure Elucidation Laboratory Credits: 02

Code	Type	Title	Credits	Hours	L	T	P

UCHPM70426	Minor	Instrumentation and Structure Elucidation Laboratory	2	4	0	0	4

Hands on experience to handle instruments such as UV-Visible, X-RD, FT-IR, HPLC, Fluorescence, FT-Raman, NMR & electrochemical work station etc. and collecting & analysing the data & interpretation of results. Structure elucidation using various spectroscopic and diffraction techniques.

Semester-VIII

SEMESTER-VIII							
S.No.	**Category of Course**	**Course Code**	**Course Title**	**Hours**			**Credits**
				L	**T**	**P**	
1	Minor	UCHTM80427	Organometallic Chemistry	3	1	0	4
2	Minor	UCHTM80428	Organic Chemistry-III	3	1	0	4

Semester-VIII: Organometallic Chemistry Credits: 04

Code	**Type**	**Title**	**Credits**	**Hours**	**L**	**T**	**P**
UCHTM80427	Minor	Organometallic Chemistry	4	4	3	1	0

Course Learning Outcomes (CLOs)

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

CLO-1: Understand the basics of Organometallic (OM) chemistry. Illustrate organometallic complexes with phosphines, carbenes, alkyl, alkene, and alkyne as ligands.
CLO-2: Evaluate Pi-Conjugated systems as ligands, synthesis, and reactivity of metallocenes,fluxionality and dynamic NMR.
CLO-3: Explain the structure, bonding, reactivity, and spectral study of metal carbonyls, carbonyl clusters and isolobal analogy.
CLO-4: Devise special reactions of organometallic chemistry: Oxidative addition, reductive elimination and migratory insertion.
CLO-5: Design the catalytic cycles, mechanistic studies and apply metal-catalyzed reactions for industrial applications.

Detailed Syllabus:

UNIT I-Organometallic Chemistry 1: Introduction, history, classification of ligands, 18-electron rule, metal carbonyls: synthesis, structure, π- bonding and infrared spectroscopy and reactions of metal carbonyls. Organometallic complexes (OMCs) with alkyl group, alkene and alkyne as ligands, synthesis, reactions and bonding models. OMC of neutral spectator ligands: phosphines, multidentate phosphines, chiral phosphines and NHCs. **(20Hrs)**

UNIT II-Organometallic Chemistry 2: Brief about organometallic compounds of ***s***-and ***p***-block elements. Complexes containing η^5- cyclopentadienyl ligands: ferrocene and other metallocenes: structure, bonding and reactions. OMCs containing η^{4-}- η^6- η^7- and η^8 ligands. Multinuclear carbonyl clusters, metal-metal bond, Mingo's rules, isolobal analogy. Hydride, dihydrogen complexes and fluxionality. (**15 Hrs**)

UNIT III-Unique reactions of Organometallic Complexes: Oxidative addition, reductive elimination, β- hydride elimination, α- hydrogen abstraction and migratory insertion. **(5 Hrs)**

UNIT IV-Catalysis: Homogeneous and Heterogeneous catalysis. Olefin hydrogenation: Wilkinson catalyst, iridium and ruthenium-based catalysts, directing effects in hydrogenation and asymmetric hydrogenation. hydrocyanation and hydrosilylation of alkenes. Hydroformylation: cobalt catalysts, rhodium-phosphine catalysts, *n*/*iso* ratio of products, enantioselective hydroformylation. Monsanto acetic acid process, Cativa and Wacker processes. metathesis: Grubb's and Schrock Catalysts, ring opening metathesis (ROM), ring closing metathesis (RCM), enyne metathesis (EM). Olefin polymerization: Ziegler-Natta and metallocene based catalysts. Coupling reactions: Industrial applications, different catalysts for coupling. Suzuki-Miyaura, Heck, Sonogashira, Stille, Kumada, Negishi, Hiyama and Buchwald-Hartwig C-N cross coupling reactions. **(20 Hrs)**

Reference Books:

1. R. H. Crabtree, *The organometallic chemistry of transition metals*, 7th Edn. Wiley, 2019.
2. Ch.Elsenbroich, A. Salzar, *Organanometallics*, 2nd Edn, VCH Publishers Inc, NY, 1992.
3. B. D. Gupta, A. J. Elias, *Basic Organometallic chemistry*, 2nd Edn, University Press, 2013.
4. J. E. Huheey, E. A. Keiter & R. L. Keiter, *Inorganic Chemistry: Principles of Structure and Reactivity*, Pearson Education, 4th Edn. 1992.
5. R. Whyman, *Applied organometallic chemistry and catalysis*, Oxford University Press, 2001.
6. C. E. Housecraft and A. G. Sharpe, *Inorganic Chemistry*, Pearson, 5th Edn. 2018.
7. J. P. Collman, L.S. Hegedus, J. R. Norton, R. G. Finke, P*rinciples and applications of organotransition metal chemistry*, University Science Books, 1987.
8. K. F. Purcell and J. C. Kotz, *Inorganic chemistry*, W.B. Saunders Company,1977.

Semester-VIII: Organic Chemistry-III ***Credits: 04***

Code	Type	Title	Credits	Hours	L	T	P
UCHTM80428	Minor	Organic Chemistry-III	4	4	3	1	0

Course Learning Outcomes (CLOs)

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

CLO-1: Summarize photochemical intermediates involved in organic reactions.
CLO-2: Develop organic synthetic strategies using the disconnection approach.
CLO-3: Assess the reactivity patterns of enolates and their mechanisms
CLO-4: Synthesis of heterocyclic compounds with mono and di heteroatoms.
CLO-5: Write the synthetic schemes based on photochemistry, enolates, and heterocyclics.

UNIT-I: Photochemistry: Franck-Condon principle, Jablonski diagram, fluorescence and phosphorescence, Singlet and triplet states, Photosensitization, Quantum efficiency, Photochemistry of carbonyl compounds, Norrish type-I and type-II cleavages, Paterno-Buchi reaction, Photoreduction, Photochemistry of enones and para-benzoquinones, Di π – methane rearrangement, Photodynamic therapy, Photochemical [4+2] cycloaddition using singlet Oxygen; Barton reaction. **(16 Hrs)**

UNIT-II: Synthetic strategies: Synthon, Synthetic equivalent, Functional group interconversion (FGI), Functional group addition, Functional group elimination. Criteria for selection of target; Linear and convergent synthesis; Retrosynthetic analysis and synthesis involving chemo selectivity, regioselectivity, reversal of polarity and cyclizations; Criteria for disconnection of strategic bonds; One group and two group C-X disconnections in 1,2-, 1,3-, 1,4- difunctional compounds. Protection and deprotection of functional groups in synthetic strategy: Protection of alcohols by silyl ethers and ester formations and their deprotection; Protection of 1, 2 diols- by acetal, ketal and their deprotection. **(18 Hrs)**

UNIT-III: Enolate of carbonyl compounds: Kinetic and thermodynamic control, Potential energy diagrams, methods of determining mechanisms, isotopes effects, region and stereo-selective reactions. Enolates: Regio- and stereo-selectivity in enolate generation. "O" versus "C" alkylation, Effect of solvent, Counter cation and Electrophiles; Symbiotic effect; Thermodynamically and kinetically controlled enolate formations; Various transition state models to explain stereoselective enolate formation; Enamines; Regioselectivity in generation, Application in controlling the selectivity of alkylation. **(12 Hrs)**

UNIT-IV: Heterocycles in Chemistry: Introduction to heterocycles; Nomenclature; Single heteroatom heterocycles Furan, pyrrole, thiophene, indole, pyridine, quinoline, isoquinoline synthesis, reactivities and application. Synthesis and reaction of five membered heterocycles containing two heteroatoms, imidazole, oxazole, thiazole; Benzo-fused five-membered and six membered heterocycles. **(14 Hrs)**

Reference books:

1. Finar, I.L. (2006). *Organic Chemistry: Stereochemistry and the Chemistry of Natural Products.* Dorling Kindersley Pvt. Ltd., 6th edition, India.
2. McMurry J., *Organic Chemistry***,** Asian Book Pvt. Ltd, 8th edition, New Delhi.
3. Morrison, R.T., Boyd, R.N. (2011). *Organic Chemistry*, Prentice- Hall of India, 6th edition, New Delhi.
4. Clayden,J.;Greeves,N.;Warren,S., (2012). *Organic Chemistry*, Oxford University press, 2nd edition.
5. Warren S.; Wyatt, P. (2008). *Organic Synthesis The Disconnection Approach*, Wiley 2nd edition.
6. Coyle, J. D. (1991), *Introduction to organic photochemistry*, Wiley.
7. Halton, B.; Coxon J. M. (2011), *Organic Photochemistry*, Cambridge University Press.
8. Smith, M. B.; March, J. (2007), *March's Advanced Organic Chemistry*, Wiley 6th edition.

Syllabus of Multidisciplinary Courses (MDC) offered by Department of Chemistry to Other Disciplines

Semester-I: Inorganic Chemistry in day-to-day life Credits: 02

Code	Type	Title	Credits	Hours	L	T	P
	Multidisciplinary Course (MDC)	Inorganic Chemistry in day-to-day life	2	2	1	1	0

Syllabus:

Inorganic chemistry in cooking, cool and hot drinks, ceramic industry, cooking appliances, electrical appliances, human body and other biological systems. Also applications of Inorganic chemistry in medicine, healthcare products, pigments, laser, water and its purification. Other application in our day-to-day life.

Semester-II: Organic Chemistry in day-to-day life Credits: 02

Code	Type	Title	Credits	Hours	L	T	P
	Multidisciplinary Course (MDC)	Organic Chemistry in day-to-day life	2	2	1	1	0

Syllabus:

Organic chemistry in cooking oil, butter, lipids, proteins, steroids, drugs and its impact, carbohydrates, carbohydrates role in type-I, type-II diabetes. Other application in our day-to-day life. Fatty acids, Soaps, detergents.

Semester-III: Physical Chemistry in day-to-day life Credits: 02

Code	Type	Title	Credits	Hours	L	T	P
	Multidisciplinary Course (MDC)	Physical Chemistry in day-to-day life	2	2	1	1	0

Syllabus:

Physical chemistry in cooking, cool and hot drinks, ceramic industry, cooking appliances, electrical appliances, human body and other biological systems. Also applications of physical chemistry in energy science such as batteries, fuel cells, capacitors, medicinal field, healthcare products, pigments, laser, water and its purification systems. Application of physical chemistry in our day-to-day life.

Syllabus of Skill Enhancement Course (SEC) offered by Department of Chemistry

Semester-I: Mathematics for Chemists ***Credits: 03***

Code	Type	Title	Credits	Hours	L	T	P
UCHTS10101	Skill Enhancement Course (SEC)	Mathematics for Chemists	3	4	2	0	2

Prerequisite Course/Knowledge (If any): **Fundamentals of Mathematics**

Course Learning Outcomes (CLOs)

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

CLO-1: understand basic and different areas of mathematics.
CLO-2: nurture a mathematical aptitude, thinking, and inculcate skills to solve problems.
CLO-3: inculcate mathematical reasoning and enable them to understand the mathematical models in chemistry.
CLO-4: prepare the students to apply the mathematics knowledge in learning and understanding other courses in physical and inorganic chemistry better, especially like quantum chemistry and molecular spectroscopy etc.
CLO-5: learn the basics of group theory and its application in chemistry. This knowledge may equip them to learn other courses in M.Sc. Chemistry like spectroscopy and coordination chemistry etc.

Detailed Syllabus:

UNIT-I: Numbers: Real and Complex number algebra. Vector algebra. Functions & Variables: Differential calculus-first- and higher-order derivatives, evaluation of minimum and maximum, limits & continuity. Partial differentiations. Exact and inexact differentials. Numerical differentiation. The gamma and delta functions. Integral Calculus: Indefinite and definite integrals, improper integrals. Methods of integration. Surface and volume integrals. Numerical integrations. **(15 Hrs)**

UNIT-II: Differential Equations: Ordinary first- and second-order differential equations. Partial differential equations. Solution of inexact differential equations by the method of integrating factors. Power series and extended power series solutions. Numerical solutions. Special functions: Hermite, Legendre and Laguerre polynomials, recursion relations. Matrices and Determinants. Eigen values and eigen vectors. Orthogonal transformation. Rank & inverse of matrix. **(15 Hrs)**

Reference books:

1. Mathematics for Physical Chemistry. R. G. Mortimer, Academic Press.
2. Advanced Engineering Mathematics. E. Kreyszig, Wiley.

3. Mathematics for Chemistry and Physics. G. Turrell, Academic Press.
4. Numerical Analysis: A Practical Approach. Melvin J. Maron, Macmillan Publishing Co., Inc. NY & Collier Macmillan Publishers, London.

Semester-II: Food Chemistry ***Credits: 03***

Code	Type	Title	Credits	Hours	L	T	P
UCHTS10102	Skill Enhancement Course (SEC)	Food Chemistry	3	4	2	0	2

Detailed Syllabus:

Unit 1: Food Chemistry: Flavours
Definition and basic tastes; chemical structure and taste; definition of food flavours; flavour enhancers**;** recognition tests for various food flavours.

Unit 2: Food additives
Introduction, need of food additives in food processing and preservation; Characteristics and classification of food additives. Antimicrobial agents: Nitrites, sulphides, sulphur di oxide, sodium chloride, hydrogen peroxide. Antioxidants: Introduction, mechanism of action, natural and synthetic anti-oxidants, technological aspect of antioxidants.

Unit 3: Sweeteners- Introduction, importance, classification- natural and artificial, chemistry, technology and toxicology, consideration for choosing sweetening agents.

Unit 4: Colors: Introduction, importance, classification- natural, artificial, and natural identical, FD&C Dyes and Lakes. Use of plant tissue culture, polymeric colors etc for color.

References:
1. Fennema, Owen R, Food Chemistry, 3rd Ed., Marcell Dekker, New York, 1996
2. DeMan, J.M., Principles of Food Chemistry, AVI, NewYork, 1980

Semester-III: Green Chemistry ***Credits: 03***

Code	Type	Title	Credits	Hours	L	T	P
UCHTS30103	Skill Enhancement Course (SEC)	Green Chemistry	3	4	2	0	2

Detailed Syllabus:

Unit 1: Introduction to Green Chemistry

Definition of green chemistry and its need. Goals of green chemistry; Limitations/ obstacles in the pursuit of the goals of green chemistry.

Unit 2: Principles of Green Chemistry and Designing a Chemical synthesis

Twelve principles of green chemistry. Designing a green synthesis using these principles; prevention of waste/ byproducts; maximum incorporation of the materials used in the process into the final products. Atom economy, calculation of atom economy of the rearrangement, addition, substitution and elimination reactions. Prevention/ minimization of hazardous/toxic products reducing toxicity.

Unit 3: Solvents and reagents for green chemistry

Green solvents–supercritical fluids, water as a solvent for organic reactions, ionic liquids, PEG, solventless processes. Energy requirements for reactions – alternative sources of energy: use of microwaves and ultrasonic energy. Use of catalytic reagents (wherever possible) in preference to stoichiometric reagents; catalysis and green chemistry.

Unit 4: Examples of Green Synthesis

1. Microwave assisted reactions in water: Hofmann elimination, methyl benzoate to benzoic acid, oxidation of toluene and alcohols; microwave assisted reactions in organic solvents: Diels-Alder reaction and Decarboxylation reaction
2. Ultrasound assisted reactions: sonochemical Simmons-Smith Reaction (Ultrasonic alternative to Iodine).

References

1. Matlack, A.S. Introduction to Green Chemistry, Marcel Dekker (2001).
2. Cann, M.C. & Connely, M.E. Real-World cases in Green Chemistry, American Chemical Society, Washington (2000).
3. Ryan, M.A. & Tinnesand, M. Introduction to Green Chemistry, American Chemical Society, Washington (2002).
4. Ahluwalia, V. K & Kidwai, M. R. New Trends in Green Chemistry, Anamalaya Publishers, 2005.

Semester-III: Quality Control Chemist ***Credits: 03***

Code	Type	Title	Credits	Hours	L	T	P
UCHTS10104	Skill Enhancement Course (SEC)	Quality Control Chemist	3	4	2	0	2

Detailed Syllabus:

As per NSQF, Government of India.