BACHELOR OF SCIENCE IN CHEMISTRY

(04 Yrs.)

(Revised Framework- 2024-25 Batch onwards)

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

JULY 2024

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+4+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+2+4+2+4	4	-	-	-	-	20
VI	4+2+4+2+4+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+2+4+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+2+4+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 2024-25

SEMESTER-I							
S.No.	**Category of Course**	**Course Code**	**Course Title**	**Hours**			**Credits**
				L	**T**	**P**	
1	Major	UCHTC11100	Inorganic Chemistry-I	3	1	0	4
2	Major	UCHPC11100	Inorganic Chemistry-I 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)	UCHTD11100	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)	UCHCS11100	Food Chemistry	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	UCHTC21101	Organic Chemistry-I	3	1	0	4
2	Major	UCHPC21101	Organic Chemistry-I 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)	UCHTD21101	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)	UCHCS21101	Mathematics for Chemists	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	UCHTC31102	Physical Chemistry-I	3	1	0	4
2	Major	UCHPC31102	Physical Chemistry-I Laboratory	0	0	4	2
3	Minor	-	Physics / Mathematics / Life Science / Computer Science	3	1	0	4
4	Multidisciplinary Course (MDC)	UCHTD31102	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)	UCHCS31102	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	UCHTC41200	Organic Chemistry-II	3	1	0	4
2	Major	UCHPC41200	Organic Chemistry-II Laboratory	0	0	4	2
3	Major	UCHTC41201	Physical Chemistry-II	3	1	0	4
4	Major	UCHPC41201	Physical Chemistry-II Laboratory	0	0	4	2
5	Minor	-	Physics / Mathematics / Life Science / Computer Science	3	1	0	4
6	Ability Enhancement Course (AEC)	-	A course on Language	2	0	0	2
7	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	UCHTC51202	Inorganic Chemistry-II	3	1	0	4
2	Major	UCHPC51202	Inorganic Chemistry-II Laboratory	0	0	4	2
3	Major	UCHTC51300	Organic Chemistry-III	3	1	0	4
4	Major	UCHPC51300	Organic Chemistry-III Laboratory	0	0	4	2
5	Major	UCHTC51301	Introduction to Quantum Chemistry	3	1	0	4
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	UCHTC61302	Molecular Spectroscopy & Photochemistry	3	1	0	4
2	Major	UCHPC61301	Spectroscopy Laboratory	0	0	4	2
3	Major	UCHTC61303	Physical Chemistry-III	3	1	0	4
4	Major	UCHPC61302	Physical Chemistry-III Laboratory	0	0	4	2
5	Major	UCHTC61304	Inorganic Chemistry-III	3	1	0	4
6	Major	UCHPC61303	Inorganic Chemistry-III Laboratory	0	0	4	2
7	Internship	UCHIC61300	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	UCHTC71400	Analytical Chemistry	3	1	0	4
2	Major	UCHPC71400	Analytical Chemistry Laboratory	2	0	0	2
3	Major	UCHTC71401	Chemistry of Materials	3	1	0	4
4	Major	UCHPC71401	Materials Chemistry 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 for B.Sc Research							
S.No.	**Category of Course**	**Course Code**	**Course Title**	**Hours**			**Credits**
				L	**T**	**P**	
1	Major **Any 2 Electives**	UCHTC81500	Green Chemistry	3 + 3	1 + 1	0	4 + 4
		UCHTC81501	Medicinal Chemistry				
		UCHTC81502	Electrochemistry				
		UCHTC81503	Polymer Chemistry				
		UCHTC81504	Environmental Chemistry				
		UCHTC81505	Advanced Material Chemistry				
		UCHTC81506	Advanced Analytical Chemistry				
		UCHTC81507	Nuclear & Radiation Chemistry				
		UCHTC81508	Organic spectroscopy				
		UCHTC81509	Heterocyclic chemistry				
		UCHTC81510	Biochemistry				
		UCHTC81511	Organometallics and Bioinorganic chemistry				
		UCHTC81512	Introduction to Nanochemistry & applications				
		UCHTC81513	Advanced Organic Chemistry				
2	Major *B.Sc. Research*	UCHRC81500	Research Project	0	0	24	12
Total				6	2	24	**20**

Or

SEMESTER-VIII for B.Sc Honours							
S.No.	**Category of Course**	**Course Code**	**Course Title**	**Hours**			**Credits**
				L	**T**	**P**	
1	Major	UCHTC81500	Green Chemistry			0	4 + 4

	Any 2 Electives For B.Sc. Honours	UCHTC81501	Medicinal Chemistry	3 + 3	1 + 1		
		UCHTC81502	Electrochemistry				
		UCHTC81503	Polymer Chemistry				
		UCHTC81504	Environmental Chemistry				
		UCHTC81505	Advanced Material Chemistry				
		UCHTC81506	Advanced Analytical Chemistry				
		UCHTC81507	Nuclear & Radiation Chemistry				
		UCHTC81508	Organic spectroscopy				
		UCHTC81509	Heterocyclic chemistry				
		UCHTC81510	Biochemistry				
		UCHTC81511	Organometallics and Bioinorganic chemistry				
		UCHTC81512	Introduction to Nanochemistry & applications				
		UCHTC81513	Advanced Organic Chemistry				
2	Major	UCHSC81500	Literature Survey and Seminar	0	1	6	4
Total				6	3	6	**12**

***The theory courses are given 3 lectures and 1 tutorial hours.**

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	UCHTC11100	Inorganic Chemistry-I	3	1	0	4
2	Major	UCHPC11100	Inorganic Chemistry-I 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)	UCHCS11100	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: Inorganic Chemistry-I Credits: 04

Code	Type	Title	Credits	Hours	L	T	P
UCHTC11100	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 theories of atoms and the concept of wave function.

CLO-2: Understand the periodic properties of s, p block elements

CLO-2: Apply theories to draw the reasonable structure of molecules.

CLO-4: Characterize weak bonding in different molecules and its consequence in biology.

Detailed Syllabus:

Unit-1: Atomic Structure:

Bohr's theory, its limitations and atomic spectrum of hydrogen atom, Sommerfeld theory. Wave mechanics: de' Broglie equation, Heisenberg's Uncertainty Principle and its significance, Schrödinger's time independent wave equation, significance of ψ and ψ^2. Quantum numbers and their significance. Normalized and orthogonal wave functions. Sign of wave functions. Radial and angular wave functions for hydrogen atom. Radial and angular distribution curves. Shapes of s, p, d and f orbitals. Contour boundary and probability diagrams. Pauli's Exclusion Principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations, Variation of orbital energy with atomic number. **(10 Hrs)**

Unit 2: Periodicity of Elements

s, p, d, f block elements, the long form of periodic table. Detailed discussion of the following properties of the elements, with reference to *s* and *p*-block:(a) Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table; (b) Atomic radii (van'der Waals); (c) Ionic and crystal radii; (d) Covalent radii; (e) Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization energy. Applications of ionization enthalpy; (f) Electron gain enthalpy, trends of electron gain enthalpy; (g) Electronegativity, Pauling, Mullikan, Allred-Rachow, Sanderson and Allen scales, electronegativity and bond order, partial charge, hybridization, group electronegativity.

(10 Hrs)

Unit 3: Chemical Bonding

(i) *Ionic bond:* General characteristics, types of ions, size effects, radius ratio rule and its limitations. Packing of ions in crystals. Born-Landé equation with derivation, expression for lattice energy, Madelung constant, Born-Haber cycle, Born-Mayer and Kapustinskii;s modifications on Born-Landé equation. Application of lattice energy, Solvation energy.

(ii) *Covalent bond:* Lewis structure, Valence Shell Electron Pair Repulsion Theory (VSEPR), Shapes of simple molecules and ions containing lone-and bond-pairs of electrons multiple bonding, sigma and pi-bond approach, Valence Bond theory, (Heitler-London approach). Hybridization containing s, p and s, p, d atomic orbitals, shapes of hybrid orbitals, Bents rule, Resonance and resonance energy, Molecular orbital theory. Molecular orbital diagrams of simple homonuclear and heteronuclear diatomic molecules, MO diagrams of simple di- and tri-atomic molecules, e.g., N_2, O_2, C_2, B_2, F_2, CO, NO, and their ions; HCl, BeF_2, CO_2 (idea of s-p mixing and orbital interaction to be given). Covalent character in ionic compounds, polarizing power and polarizability. Fajan rules, polarization. Ionic character in covalent compounds: Bond moment and dipole moment. ionic character from dipole moment and electronegativities.

(**20 Hrs**)

Unit 4: Metallic bonding and Weak chemical forces

(i) *Metallic Bond:* Qualitative idea of free electron model, Semiconductors, Insulators.

(ii) *Weak Chemical Forces:* van'der Waals, ion-dipole, dipole-dipole, induced dipole dipoleinduced dipole interactions, Lenard-Jones 6-12 formula, hydrogen bond, effects of hydrogen bonding on melting and boiling points, solubility, dissolution. (**5 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. Douglas, B.E., McDaniel, D.H., Alexander J.J., *Concepts & Models of Inorganic Chemistry, (Third Edition)* John Wiley & Sons,1999.

5. Housecroft, C. E. and Sharpe, A. G., *Inorganic Chemistry*, 4th Edition, Pearson Edu, Ltd, 2018.

6. Rodger, G. E., *Inorganic and Solid State Chemistry*, Cengage Learning, 2002.

7. Mingos, D. M. P., *Essential Trends in Inorganic Chemistry*, Oxford University Press, 1998.

8. Wulfsberg G., *Inorganic Chemistry*, Viva Students Edition, 2002.

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

Code	Type	Title	Credits	Hours	L	T	P
UCHPC11100	Major	Inorganic Chemistry-I 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. TITRIMETRIC ANALYSIS

1. Calibration and use of apparatus.
2. Preparation of solutions of different Molarity/Normality of titrants.
3. Use of primary and secondary standard solutions.

II. ACIDIMETRY

4. Estimation of citric acid in Lemon
5. Estimation of sodium carbonate and sodium bicarbonate present together in a mixture

III. PERMANGANOMETRY

6. Estimation of oxalic acid
7. Estimation of FAS

IV. DICHROMETRY

8. Estimation of Fe (II) with $K_2Cr_2O_7$ using internal (diphenylamine, anthranilic acid) and external indicator.

V. IODOMETRY

9. Estimation of sodium thiosulphate
10. Estimation of iodine content in iodised salt

VI. COMPLEXOMETRY

11. Estimation of Zn^{2+}

12. Estimation of temporary and permanent hardness of water

VII. GRAVIMETRY

13. Estimation of barium as barium chromate

14. Estimation of nickel as Ni-DMG

References:

1. V. Venkateswaran, R.Veerasamy, A.R.Kulandaivelu, Basic principles of practical Chemistry, 2nd Edt, Sultan Chand & sons publisher, 1997.

2. Mendham, J., A. I. Vogel's *Quantitative Chemical Analysis* Sixth Edition, Pearson, 2009.

3. 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	UCHTC21101	Organic Chemistry-I	3	1	0	4
2	Major	UCHPC21101	Organic Chemistry-I 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)		Mathematics for Chemists / Green Chemistry / Food Chemistry / Quality Control Chemist(VD)	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: Organic Chemistry-I ***Credits: 04***

Code	Type	Title	Credits	Hours	L	T	P
UCHTC21101	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: Understand the basics of organic molecules structure, bonding, reactivity and reaction mechanisms.
CLO-2: Understand the geometry, 3-D structure of organic molecules, identifying chiral centers.
CLO-3: Analyze the Stereochemistry of organic molecules – conformation and configuration, asymmetric molecules.
CLO-4: Understand the difference between nucleophilic substitution and elimination reactions.

Unit 1: Basics of Organic Chemistry

Organic Compounds: Classification, and Nomenclature, Hybridization, Shapes of molecules, Influence of hybridization on bond properties. Electronic Displacements: Inductive, electromeric, resonance and mesomeric effects, hyperconjugation and their applications; Dipole moment; Organic acids and bases; their relative strength. Homolytic and Heterolytic fission with suitable examples. Curly arrow rules, formal charges; Electrophiles and Nucleophiles; Nucleophlicity and basicity; Types, shape and relative stabilities of reaction intermediates (Carbocations, Carbanions, Free radicals and Carbenes).
Organic reactions and their mechanism: Addition, Elimination and Substitution reactions.

(8 hr)

Unit 2: Stereochemistry

Concept of asymmetry, Fischer Projection, Newmann and Sawhorse projection formulae and their interconversions; Geometrical isomerism: cis–trans and, syn-anti isomerism E/Z notations with C.I.P rules. Optical Isomerism: Optical Activity, Specific Rotation, Chirality/Asymmetry, Enantiomers, Molecules with two or more chiral-centres, Distereoisomers, meso structures, Racemic mixtures, Relative and absolute configuration: D/L and R/S designations.

Cycloalkanes and Conformational Analysis

Cycloalkanes and stability, Baeyer strain theory, Conformation analysis, Energy diagrams of cyclohexane: Chair, Boat and Twist boat forms. **(17 hr)**

Unit 3: Chemistry of Aliphatic Hydrocarbons:

A. Carbon-Carbon sigma bonds

Chemistry of alkanes: Formation of alkanes, Wurtz Reaction, Wurtz- Fittig Reactions, Free radical substitutions: Halogenation - relative reactivity and selectivity.

B. Carbon-Carbon pi-bonds

Formation of alkenes and alkynes by elimination reactions, Mechanism of E1, E2, E1cb reactions. Saytzeff and Hofmann eliminations. Reactions of alkenes: Electrophilic additions their mechanisms (Markownikoff/ Anti Markownikoff addition), mechanism of oxymercuration demercuration, hydroboration- oxidation, ozonolysis, reduction (catalytic and chemical), syn and anti-hydroxylation (oxidation). 1, 2- and 1, 4- addition reactions in conjugated dienes and, Diels- Alder reaction; Allylic and benzylic bromination and mechanism, e.g. propene, 1-butene, toluene, ethyl benzene. Reactions of alkynes: Acidity, Electrophilic and Nucleophilic additions. **(14 hr)**

Unit 4: Aromatic Hydrocarbons

Aromaticity: Huckel's rule, aromatic character of arenes, cyclic carbocations/carbanions and heterocyclic compounds with suitable examples. Electrophilic aromatic substitution: halogenation, nitration, sulphonation and Friedel-Craft's alkylation/acylation with their mechanism. Directing effects of substituent groups. **(6 hr)**

Recommended Books/References:

1. Pine S. H. Organic Chemistry, Fifth Edition, McGraw Hill, 2007
2. F. A. Carey, Organic Chemistry, Seventh Edition, Tata McGraw Hill. 2008
3. Clayden, J. et al., Organic Chemistry, 2nd Ed., Oxford University Press, 2001.
4. Hornback, J. M., Organic Chemistry, 2nd Ed., Cengage Learning, 2006.
5. Morrison, R. M. and Boyd, R. N., Organic Chemistry, 6th Ed., Pearson Education, 2008.
6. Smith, M. B. and March, J., Advanced Organic Chemistry, 6th Ed., John Wiley and Sons, 2007.
7. Carey, F. A, Sundberg, R. J., Advanced Organic Chemistry, Parts A and B, Springer, 2007.

8. Kalsi, P.S., (2010). *Stereochemistry: Conformation and Mechanism*, New Age International (p) Ltd. New Delhi.
9. Nasipuri, D. (Latest edition). *Stereochemistry of Organic Compounds: Principles & Applications*, New Age International Publishers.
10. Bruice Paula, Y., (2015). *Organic Chemistry*, 7th Edition, Pearson Edition.
11. Solomons, T.W G., Fryhle, B. Craig. *Organic Chemistry*, John Wiley & Sons, Inc, 2009.

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

Code	Type	Title	Credits	Hours	L	T	P
UCHPC21101	Major	Organic Chemistry-I Laboratory	2	4	0	0	4

Syllabus:

1. Checking the calibration of the thermometer.

2. Purification of organic compounds by crystallization using the following solvents:

a. Water b. Alcohol c. Alcohol-Water

3. Determination of the melting points of given organic compounds and unknown organic compounds (using Kjeldahl method and electrically heated melting point apparatus).

4. Effect of impurities on the melting point – mixed melting point of two unknown organic compounds.

5. Determination of boiling point of liquid compounds. (boiling point lower than and more than 100 °C by distillation and capillary method).

5.Chromatography:

a. Separation of a mixture of two amino acids by ascending and horizontal paper chromatography

b. Separation of a mixture of two sugars by ascending paper chromatography

c. Separation of a mixture of *o*-and *p*-nitrophenol or o-and p-aminophenol by thin layer chromatography (TLC).

Reference Books:

1. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry*, Pearson Education, 2009.
2. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. *Practical Organic Chemistry, 5th Ed.*, Pearson, 2012.

3. Svehla, G. Vogel's *Qualitative Inorganic Analysis*, Pearson Education, **2012**.
4. Mendham, J. Vogel's *Quantitative Chemical Analysis*, Pearson, **2009**.
5. 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	UCHTC31102	Physical Chemistry-I	3	1	0	4
2	Major	UCHPC31102	Physical Chemistry-I 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)		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: Physical Chemistry-I — ***Credits: 04***

Code	Type	Title	Credits	Hours	L	T	P
UCHTC31102	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 role of gases and different laws governing them.
CLO-2: Understand the Liquid state and its physical properties related to temperature and pressure variation.
CLO-3: Understand the properties of liquid as solvent in reactions.
CLO-4: Understand the lattice parameters – its calculation, application of symmetry, solid characteristics of simple salts.
CLO-5: Apply ionic equilibria concepts to solve problems in solutions.

Detailed Syllabus:

Unit 1: Gaseous state:

Behavior of real gases: Deviations from ideal gas behavior, compressibility factor, and its variation with pressure for different gases. Causes of deviation from ideal behavior. van der Waals equation of state, its derivation and application in explaining real gas behaviour; van der Waals equation expressed in virial form, Boyle temperature. Isotherms of real gases and their comparison with van der Waals isotherms, continuity of states, critical state, critical and van der Waals constants, law of corresponding states.

Kinetic molecular model of a gas: postulates and derivation of the kinetic gas equation; collision frequency; collision diameter; mean free path and viscosity of gases, including their temperature and pressure dependence, relation between mean free path and coefficient of viscosity, calculation of σ from η; variation of viscosity with temperature and pressure. Maxwell distribution and its use in evaluating molecular velocities (average, root mean square and most probable) and average kinetic energy, law of equipartition of energy, degrees of freedom and molecular basis of heat capacities. (**15 Hrs**)

Unit 2: Liquid state

Structure and physical properties of liquids; vapour pressure, surface tension, viscosity, and their dependence on temperature, Effect of addition of various solutes on surface tension, cleansing action of detergents. Structure of water. (**5 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; dissociation constants of mono-, di- and tri-protic acids.

Salt hydrolysis, hydrolysis constants, degree of hydrolysis and pH for different salts. Buffer solutions; Henderson equation, buffer capacity, buffer range, buffer action, applications of buffers in analytical chemistry, Solubility and solubility product.

Brönsted-Lowry concept of acid-base reactions, solvated proton, relative strength of acids, types of acid-base reactions, levelling solvents, Lewis acid-base concept, Classification of Lewis acids. Hard and Soft Acids and Bases (HSAB) Application of HSAB principle. Qualitative treatment of acid – base titration curves (calculation of pH at various stages). Theory of indicators; selection of indicators and their limitations. Multistage equilibria in polyelectrolytes. (**15 Hrs**)

Unit 4: Solid state

Nature of the solid state, law of constancy of interfacial angles, law of rational indices, Miller indices, elementary ideas of symmetry, symmetry elements and symmetry operations, qualitative idea of point and space groups, seven crystal systems and fourteen Bravais lattices; X-ray diffraction, Bragg's law, a simple account of rotating crystal method and powder pattern method. Analysis of powder diffraction patterns of NaCl, CsCl and KCl. Various types of defects in crystals, Glasses and liquid crystals. (**10 Hrs**)

Suggested Books

1. Ball, D. W. *Physical Chemistry* Thomson Press, India, **2007**.
2. Mortimer, R. G. *Physical Chemistry* 3rd Ed. Elsevier: NOIDA, UP, **2009**.
3. G. M. Barrow, Tata McGraw Hill (Fifth Edition), **2007**.
4. Puri, B. R, Sharma, L.R, Pathania, M.S., Principles of Physical Chemistry, Vishal Publishing Co., 47th Edition, **2020**
5. Physical chemistry by G. M. Barrow, Mc Graw Hill. NewYork
6. Kapoor K. L., A Textbook of Physical Chemistry, Volume 1 to Volume 6, McGraw Hill Education (India) Private Limited, **2015**
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.**

Semester-III: Physical Chemistry-I Laboratory Credits: 02

Code	Type	Title	Credits	Hours	L	T	P
UCHPC31102	Major	Physical Chemistry-I Laboratory	2	4	0	0	4

Detailed Syllabus

I. Surface tension measurements.

1) Determine the surface tension by (i) drop number (ii) drop weight method.
2) Study the variation of surface tension of detergent solutions with concentration.

II. Viscosity measurements using Ostwald's viscometer.

3) Determination of viscosity of solutions of a given polymer
4) Determination of viscosity ethanol and/or sugar at room temperature.
5) Viscosity of sucrose solution with the concentration of solute.
6) Determination of concentration of glycerol using viscosity measurements

III. pH metry

7) Effect on pH of addition of HCl/NaOH to solutions of acetic acid, sodium acetate and their mixtures.
8) Preparation of buffer solutions of different pH using Sodium acetate-acetic acid and measurement of pH using pH meter
9) Preparation of buffer solutions of different pH using ammonium chloride-ammonium hydroxide and measurement of pH using pH meter
10) pH metric titration of any given strong acid vs. strong base
11) pH metric titration of any given weak acid vs. strong base.
12) Determination of dissociation constant of a weak acid.

Reference Books:

1. Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry,* R. Chand & Co.: New Delhi (2011).
2. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry 8th Ed*.; McGraw-Hill: New York (2003).
3. Halpern, A. M. & McBane, G. C. *Experimental Physical Chemistry 3rd Ed.;* W.H. Freeman & Co., New York (2003).
4. Athawale V. D. amd Mathur P. *Experimental Physical Chemistry*, New Age International, 2001.

5. Viswanathan, B., Raghavan, P.S., *Practical Physical Chemistry*, Viva Books Private Ltd, 2012
6. Maity, S.K., Ghosh, N.K., *Physical Chemistry Practicals*, New Central Book Agency Ltd, 1st Edition, 2012
7. A.Findlay, Practical Physical Chemistry (Longmans, Green and Co).
8. J.M.Wilson, K.J.Newcombe, A.R.Denko, R.M.W.Richett, Experiments in Physical Chemistry, (Pergamon Press).
9. 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	UCHTC41200	Organic Chemistry-II	3	1	0	4
2	Major	UCHPC41200	Organic Chemistry-II Laboratory	0	0	4	2
3	Major	UCHTC41201	Physical Chemistry-II	3	1	0	4
4	Major	UCHPC41201	Physical Chemistry-II Laboratory	0	0	4	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: Organic Chemistry-II ***Credits: 04***

Code	Type	Title	Credits	Hours	L	T	P
UCHTC41200	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: Understand the chemistry of various functional groups.
CLO-2: Understand the role of organometallic compounds in organic synthesis
CLO-3: Use reagents in various organic transformation reactions.
CLO-4: Understand the named reactions and their mechanisms.

Detailed Syllabus:

Unit-1: Chemistry of Halogenated Hydrocarbons:

Alkyl halides: Methods of preparation, nucleophilic substitution reactions – S_N1, S_N2 and S_Ni mechanisms with stereochemical aspects and effect of solvent etc.; nucleophilic substitution vs. elimination.

Aryl halides: Preparation, including preparation from diazonium salts. nucleophilic aromatic substitution; S_NAr, Benzyne mechanism.

Relative reactivity of alkyl, allyl/benzyl, vinyl and aryl halides towards nucleophilic substitution reactions.

Organometallic compounds of Mg and Li and their use in synthesis. **(12 hr)**

Unit-2: Alcohols, Phenols, Ethers and Epoxides

Alcohols: preparation, properties and relative reactivity of 1°, 2°, 3° alcohols, Bouvaelt-Blanc Reduction; Preparation and properties of glycols: Oxidation by periodic acid and lead tetraacetate, Pinacol-Pinacolone rearrangement.

Phenols: Preparation and properties; Acidity and factors effecting it, Ring substitution reactions, Reimer–Tiemann and Kolbe's–Schmidt Reactions, Fries and Claisen rearrangements with mechanism.

Ethers and Epoxides: Preparation and reactions with acids. Reactions of epoxides with alcohols, ammonia derivatives and LiAlH4 **(7 hr)**

Unit-3: Carbonyl Compounds

Structure, reactivity and preparation; Nucleophilic additions, Nucleophilic addition-elimination reactions with ammonia derivatives with mechanism; Mechanisms of Aldol and Benzoin condensation, Knoevenagel condensation, Claisen-Schmidt, Perkin, Cannizzaro and Wittig reaction, Beckmann and Benzil-Benzilic acid rearrangements, haloform reaction and Baeyer Villiger oxidation, α-substitution reactions, oxidations and reductions (Clemmensen, Wolff-Kishner, $LiAlH_4$, $NaBH_4$, MPV, PDC and PGC); Addition reactions of unsaturated carbonyl compounds: Michael addition. Active methylene compounds: Keto-enol tautomerism. Preparation and synthetic applications of diethyl malonate and ethyl acetoacetate.

(14 hr)

Unit-4: Carboxylic Acids and their Derivatives

Preparation, physical properties and reactions of monocarboxylic acids: Typical reactions of dicarboxylic acids, hydroxy acids and unsaturated acids: succinic/phthalic, lactic, malic, tartaric, citric, maleic and fumaric acids; Preparation and reactions of acid chlorides, anhydrides, esters and amides; Comparative study of nucleophilic substitution at acyl group - Mechanism of acidic and alkaline hydrolysis of esters, Claisen condensation, Dieckmann and Reformatsky reactions, Hofmann bromamide degradation and Curtius rearrangement. **(10 hr)**

Unit-4: Sulphur containing compounds

Preparation and reactions of thiols, thioethers and sulphonic acids. **(2 hr)**

Recommended Books/references:

1. Solomons, T.W. G., Fryhle, B. Craig. *Organic Chemistry,* John Wiley & Sons, Inc, 2009.

2. McMurry, J. E. *Fundamentals of Organic Chemistry,* Seventh edition Cengage Learning, 2013.

3. P. Sykes, *A Guide Book to Mechanism in Organic Chemistry*, 6th Edition, Orient Longman, New Delhi, 1997.

4. Morrison R. T. and Boyd R. N. Organic Chemistry, Sixth Edition Prentice Hall India, 2003.

5. Smith, M. B., March J., (Latest Ed.) *March's Advanced Organic Chemistry,* John Wiley and Sons, 6^{th} edition, New York.

Semester-IV: Organic Chemistry-II Laboratory ***Credits: 02***

Code	Type	Title	Credits	Hours	L	T	P
UCHPC41200	Major	Organic Chemistry-II Laboratory	2	4	0	0	4

Detailed Syllabus:

(List of experiments given are suggestive. One experiment from each group to be demonstrated)

I. Identification of elements (N, S, and halogen) and Functional group tests for alcohols, phenols, carbonyl, carboxylic acid and amine group of compounds.

II. Organic preparations:

1. Acetylation of one of the following compounds: amines (aniline, *o*-, *m*-, *p*-toluidines and *o*-, *m*-, *p*-anisidine) and phenols (β-naphthol, vanillin, salicylic acid) by any one method: (Using conventional method.and Using green chemistry approach)
2. Benzolyation of one of the amines (aniline, *o*-, *m*-, *p*- toluidines and *o*-, *m*-, *p*-anisidine) and one of the phenols (*β*-naphthol, resorcinol, *p*-cresol) by Schotten-Baumann reaction.
3. Oxidation of ethanol/ isopropanol (Iodoform reaction).
4. Bromination (any one)
    a) Acetanilide by conventional methods
    b) Acetanilide using green approach (Bromate-bromide method)
5. Nitration: (any one)
    a) Acetanilide/nitrobenzene by conventional method
    b) Salicylic acid by green approach (using ceric ammonium nitrate).
6. Selective reduction of *meta* dinitrobenzene to *m*-nitroaniline.
7. Reduction of *p*-nitrobenzaldehyde by sodium borohydride.
8. Hydrolysis of amides and esters.
9. Semicarbazone of any one of the following compounds: acetone, ethyl methyl ketone,
10. cyclohexanone, benzaldehyde.
11. *S*-Benzylisothiouronium salt of one each of water soluble/ insoluble acids (benzoic acid, oxalic acid, phenyl acetic acid and phthalic acid).
12. Aldol condensation with either conventional or green method.
13. Benzil-Benzilic acid rearrangement.
14. Collected solid samples may be used for recrystallization, melting point and TLC.

Recommended Books/References:

1. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry*, Pearson Education, 2009.

2. Furniss, B.S., Hannaford, A.J., Smith, P.W.G. & Tatchell, A.R. *Practical Organic Chemistry, 5th Ed.* Pearson, 2012.
3. Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis,* University Press, 2000.
4. Ahluwalia, V.K. & Dhingra, S. *Comprehensive Practical Organic Chemistry: Qualitative Analysis,* University Press, 2000.

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

Code	Type	Title	Credits	Hours	L	T	P
UCHTC41201	Major	Physical Chemistry-II	4	4	3	1	4

Course Learning Outcomes (CLOs)

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

CLO-1: Understand various laws of thermodynamics and theories of dilute solutions.
CLO-2: Apply the concept of heat of reactions in calculating bond energy, enthalpy, etc.
CLO-3: Understand the concept of entropy and the calculation of entropy using laws of thermodynamics.
CLO-4: Apply thermodynamics to partial molar quantities.
CLO-5: Recognize the problems in thermodynamics, thermochemistry and dilute solutions.

Detailed Syllabus:

Unit-1: Introduction to thermodynamics:

Intensive and extensive variables; state and path functions; isolated, closed and open systems; zeroth law of thermodynamics. *First law:* Concept of heat, *q*, work, *w*, internal energy, *U*, and statement of first law; enthalpy, *H*, relation between heat capacities, calculations of *q*, *w*, *U* and *H* for reversible, irreversible and free expansion of gases (ideal and van der Waals) under isothermal and adiabatic conditions. **(10 hr)**

Unit 2: Thermochemistry:

Heats of reactions: standard states; enthalpy of formation of molecules and ions and enthalpy of combustion and its applications; calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data, effect of temperature (Kirchhoff's equations), pressure on enthalpy of reactions. **(5 hr)**

Unit 3: Second Law

Concept of entropy; thermodynamic scale of temperature, statement of the second law of thermodynamics; molecular and statistical interpretation of entropy. Calculation of entropy change for reversible and irreversible processes. **(5 hr)**

Unit 4: Third law of thermodynamics:

Third Law of thermodynamics, residual entropy, calculation of absolute entropy of molecules **(5 hr)**

Unit 5: Free Energy Functions

Gibbs and Helmholtz energy; variation of S, G, A with T, V, P; Free energy change and spontaneity. Relation between Joule-Thomson coefficient and other thermodynamic parameters; inversion temperature; Gibbs-Helmholtz equation; Maxwell relations; thermodynamic equation of state. **(5 hr)**

Unit 6: Partial molar quantities:

Partial molar quantities, dependence of thermodynamic parameters on composition; Gibbs-Duhem equation, chemical potential of ideal mixtures, change in thermodynamic functions in mixing of ideal gases. **(5 hr)**

Unit 7: Dilute solutions

Dilute solutions; lowering of vapour pressure, Raoult's and Henry's Laws and their applications. Excess thermodynamic functions. Thermodynamic derivation using chemical potential to derive relations between the four colligative properties: [(i) relative lowering of vapour pressure, (ii) elevation of boiling point, (iii) Depression of freezing point, (iv) osmotic pressure] and amount of solute. Applications in calculating molar masses of normal, dissociated and associated solutes in solution. **(10 hr)**

Recommended Books/References:

1. Atkins P. and De Paula, J. *Physical Chemistry* Tenth Ed., OUP, 2014.
2. Castellan, G. W. *Physical Chemistry 4th Ed.,* Narosa, 2004.
3. Engel, T. and Reid, P. *Physical Chemistry 3rd Ed.,* Prentice Hall, 2012.
4. McQuarrie, D. A. and Simon, J. D. *Molecular Thermodynamics* Viva Books, 2004.
5. Roy, B. N. Fundamentals of Classical and Statistical Thermodynamics Wiley, 2001
6. *Commonly Asked Questions in Thermodynamics.* CRC Press, 2011.
7. Levine, I .N. *Physical Chemistry* 6th Ed., Tata Mc Graw Hill, 2010.
8. Metz, C.R. *2000 solved problems in chemistry,* Schaum Series, 2006.
9. Rajaram J, Kuriacose J. C., Chemical Thermodynamics: Classical, Statistical and Irreversible, Pearson Education India, 1st Edition, 2013.

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

Semester-IV: *Physical Chemistry-II Laboratory* ***Credits: 02***

Code	Type	Title	Credits	Hours	L	T	P
UCHPC41201	Major	Physical Chemistry-II Laboratory	2	4	0	0	4

Detailed Syllabus:

I. Phase equilibrium

1) Determination of critical solution temperature and composition of the phenol-water system and to study the effect of impurities on it.

2) Study of two component simple eutectic system

II. Study the equilibrium of the following reactions by the distribution method:

3) I_2 (aq) + I^- $\rightarrow$ I_3^-(aq)

4) Cu^{2+}(aq) + $n$$NH_3$ $\rightarrow$ $Cu(NH_3)_n$

III. Study the kinetics of the following reactions.

5) Acid hydrolysis of methyl acetate with hydrochloric acid.

6) Saponification of ethyl acetate.

7) Determination of rate constant of reaction between potassium persulfate and potassium iodide by titration.

IV. Adsorption

8) Verification of Freundlich adsorption isotherm

9) Verification of Langmuir isotherm for adsorption on acidic acid or organic dyes on activated charcoal.

V. Thermodynamics based experiments

10) Heat of solution of oxalic acid from solubility measurements

11) Heat of neutralisation of a given strong acid by a strong base

12) Partition coefficient for the distribution of iodine between water and CCl_4

Recommended Books/References:

1. Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry*, R. Chand, New Delhi, 2011.

2. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry*, Eighth Edition, McGraw-Hill, 2003.
3. Halpern, A. M. and McBane, G. C. *Experimental Physical Chemistry*, Third Edition, W, H. Freeman, 2003.
4. Viswanathan, 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, 1st Edition, 2012

Semester-V — No. of credits = 20

SEMESTER-V							
S.No.	Category of Course	Course Code	Course Title	Hours			Credits
				L	T	P	
1	Major	UCHTC51202	Organic Chemistry-III	3	1	0	4
2	Major	UCHPC51202	Organic Chemistry-III Laboratory	0	0	4	2
3	Major	UCHTC51300	Inorganic Chemistry-II	3	1	0	4
4	Major	UCHPC51300	Inorganic Chemistry-II Laboratory	0	0	4	2
5	Major	UCHTC51301	Introduction to Quantum Chemistry	3	1	0	4
6	Minor		Physics / Mathematics / Life Science	3	1	0	4
Total				12	4	8	**20**

Semester-V: Organic Chemistry-III — ***Credits: 04***

Code	Type	Title	Credits	Hours	L	T	P
UCHTC51202	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: Understand the nitrogen containing compounds, heterocycles, polynuclear hydrocarbons and their reactions
CLO-2: Elucidate the structures of alkaloids and terepenes.

CLO-3: Understand the synthesis and applications of nitriles, isonitriles, amines and diazonium salts.
CLO-4: Derivatize naphthalene and anthracene.
CLO-5: Write the named reactions and their mechanisms related to heterocyclic compounds.

Detailed Syllabus:

Unit-1: Nitrogen Containing Functional Groups

Preparation and important reactions of nitro and compounds, nitriles and isonitriles Amines: Effect of substituent and solvent on basicity; Preparation and properties: Gabriel phthalimide synthesis, Carbylamine reaction, Mannich reaction, Hoffmann's exhaustive methylation, Hofmann-elimination reaction; Distinction between 1°, 2° and 3° amines with Hinsberg reagent and nitrous acid. Diazonium salts: Preparation and synthetic applications. **(9 hr)**

Unit-2: Polynuclear Hydrocarbons

Reactions of naphthalene phenanthrene and anthracene Structure, Preparation and structure elucidation and important derivatives of naphthalene and anthracene; Polynuclear hydrocarbons. **(7 hr)**

Unit-3: Heterocyclic Compounds

Classification and nomenclature, Structure, aromaticity in 5-numbered and 6-membered ring containing one heteroatom; Synthesis, reactions and mechanism of substitution reactions of Furan, Pyrrole (Paal-Knorr synthesis, Knorr pyrrole synthesis, Hantzsch synthesis), Thiophene, Pyridine (Hantzsch synthesis), Pyrimidine, Structure elucidation of indole, Fischer indole synthesis and Madelung synthesis), Structure elucidation of quinoline and isoquinoline, Skraup synthesis, Friedlander's synthesis, Knorr quinoline synthesis, Doebner-Miller synthesis, Bischler-Napieralski reaction, Pictet-Spengler reaction, Pomeranz-Fritsch reaction Derivatives of furan: Furfural and furoic acid. **(14 hr)**

Unit-4: Alkaloids

Natural occurrence, General structural features, Isolation and their physiological action, Hoffmann's exhaustive methylation, Emde's modification, Structure elucidation and synthesis of Hygrine and Nicotine. Medicinal importance of Nicotine, Hygrine, Quinine, Morphine, Cocaine, and Reserpine. **(7 hr)**

Unit-5: Terpenes & Steroids

Occurrence, classification, isoprene rule; Elucidation of stucture and synthesis of Citral, Neral and α-terpineol. Introduction to steroids, classification, Cholesterol, Introduction to steroidal

hormones. **(8 hr)**

Recommended Text Books/references:

1.Morrison, R. T., Boyd, R. N., Bhatterjee, S.K., Organic Chemistry, 7th Edn., Pearson.

2. Acheson, R.M. *Introduction to the Chemistry of Heterocyclic compounds*, John Welly & Sons, 1976.

3. Solomons, T.W., Fryhle Craig, *Organic Chemistry*, John Wiley & Sons, Inc, 2009.

4. McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition,

2013.

5. Kalsi, P. S. *Organic reacations and their mechanisms*, New Age Science, 2010.

6. Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; *Organic Chemistry*, Oxford University Press Inc., New York, 2001.

7. Singh, J.; Ali, S.M. & Singh, J. *Natural Product Chemistry*, Prajati Parakashan (2010).

8. Bansal R. K. *Heterocyclic Chemistry: Syntheses, Reactions and Mechanisms*, New Age, Third Edition (1999).

9. Clayden J., Greeves N., Warren S., Organic Chemistry, (2nd Ed)., (2012), Oxford University Press.

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

Code	Type	Title	Credits	Hours	L	T	P
UCHPC51202	Major	Organic Chemistry – III Laboratory	2	4	0	0	4

Detailed Syllabus:

1. Qualitative analysis of unknown organic compounds containing monofunctional groups (carbohydrates, aryl halides, aromatic hydrocarbons, nitro compounds, amines and amides) and simple bifunctional groups, for e.g. salicylic acid, cinnamic acid, nitrophenols, etc.

2. Identification of functional groups of simple organic compounds by IR spectroscopy and NMR spectroscopy (IR and NMR of simple organic compounds may be done wherever facilities are available, otherwise sample spectra may be provided for simple organic compounds like Ethanol, Aniline, Phenol, acetic acid, other simple aldehydes, carboxylic acid, etc., for identification of functional groups. References from standard spectroscopy books may also be taken for such purpose for enhancing students understanding and skill).

3. Preparation of methyl orange.

4. Extraction of caffeine from tea leaves.

5. Analysis of Carbohydrate: aldoses and ketoses, reducing and non-reducing sugars using simple lab procedures.

Reference books:

1.Vogel, A.I. *Quantitative Organic Analysis,* Part 3, Pearson (2012).

2. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry,* Pearson Education (2009)

3. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. *Practical Organic Chemistry, 5th Ed.*, Pearson, 2012.

4. Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis,* University Press, 2000.

5. Ahluwalia, V.K. & Dhingra, S. *Comprehensive Practical Organic Chemistry: Qualitative Analysis,* University Press, 2000.

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

Code	Type	Title	Credits	Hours	L	T	P
UCHTC51300	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: Recognize the importance of reduction potential in the extraction of metals.
CLO-2: Understand different physical and chemical methods used for metal refining.
CLO-3: Understand the chemistry of berrylium, boron, silicon, nitrogen, phosphorous, sulphur and halogen compounds.
CLO4: Apply bonding theories to elucidate the structure of noble gas compounds.
CLO-5: Understand the synthesis and properties of inorganic polymers.

Detailed Syllabus:

Unit-1: Oxidation-Reduction and general principle of metallurgy

Redox equations, Standard Electrode Potential and its application to inorganic reactions. Occurrence of metals based on standard electrode potentials. Ellingham diagrams for reduction of metal oxides using carbon or carbon monoxide as reducing agent. Electrolytic Reduction, Hydrometallurgy. Methods of purification of metals: Electrolytic Kroll process, Parting process, van Arkel- de Boer process and Mond's process, Zone refining. (**15 Hrs**)

Unit-2: Chemistry of *s* and *p* Block Elements:

Inert pair effect, Relative stability of different oxidation states, diagonal relationship and anomalous behavior of first member of each group. Allotropy and catenation. Complex, formation tendency of *s* and *p* block elements. Hydrides and their classification ionic, covalent and interstitial. Basic beryllium acetate and nitrate. Structure, bonding, preparation properties and uses. Boric acid and borates, boron nitrides, borohydrides (diborane), carboranes and graphitic compounds, silanes, Oxides and oxoacids of nitrogen, Phosphorus and chlorine. Per-oxo acids of Sulphur inter-halogen compounds, polyhalide ions, pseudo-halogens, properties of halogens. (**20 Hrs**)

Unit-3: Noble Gases:

Occurrence and uses, rationalization of inertness of noble gases, Clathrates; preparation and properties of XeF_2, XeF_4 and XeF_6; Bonding in noble gas compounds (Valence bond and MO treatment for XeF_2), Shapes of noble gas compounds (VSEPR theory). (**5 Hrs**)

Unit-4: Inorganic Polymers:

Types of inorganic polymers, comparison with organic polymers, synthesis, structural aspects and applications of silicones and siloxanes. Borazines, silicates and phosphazenes, and polysulphates. (**5 Hrs**)

Recommended books/references:

1 Lee, J.D. *Concise Inorganic Chemistry*, ELBS, 1991.

2 Douglas, B.E; Mc Daniel, D.H. & Alexander, J.J. *Concepts & Models of Inorganic Chemistry 3rd Ed.*, John Wiley Sons, N.Y. 1994.

3 Greenwood, N.N., Earnshaw. *Chemistry of the Elements*, Butterworth-Heinemann. 1997.

4 Cotton, F.A. & Wilkinson, G. *Advanced Inorganic Chemistry*, Wiley, VCH, 1999.

5 Rodger, G.E. *Inorganic and Solid State Chemistry*, Cengage Learning India Edition, 2002.

6 Miessler, G. L. & Donald, A. Tarr. *Inorganic Chemistry* Fourth Ed., Pearson, 2010

7 Atkins, P. W and Shriver D. N. *Atkins' Inorganic Chemistry* 5th Ed. Oxford University Press (2010).

8. Mingos, D. M. P., *Essential Trends in Inorganic Chemistry*, Oxford University Press, 1998.

9. Wulfsberg G., *Inorganic Chemistry*, Viva Students Edition, 2002.

10. Allcock, H. R.,*Inorganic Polymers*, Oxford University Press, 2005.

Semester-V: Inorganic Chemistry-II Laboratory ***Credits: 02***

Code	Type	Title	Credits	Hours	L	T	P
UCHPC51300	Major	Inorganic Chemistry-II Laboratory	2	4	0	0	4

Course Learning Outcomes (CLOs)

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

CLO-1: Identify the cations in a given mixture or alloy or ore
CLO-2: Understand the chemistry behind the group separation of each cation
CLO-3: Differentiate interfering and noninterfering cations.
CLO4: Apply this knowledge in characterizing counter anions in metal complexes.

Detailed Syllabus:

A mixture of inorganic salts which contains two cations and 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

References

1. V.V. Ramanujam, Inorganic Semimicro qualitative analysis, National Publishing company, Madras, 1974

Semester-V: Introduction to Quantum Chemistry ***Credits: 04***

Code	Type	Title	Credits	Hours	L	T	P
UCHTC51301	Major	*Introduction to Quantum 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 fundamentals of quantum chemistry.
CLO-2: Develop problem-solving ability in quantum chemistry.
CLO-3: Recognize the role of multidisciplinary streams especially basic physics &

mathematics knowledge in the development of quantum chemistry,

CLO-4: Apply the fundamental knowledge in quantum chemistry & thermodynamics to an existing and emerging problem in basic science

Detailed Syllabus:

Unit-I:

Introduction to black-body radiation and distribution of energy, photo-electric effect, concept of quantization, wave particle duality (de-Broglie's hypothesis), The uncertainty principle, the wave function: wave function and its interpretation, conditions of normalization and Orthogonality and its significance. Basic idea about operators, eigen function and values, Schrodinger equation and application to free-particle and particle in a box, boundary conditions, wave functions and energies, degeneracy, hydrogen atom, Schrodinger equation in polar coordinates, radial and angular parts of the hydrogenic orbitals, degeneracies, spherical harmonics, representations of hydrogenic orbitals. (**15 hr**)

Unit-II:

Quantitative treatment of simple harmonic oscillator model, setting up of Schrodinger equation and discussion of solution of wave functions. Rigid rotator model and discussion of application of Schrodinger equation. idea about transformation to spherical polar coordinate, discussion on solution. (**15 hr**)

Unit-III:

Qualitative treatment of hydrogen atom and hydrogen-like ions: setting up of Schrödinger equation in spherical polar coordinates, radial part, quantization of energy (only final energy expression). Average and most probable distances of electron from nucleus. Valence bond and molecular orbital approaches, LCAO-MO treatment of H_2, H_2^+; bonding and anti-bonding orbitals, Comparison of LCAO-MO and VB treatments of H_2 (only wavefunctions, detailed solution not required) and their limitations. (**15 hr**)

Recommended books/References:

1. Laideler K. J. and Meiser J. M. *Physical Chemistry* Third Edition (International)1999
2. Levine I. N., *Physical Chemistry,* Fourth Edition), McGraw-Hill (International), 1995.
3. McQuarrie D. A. and Simon J. D. *Physical Chemistry- A Molecular Approach,* University Science Books, 1998.
4. Chandra, A. K. *Introductory Quantum Chemistry* Tata McGraw-Hill (2001).
5. House, J. E. *Fundamentals of Quantum Chemistry* 2nd Ed. Elsevier: USA (2004).
6. McQuarrie D. A. *Quantum Chemistry*, Viva Publications (2016).

7. Atkins P. and De Paula, J. *Physical Chemistry* Tenth Ed., OUP, 2014.
8. Puri, B. R, Sharma, L.R, Pathania, M.S., Principles of Physical Chemistry, Vishal Publishing Co., 47th Edition, **2020**
9. Kapoor K. L., A Textbook of Physical Chemistry, Volume 1 to Volume 6, McGraw Hill Education (India) Private Limited, **2015**

Semester-VI No. of credits = 20

SEMESTER-VI							
S.No.	Category of Course	Course Code	Course Title	Hours			Credits
				L	T	P	
1	Major	UCHTC61302	Molecular Spectroscopy & Photochemistry	3	1	0	4
2	Major	UCHPC61301	Spectroscopy Laboratory	0	0	4	2
3	Major	UCHTC61303	Physical Chemistry-III	3	1	0	4
4	Major	UCHPC61302	Physical Chemistry-III Laboratory	0	0	4	2
5	Major	UCHTC61304	Inorganic Chemistry-III	3	1	0	2
6	Major	UCHPC61303	Inorganic Chemistry-III Laboratory	0	0	4	4
7	Internship		Chemistry Internship	0	0	4	2
Total				11	3	12	**20**

Semester-VI: Molecular Spectroscopy & Photochemistry Credits: 04

Code	Type	Title	Credits	Hours	L	T	P
UCHTC61302	Major	Molecular Spectroscopy & Photochemistry	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 concepts of rotational, vibrational, Raman and electronic spectroscopy.
CLO-2: Apply the concept in solving problems in spectroscopy.
CLO-3: Understand the laws of photochemistry, quantum yield, fluorescence and Phosphorescence.
CLO-4: Understand the kinetics of photochemical reactions.

Detailed Syllabus:

Unit-1:

Interaction of electromagnetic radiation with molecules and various types of spectra; Born-Oppenheimer approximation. Rotation spectroscopy: Selection rules, intensities of spectral lines, determination of bond lengths of diatomic and linear triatomic molecules, isotopic substitution.

Vibrational spectroscopy: Classical equation of vibration, computation of force constant, amplitude of diatomic molecular vibrations, anharmonicity, Morse potential, dissociation energies, fundamental frequencies, overtones, hot bands, degrees of freedom for polyatomic molecules, modes of vibration, concept of group frequencies. Vibration-rotation spectroscopy: diatomic vibrating rotator, P, Q, R branches. **(15 hr)**

Unit-2:

Raman spectroscopy: Qualitative treatment of Rotational Raman effect; Effect of nuclear spin, Vibrational Raman spectra, Stokes and anti-Stokes lines; their intensity difference, rule of mutual exclusion.

Electronic spectroscopy: Franck-Condon principle, electronic transitions, singlet and triplet states, fluorescence and phosphorescence, dissociation and predissociation. **(15 hr)**

Unit-3: Photophysical and photochemical processes:

Laws of photochemistry, quantum yield. Jablonski diagrams: Franck-Condon principle, Law of photochemical equivalence, quantum efficiency, low and high quantum efficiency. kinetics of photochemical reactions ($H_2 + Br_2 = HBr$, $2HI = H_2 + I_2$), energy transfer in photochemical reactions (photosensitization and quenching), fluorescence, phosphorescence, chemiluminescence, Discussion of Electronic spectra and photochemistry (Lambert-Beer law and its applications). **(15 hr)**

Recommended books/References:

1. Laideler K. J. and Meiser J. M. *Physical Chemistry* Third Edition (International)1999

2. Levine I. N., *Physical Chemistry*, Fourth Edition), McGraw-Hill (International), 1995.

3. McQuarrie D. A. and Simon J. D. *Physical Chemistry- A Molecular Approach*, University Science Books, 1998

4. Rohatgi-Mukherjee K. K. Fundamentals of Photochemistry, New age (revised second edition).

5. Banwell, C. N. & McCash, E. M. *Fundamentals of Molecular Spectroscopy* 4th Ed. Tata

McGraw-Hill: New Delhi (2006).

Semester-VI: Spectroscopy Laboratory ***Credits: 02***

Code	Type	Title	Credits	Hours	L	T	P
UCHPC61301	Major	Spectroscopy Laboratory	2	4	0	0	4

Detailed Syllabus:

I. Determination of indicator constant - colorimetry. (instructor may vary indicators available in the lab).

II. Verification of Beer's Law - Determination of concentration of solution by colorimetry. (Instructor may explain the principle of using colorimeter, its handling drawing standard calibration curve, and its application in finding unknown concentration of dyes, concentration of metal solutions (*e.g.*Ni, Cu using appropriate reagent) from standard calibration curve.

Suggested books/reference books:

1. Practicals in physical chemistry – a modern approach, P.S.Sindhu, Macmillan,
2. Experiments in Physical Chemistry, J.M.Wilson, R.J.Newcomb, A.R.Denaro, 2nd Edn., Elsevier.
3. Viswanathan, B., Raghavan, P.S., Practical Physical Chemistry, Viva Books Private Ltd, 2012
4. Maity, S.K., Ghosh, N.K., Physical Chemistry Practicals, New Central Book Agency Ltd, 1st Edition, 2012

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

Code	Type	Title	Credits	Hours	L	T	P
UCHTC61303	Major	Physical 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 the fundamentals of phase equilibria, chemical kinetics, and colloid & surface chemistry
CLO-2: Develop problem-solving ability in phase equilibria, kinetics, and surface chemistry
CLO-3: Recognize the role of basic physics & mathematics along with the role of colloid & surface science knowledge in the development of chemistry
CLO-4: Apply the fundamental knowledge in kinetics, and surface chemistry to chemical r reactions.

Detailed Syllabus:

Unit-1: Phase Equilibria

Concept of phases, components and degrees of freedom, derivation of Gibbs Phase Rule for nonreactive and reactive systems; Clausius-Clapeyron equation and its applications to solid-liquid, liquid-vapour and solid-vapour equilibria, phase diagram for one component systems, with applications. Phase diagrams for systems of solid-liquid equilibria involving eutectic, congruent and incongruent melting points, solid solutions. Three component systems, water-chloroform-acetic acid system, triangular plots. *Binary solutions:* Gibbs-Duhem-Margules equation, its derivation and applications to fractional distillation of binary miscible liquids (ideal and nonideal), azeotropes, lever rule, partial miscibility of liquids, CST, miscible pairs, steam distillation. Nernst distribution law: its derivation and applications. **(15 hr)**

Unit-2: Chemical Kinetics

Order and molecularity of a reaction, rate laws in terms of the advancement of a reaction, differential and integrated rate laws for first, second and fractional order reactions, pseudounimolecular reactions, determination of the order, kinetics of complex reactions (limited to first order): (i) Opposing reactions (ii) parallel reactions and (iii) consecutive reactions and their differential rate equations (steady-state approximation in reaction mechanisms) (iv) chain reactions. Temperature dependence of reaction rates; Arrhenius equation; activation energy. Collision theory of reaction rates, Lindemann mechanism, qualitative treatment of the theory of absolute reaction rates. **(15 hr)**

Unit-3: Catalysis:

Types of catalyst, specificity and selectivity, mechanisms of catalyzed reactions at solid surfaces; effect of particle size and efficiency of nanoparticles as catalysts. Enzyme catalysis, Michaelis- Menten mechanism, acid-base catalysis. **(7 hr)**

Unit-4: Surface chemistry:

Physical adsorption, chemisorption, adsorption isotherms (Freundlich, Temkin, Derivation of Langumuir adsorption isotherms, surface area determination), BET theory of multilayer adsorption (no derivation), Adsorption in solution. **(8 hr)**

Recommended books/References:

1. Atkins P. W. and De Paula J., *Physical Chemistry, (*tenth edition) Oxford University Press, 2014.
2. Castellan, G. W. *Physical Chemistry*, 4th Ed., Narosa, 2004.

3. McQuarrie, D. A. & Simon, J. D., *Molecular Thermodynamics*, Viva Books, 2004.
4. Engel, T. & Reid, P. *Physical Chemistry* Third Edition, Prentice-Hall,2012.
5. Zundhal, S.S. *Chemistry concepts and applications* Cengage India, 2011
6. Ball, D. W. *Physical Chemistry* Cengage India, 2012.
7. Mortimer, R. G. *Physical Chemistry 3rd Ed.*, Elsevier: NOIDA, UP, 2009.
8. Levine, I. N. *Physical Chemistry 6th Ed.*, Tata McGraw-Hill, 2011.
9. Metz, C. R. *Physical Chemistry 2nd Ed.*, Tata McGraw-Hill, 2009.
10. Adamson, A. W, Gast, A. P., *Physical Chemistry of Surfaces*, 6th Edi. Wiley India Pvt Ltd, 2011.
11. Puri, B. R, Sharma, L.R, Pathania, M.S., *Principles of Physical Chemistry*, Vishal Publishing Co., 47th Edition, **2020**
12. Kapoor K. L., A *Textbook of Physical Chemistry*, Volume 1 to Volume 6, McGraw Hill Education (India) Private Limited, **2015**

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

Code	Type	Title	Credits	Hours	L	T	P
UCHPC61302	Major	Physical Chemistry – III Laboratory	2	4	0	0	4

Detailed Syllabus:

I. Conductometry

1. Determination of cell constant
2. Equivalent conductance, degree of dissociation and dissociation constant of a weak acid.
3. Verification of Ostwald's dilution law

II.Conductometric titrations of:

4. Strong acid Vs. strong base
5. Weak acid vs. strong base,
6. Mixture of strong acid and weak acid vs. strong base, Strong acid vs. weak base.

III. Potentiometric titration of

7. Strong acid vs. strong base
8. Weak acid vs. strong base
9. Dibasic acid vs. strong base
10. Potassium dichromate vs. Mohr's salt.

11. Any Redox titration
12. Any Precipiation titration

Recommend books/References:

1. Khosla, B. D.; Garg, V. C. and Gulati, A. *Senior Practical Physical Chemistry*, R. Chand New Delhi, 2011.
2. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry* Eighth Edition*;* McGraw-Hill: New York, 2003.
3. Halpern, A. M. and McBane, G. C. *Experimental Physical Chemistry 3rd Ed.;* W.H. Freeman & Co.: New York, 2003.
4. Viswanathan, 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, 1st Edition, 2012

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

Code	Type	Title	Credits	Hours	L	T	P
UCHTC61304	Major	Inorganic 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 the basics of coordination chemistry including IUPAC nomenclature, geometry, and chelate effect.
CLO-2: Describe the bonding theories such as VBT and CFT (high spin and low spin) and applications of CFSE.
CLO-3: Recognize the oxidation state and its properties of 3d-metal compounds
CLO-4: Understand the importance of the bulk and trace metal ions in the biological system.

Detailed Syllabus:

Unit-1: Coordination Chemistry

Double salts, coordination compounds, IUPAC nomenclature of coordination compounds of mono-, di-, tri-nuclear metal complexes with stereochemical descriptors, configuration index, chirality symbol, Werner's theory, EAN rule, electroneutrality principle, valence bond theory (inner and outer orbital complexes for octahedral complexes), Crystal field theory, d-orbital splitting, weak and strong fields, pairing energies, factors affecting the magnitude of (Δ).

Octahedral vs. tetrahedral coordination, tetragonal distortions from octahedral geometry Jahn-Teller theorem, square planar complexes, CFSE, Variation of lattice energies, enthalpies of hydration and crystal radii variations in halides of first and second row transition metal series, spin only magnetic moments of metal complexes, Qualitative aspect of Ligand field theory, isomerism in coordination compounds. electronic and steric effects and symbiosis, Prussian blue and its related structures, stereochemistry of complexes with the coordination number 4 and 6, Chelate effect. **(15 Hrs)**

Unit-2: Transition Elements

General group trends with special reference to electronic configuration, colour, variable valency, metallic character, size, melting and boiling points, reactivity, ionization energy, magnetic and catalytic properties, and ability to form complexes. Stability of various oxidation states and e.m.f. (Latimer & Ebsworth diagrams). Difference between the first, second and third transition series. Chemistry of Ti, V, Cr Mn, Fe, Co, Ni and Cu in various oxidation states (excluding their metallurgy) **(10 Hrs)**

Unit-3: Lanthanoids and Actinides

Electronic configuration, oxidation states, color, spectra and magnetic behavior, lanthanide contraction, separation of lanthanides (ion-exchange method only). **(5 Hrs)**

Unit-4: Bioinorganic Chemistry

Metal ions present in biological systems, classification of elements according to their action in biological system. Geochemical effect on distribution of metals. Sodium / K-pump, carbonic anhydrase and carboxypeptidase. Excess and deficiency of some trace metals. Toxicity of metal ions (Hg, Pb, Cd and As), toxicity, chelating agents in medicine. Iron and its application in biosystems, Haemoglobin; Storage and transfer of iron. **(10 Hrs)**

Recommended text books/References:

1. Purcell, K.F & Kotz, J.C. *Inorganic Chemistry* W.B. Saunders Co, 1977.
2. Lee, J. D. *Concise Inorganic Chemistry*, Prentice Hall, 5th Edition, 2008.
3. Huheey, J.E., *Inorganic Chemistry*, Prentice Hall, 1993.
4. Cotton, F.A. & Wilkinson, G, *Advanced Inorganic Chemistry* Wiley-VCH, 1999.
5. Housecroft, C. E. and Sharpe, A. G., *Inorganic Chemistry*, 4th Edition, Pearson Edu, Ltd, 2018.
6. Wulfsberg G., *Inorganic Chemistry*, Viva Students Edition, 2002.
7. Miessler, G. L. & Donald, A. Tarr. *Inorganic Chemistry* Fourth Ed., Pearson, 2010
8. Lippard, S.J. & Berg, J.M. *Principles of Bioinorganic Chemistry* Panima Publishing Company, 1994.

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

Code	Type	Title	Credits	Hours	L	T	P
UCHPC61303	Major	Inorganic Chemistry Laboratory-III	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 analytical techniques to arrive at the correct structure.
CLO-5: Design and synthesize of a new compound using modified procedure.

Detailed Syllabus:

1) Determination of Composition of the Cu-EDTA complex by Job's Method (Stability constant)

2) Preparation and characterization of nitro- and nitrito-pentamminecobalt(III) chloride (isomerism)

3) Preparation and characterization of tris(acetylacetonato) manganese(III) (chelate effect)

4) Determination of Δ_o of Ni(II) complexes

6) Preparation and magnetic studies of $[Ni(NCS)_2(PPh_3)_2]$ (CN=4 complex)

7) Preparation of Cu^+ salts such as CuI and CAN

8) Controlled synthesis of two copper oxalate hydrate complexes: kinetic vs thermodynamic factors.

9) Preparation of acetylacetanato complexes of Cu^{2+}/Fe^{3+}. (Also find the λ_{max} of the prepared complex using instrument).

10) Synthesis of ammine complexes of Ni(II) and its ligand exchange reactions (e.g. bidentate ligands like acetylacetone, DMG, glycine) by substitution method.

Recommended text books/references:

1.Szafrran Z, et al *Microscale Inorganic chemistry*, John Wiley & Sons, 1991.

2. Marr & Rockett *Practical Inorganic Chemistry*. John Wiley & Sons 1972.

Semester-VII No. of credits = 20

SEMESTER-VII							
S.No.	Category of Course	Course Code	Course Title	Hours			Credits
				L	T	P	
1	Major	UCHTC71400	Analytical Chemistry	3	1	0	4
2	Major	UCHPC71400	Analytical Chemistry Laboratory	0	0	4	2
3	Major	UCHTC71401	Chemistry of Materials	3	1	0	4
4	Major	UCHPC71401	Materials Chemistry 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: Analytical Chemistry ***Credits: 04***

Code	Type	Title	Credits	Hours	L	T	P
UCHTC71400	Major	Analytical Chemistry	4	4	3	1	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-1: Qualitative and quantitative aspects of analysis

Tools in analytical chemistry and their applications, Sampling, evaluation of analytical data, errors, accuracy and precision, statistical test of data; F, Q and t-test, rejection of data, and confidence intervals. **(8 hr)**

Unit-2: Spectroscopy

Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules, validity of Beer-Lambert's law.

Vibration spectroscopy: Basic principles of instrumentation, sampling techniques. Application of IR spectroscopy for characterization through interpretation of data, Effect and importance of isotope substitution. Introduction to Raman spectra

UV-Visible Spectrometry: Basic principles of instrumentation, principles of quantitative analysis using estimation of metal ions from aqueous solution, Determination of composition of metal complexes using Job's method of continuous variation and mole ratio method. **(10 hr)**

Unit-3: Thermal analysis

Theory of thermogravimetry (TG and DTG), instrumentation, estimation of Ca and Mg from their mixture. **(6 hr)**

Unit-4: Electroanalytical methods

Classification of electroanalytical methods, basic principle of pH metric, potentiometric and conductometric titrations. Techniques used for the determination of equivalence points. determination of pKa values. **(6 hr)**

Unit-5: Separation techniques

Solvent extraction: Classification, principle and efficiency of the technique. Mechanism of extraction: extraction by solvation and chelation. Technique of extraction: batch, continuous and counter current extractions. Qualitative and quantitative aspects of solvent extraction: extraction of metal ions from aqueous solution, extraction of organic species from the aqueous and nonaqueous media.

Chromatography techniques: Classification, principle and efficiency of the technique. Mechanism of separation: adsorption, partition & ion exchange. Development of chromatograms: frontal, elution and displacement methods. Qualitative and quantitative aspects of chromatographic methods of analysis using LC, GLC, TLC and HPLC. **(15 hr)**

Reference books:

1. Mendham, J., *A. I. Vogel's Quantitative Chemical Analysis 6th Ed.,* Pearson, 2009.
2. Willard, H.H. *et al*.: *Instrumental Methods of Analysis*, 7th Ed. Wardsworth Publishing, California, USA, 1988.
3. Christian, G.D, *Analytical Chemistry*, 6th Ed. John Wiley & Sons, New York, 2004.
4. Harris, D.C.: *Exploring Chemical Analysis*, 9th Ed. New York, W.H. Freeman, 2016.
5. Skoog, D.A. Holler F.J. & Nieman, T.A. *Principles of Instrumental Analysis, Saunder College Publications,* 1998.

6. Mikes, O. *Laboratory Hand Book of Chromatographic & Allied Methods*, Elles Harwood John Wiley 1979.
7. Ditts, R.V. Analytical Chemistry; Methods of separation, van Nostrand, 1974.
8. Khopkar, S. M., Basic Concepts of Analytical Chemistry, New Age (Second edition,1998.
9. Skoog D.A., Holler F.J., Nieman T.A., Principles of instrumental analysis, 5th Edn., Brooks & Cole, 1997.

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

Code	Type	Title	Credits	Hours	L	T	P
UCHPC71400	Major	Analytical Chemistry Laboratory	2	4	0	0	4

Detailed Syllabus:

(Recommended to carry out at least two experiments from each section)

I. Chromatography:

(i) Paper chromatographic separation of Fe3+, Al3+, and Cr3+.

(ii) Separation and identification of the monosaccharides present in the given mixture (glucose & fructose) by paper chromatography. Reporting the Rf values.

iii. Separate a mixture of Sudan yellow and Sudan Red by TLC technique and identify them on the basis of their Rf values.

(iv) Chromatographic separation of the active ingredients of plants, flowers and juices by TLC

II. Solvent Extractions:

(i) To separate a mixture of Ni2+ & Fe2+ by complexation with DMG and extracting the Ni2+-DMG complex in chloroform, and determine its concentration by spectrophotometry.

ii. Determine the pH of the given aerated drinks fruit juices, shampoos and soaps.

iii. Determination of Na, Ca, Li in cola drinks and fruit juices using flame photometric techniques.

III. Analysis of soil:

(i) Determination of pH of soil.

(ii) Total soluble salt

(iii) Estimation of calcium, magnesium, phosphate, nitrate

IV. Ion exchange:

(i) Determination of exchange capacity of cation exchange resins and anion exchange resins.

(ii) Separation of metal ions from their binary mixture.

(iii) Separation of amino acids from organic acids by ion exchange chromatography.

V. Spectrophotometry

(i). Determination of pKa values of indicator using spectrophotometry.

(ii) Structural characterization of compounds by infrared spectroscopy.

(iii) Determination of dissolved oxygen in water.

(iv) Determination of chemical oxygen demand (COD).

(v) Determination of Biological oxygen demand (BOD).

(vi) Determine the composition of the Ferric-salicylate/ ferric-thiocyanate complex by Job's method.

Recommended text books/references:

1. Mendham, J., *A. I. Vogel's Quantitative Chemical Analysis 6th Ed.,* Pearson, 2009.

2. Willard, H.H. *et al.*: *Instrumental Methods of Analysis*, 7th Ed. Wardsworth Publishing Company, Belmont, California, USA, 1988.

3. Christian, G.D. *Analytical Chemistry*, 6th Ed. John Wiley & Sons, New York, 2004.

4. Harris, D.C. *Exploring Chemical Analysis*, 9th Ed. New York, W.H. Freeman, 2016.

5. Khopkar, S.M. *Basic Concepts of Analytical Chemistry*. New Age International Publisher, 2009.

6. Skoog, D.A. Holler F.J. and Nieman, T.A. *Principles of Instrumental Analysis*, Cengage Learning India Edition.

7. Mikes, O. & Chalmes, R.A. *Laboratory Handbook of Chromatographic & Allied Methods*, Elles Harwood Ltd. London.

8. Ditts, R.V. *Analytical Chemistry: Methods of separation.* Van Nostrand, New York, 1974.

Semester-VII: Chemistry of Materials ***Credits: 04***

Code	Type	Title	Credits	Hours	L	T	P
UCHTC71401	Major	Chemistry of Materials	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 chemistry of crystalline solids, silica based mateirals, ionic liquids, composite materials.

CLO-2: Understand the technological importance of ionic liquids, preparation of materials– using sol-gel techniques.

CLO-3: Learn the preparation of inorganic solids; host-guest chemistry, ionic liquids and its significance.

CLO-4: Understand self-assembled structures, nano-structured materials, carbon nanotubes, applications.

Detailed Syllabus:

Unit-1: Basics of crystalline solids

Crystalline solids, crystal systems, Bravais lattices, coordination number, packing factors – cubic, hexagonal, diamond structures, lattice planes, Miller indices, interplanar distances, directions, types of bonding , lattice energy, Madelung constants, Born Haber cycle, cohesive energy, Symmetry elements, operations , translational symmetries - point groups, space groups, equivalent positions, close packed structures, voids, crystal structures, Pauling rules, defects in crystals, polymorphism, twinning. (**9 hr**)

Unit-2: Silica based materials

Introduction to Zeolites, metallosilicates, silicalites and related microporous materials, Mesoporous silica, metal oxides and related functionalized mesoporous materials: Covalent organic frameworks, Organic-Inorganic hybrid materials, periodic mesoporous organo silica, metal organic frameworks: H2 /CO2 gas storage and catalytic applications (9 **hr**)

Unit-3: Inorganic solids/ionic liquids of technological importance

Preparation of inorganic solids: Conventional heat and beat methods, Co-precipitation method, Sol-gel methods, Hydro-thermal method, Ion-exchange and Intercalation methods. Introduction to Solid electrolytes, inorganic liquid crystals. Ionic liquids, forces responsible for ionic liquids, synthesis and application of imidazolium and phosphonium based ionic liquids. Host-guest chemistry (elementary ideas). (**9 hr**)

Unit-4: Nanomaterials

Overview of nanostructures and nano-materials: classification. Preparation of gold and silver metallic nanoparticles, self-assembled nanostructures-control of nano-architecture-one dimensional control. Carbon nanotubes and inorganic nanowires. (**9 hr**)

Unit-5: Composite materials

Introduction, limitations of conventional engineering materials, role of matrix in composites, classification, matrix materials, reinforcements, metal-matrix composites, polymer-matrix composites, fibre-reinforced composites, environmental effects on composites, applications of composites. (**9 hr**)

Recommend books/References:

1. Atkins P, Overton T., Rourke J. Weller M. and Armstrong F *Shriver and Atkins. Inorganic Chemistry* Oxford University Press, Fifth Edition, 2012.
2. Adam, D.M. *Inorganic Solids: An introduction to concepts in solid-state structural chemistry*. John Wiley,1974.
3. Poole, C.P. & Owens, F.J. *Introduction to Nanotechnology* John Wiley 2003.

4. Rodger, G.E. *Inorganic and Solid State Chemistry*, Cengage Learning, 2002.

Semester-VII: Materials Laboratory ***Credits: 02***

Code	Type	Title	Credits	Hours	L	T	P
UCHPC71401	Major	Materials Laboratory	2	4	0	0	4

Course Learning Outcomes (CLOs)

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

1. Preparation of urea-formaldehyde resin
2. Preparations of novalac resin/resol resin
3. Synthesis of materials/porous materials (Sol-gel, hydrothermal, microwave). (Similarly other materials synthesis can be designed).
4. Preparation of silver nano material. (Similarly other nano materials of other metals synthesis can be designed).
5. Analysis of XRD pattern of crystals.
6. Interpretation of FTIR, NMR and UV-Vis data of given material.
7. Estimation of particle size from the BET, SEM techniques.
8. Density measurement of ionic liquids
9. Determining dynamic viscosities of given ionic liquids
10. Determination of hydration number IR spectra.

Semester-VIII for B.Sc. Research No. of credits = 20

SEMESTER-VIII for B.Sc Research							
S.No.	**Category of Course**	**Course Code**	**Course Title**	**Hours**			**Credits**
				L	**T**	**P**	
1	Major	UCHTC81500	Green Chemistry	3 + 3	1 + 1	0	4 + 4
	Any 2 Electives	UCHTC81501	Medicinal Chemistry				
		UCHTC81502	Electrochemistry				
		UCHTC81503	Polymer Chemistry				
		UCHTC81504	Environmental Chemistry				
		UCHTC81505	Advanced Material Chemistry				
		UCHTC81506	Advanced Analytical Chemistry				

		UCHTC81507	Nuclear & Radiation Chemistry				
		UCHTC81508	Organic spectroscopy				
		UCHTC81509	Heterocyclic chemistry				
		UCHTC81510	Biochemistry				
		UCHTC81511	Organometallics and Bioinorganic chemistry				
		UCHTC81512	Introduction to Nanochemistry & applications				
		UCHTC81513	Advanced Organic Chemistry				
2	Major *B.Sc. Research*	UCHRC81500	Research Project	0	0	24	12
Total				6	2	24	**20**

Or

Semester-VIII for B.Sc. Honours No. of credits = 12

SEMESTER-VIII for B.Sc Research							
S.No.	**Category of Course**	**Course Code**	**Course Title**	**Hours**			**Credits**
				L	**T**	**P**	
1	Major	UCHTC81500	Green Chemistry	3 + 3	1 + 1	0	4 + 4
	Any 2 Electives	UCHTC81501	Medicinal Chemistry				
		UCHTC81502	Electrochemistry				
		UCHTC81503	Polymer Chemistry				
		UCHTC81504	Environmental Chemistry				
		UCHTC81505	Advanced Material Chemistry				
		UCHTC81506	Advanced Analytical Chemistry				
		UCHTC81507	Nuclear & Radiation Chemistry				
		UCHTC81508	Organic spectroscopy				
		UCHTC81509	Heterocyclic chemistry				
		UCHTC81510	Biochemistry				
		UCHTC81511	Organometallics and Bioinorganic chemistry				
		UCHTC81512	Introduction to Nanochemistry & applications				
		UCHTC81513	Advanced Organic Chemistry				
2	Major	UCHSC81500	Research Project	0	1	6	4
Total				6	3	6	**12**

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

Code	Type	Title	Credits	Hours	L	T	P

UCHTC81500	Major	Green Chemistry	4	4	3	1	0

Detailed Syllabus:

Unit-1: Introduction to Green Chemistry

Basic introduction and explaining goals of Green Chemistry. Limitations/Obstacles in the pursuit of the goals of Green Chemistry **(4 hr)**

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

Twelve principles of Green Chemistry with their explanations and examples and special emphasis on 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). **(12 hr)**

Unit-3: Green Synthesis / Reactions

1. Green Synthesis of adipic acid, catechol, disodium iminodiacetate (alternative to Strecker synthesis).

2. Microwave assisted reactions in water: (Hofmann Elimination, methyl benzoate to benzoic acid, oxidation of toluene and alcohols) and reactions in organic solvents (Diels-Alder reaction and Decarboxylation reaction).

3. Ultrasound assisted reactions: sonochemical Simmons-Smith Reaction (Ultrasonic alternative

to Iodine)

4. Surfactants for carbon dioxide – replacing smog producing and ozone depleting solvents with CO2 for precision cleaning and dry cleaning of garments.

5. Designing of Environmentally safe marine antifoulant.

6. An efficient, green synthesis of a compostable and widely applicable plastic (poly lactic acid) made from corn.

7. Healthier Fats and oil by Green Chemistry: Enzymatic Inter esterification for production of Trans-Fats and Oils (**16 hr**)

Unit-4: Future Trends in Green Chemistry

Oxidation reagents and catalysts; Biomimetic, multifunctional reagents; Combinatorial green chemistry; Proliferation of solventless reactions; co crystal controlled solid state synthesis (C2S3); Green chemistry in sustainable development. **(8 hr)**

Recommended Books/References:

1.Ahluwalia, V.K., Kidwai, M.R. *New Trends in Green Chemistry*, Anamalaya Publishers, 2005.

2. Anastas, P.T. & Warner, J.K, *Green Chemistry- Theory and Practical*, Oxford University Press, 1998.

3. Matlack, A.S. *Introduction to Green Chemistry*, Marcel Dekker, 2001.

4. Cann, M.C.and Connely, M.E. *Real-World cases in Green Chemistry*, ACS, 2000.

5. Ryan, M.A. and Tinnesand, M. *Introduction to Green Chemistry*, American Chemical Society, 2002.

6. Lancaster, M. *Green Chemistry: An Introductory Text* RSC Publishing, Second Edition, 2010.

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

Code	Type	Title	Credits	Hours	L	T	P
UCHTC81501	Major	Medicinal Chemistry-III	4	4	3	1	0

Detailed Syllabus:

Unit-1: Bio-physicochemical properties

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

Unit-2: Structural properties

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

Unit-3: Drug target understanding

Metabolism, Drug metabolism, Anti-metabolite, Enzyme inhibitor, Agonist, Antagonist, Examples.

Unit-5: Medicinal Chemistry of Therapeutic Agent

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

Unit-6: Steroids, Prostaglandins, Enzyme, Hormone and Vitamins

Biophysico-chemical properties, Steroid Hormone Receptors, Chemical Contraceptive agents, COX-2 inhibitors, Prostaglandins for Ophthalmic use, pharmaceutically important enzyme products such as Pancreatin, Trypsin, Insulin. Classification of vitamins with examples.

Unit-7: Concept of rational drug design

Structure activity relationship, Drug-receptor understanding, Molecular modeling, Structure based drug design. QSAR.

Recommended books/References:

1. Wilson and Gisvold's Textbook of Organic Medicinal and Pharmaceutical ...by Charles Owens Wilson, John H. Block, Ole Gisvold, John Marlowe Beale

2. Foye's Principles of Medicinal Chemistry by David A. Williams, Thomas L. Lemke, William O. Foye (2008), Kluwer publication.

3. Remington: The Science and Practice of Pharmacy Vol 1, Ed. 19 by Joseph Price Remington, Alfonso R. Gennaro. (1995), MACK Publishing.

4. Burgers Medicinal Chemistry by Manfred E. Wolff, Alfred Burger

5. Burgers Medicinal Chemistry and Drug Discovery by Abraham D. J., Lewis F. L., Burger A., vol.5, 6th Edn., 2003, Hoboken N.J.Wiley,

6. The Organic Chemistry of Drug Design and Drug Action by Silverman R. B., 2nd Edn., Academic Press. 2012.

Semester-VIII: Electro Chemistry *Credits: 04*

Code	Type	Title	Credits	Hours	L	T	P
UCHTC81502	Major	Electro Chemistry	4	4	3	1	0

Detailed Syllabus:

Unit-1:

Arrhenius theory of electrolytic dissociation. Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Molar conductivity at infinite dilution. Kohlrausch law of independent migration of ions. Debye-Hückel-Onsager equation, Wien effect, Debye-Falkenhagen effect, Walden's rules. Ionic velocities, mobilities and their determinations, transference numbers and their relation to ionic mobilities, determination of transference numbers using Hittorf and Moving Boundary methods. Applications of conductance measurement: (i) degree of dissociation of weak electrolytes, (ii) ionic product of

water (iii) solubility and solubility product of sparingly soluble salts, (iv) conductometric titrations, and (v) hydrolysis constants of salts.

Unit-2

Quantitative aspects of Faraday's laws of electrolysis, rules of oxidation/reduction of ions based on half-cell potentials, applications of electrolysis in metallurgy and industry. Chemical cells, reversible and irreversible cells with examples. Electromotive force of a cell and its measurement, Nernst equation; Standard electrode (reduction) potential and its application to different kinds of half-cells. Application of EMF measurements in determining (i) free energy, enthalpy and entropy of a cell reaction, (ii) equilibrium constants, and (iii) pH values, using hydrogen, quinone-hydroquinone, glass and SbO/Sb2O3 electrodes. Concentration cells with and without transference, liquid junction potential; determination of activity coefficients and transference numbers. Qualitative discussion of potentiometric titrations (acid-base, redox, precipitation).

Unit-3: Electroanalytical methods

Classification of electroanalytical methods, basic principle of pH metric, potentiometric and conductometric titrations. Techniques used for the determination of equivalence points. Techniques used for the determination of pKa values.

Unit-4: Electrical & Magnetic Properties of Atoms and Molecules

Basic ideas of electrostatics, Electrostatics of dielectric media, Clausius-Mosotti equation, Lorenz-Laurentz equation, Dipole moment and molecular polarizabilities and their measurements. Diamagnetism, paramagnetism, magnetic susceptibility and its measurement, molecular interpretation.

Recommended books/reference books

1.Atkins, P.W & Paula, J.D. Physical Chemistry, 10th Ed., Oxford University Press, 2014.

2.Castellan, G. W. Physical Chemistry 4th Ed., Narosa, 2004.

3.Mortimer, R. G. Physical Chemistry 3rd Ed., Elsevier: NOIDA, UP, 2009.

4.Barrow, G. M., Physical Chemistry 5th Ed., Tata McGraw Hill: New Delhi, 2006.

5.Engel, T. & Reid, P. Physical Chemistry 3rd Ed., Prentice-Hall, 2012.

6.Rogers, D. W. Concise Physical Chemistry Wiley, 2010.

7.Silbey, R. J.; Alberty, R. A. & Bawendi, M. G. Physical Chemistry 4th Ed., John Wiley & Sons, Inc., 2005.

Semester-VIII: Polymer Chemistry Credits: 04

Code	Type	Title	Credits	Hours	L	T	P
UCHTC81503	Major	Polymer Chemistry	4	4	3	1	0

Detailed Syllabus:

Unit-1: Introduction

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

Unit-2: Polymeric Structure and Property Relationship

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

Unit-3: Polymerization Chemistry

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

Unit-4: Characterization of Polymers

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

Recommended books/References:

1. D.W. Van Krevelen and P.J. Hoftyzen, "Properties Of Polymer, 3rd Edition Elsevier Scientific, Publishing Company Amsterdam - Oxford - Newyork. 1990.

2. J.E. Mark Ed.AIP, Physical Properties Of Polymers Hand Book, Williston, Vt, 1996.

3. Reaction Engineering of Step Growth Polymerization, S K Gupta and Anil Kumar, Plenum Press, 1987.

4. Odian; George, Principles of Polymerization, McGraw-Hill Book Co., New York (1970).

5. W. Billmeyer, Text book of polymer science, 3rd Edn., 2007, Wiley.

6. J.R.Fried, Polymer Science and Technology, PHI publication, 2005.

7. Billmeyer Jr.; Fred W., Textbook of Polymer Science, Wiley- Interscience Publishers, New

York,1962.

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

Code	Type	Title	Credits	Hours	L	T	P
UCHTC81504	Major	Environmental Chemistry	4	4	3	1	0

Detailed Syllabus:

Unit-1: Environment

Composition of atmosphere, temperature variation of earth atmospheric system (temperature vs. altitude curve), biogeochemical cycles of C, N, P, S and O system.

Unit-2: Hydrosphere: Hydrological cycle, aquatic pollution and water quality parameters – Dissolve oxygen, biochemical oxygen demand, chemical oxygen demand, Analytical methods for the determination fluoride, chromium and arsenic, residual chlorine and chlorine demand, purification and treatment of municipal water and waste water.

Unit-3: Atmosphere

Chemical composition of atmosphere – particle, ions, and radicals in their formation, chemical and photochemical reactions in atmosphere, smog formation, oxides of N, C, S, and O and their effect, pollution by chemicals, CFC, Green House effect, acid rain, air pollution and control.

Unit-4: Aquatic chemistry

Water and its necessities, various water quality parameters (DO, BOD, COD, conductivity, pH, alkalinity, hardness) and its determination, Industrial, municipal water treatment processes, Waste water treatment procedure (primary, secondary and tertiary), Solid waste treatment. Soil pollution and Noise pollution.

Recommended Books/References:

1. De.A.K.Environmental Chemistry, Wiley Eastern Ltd, 1990.

2. Miller T.G.Jr., Environmental Science, Wadsworth publishing House, Meerut Odum.E.P.1971.

3. Odum, E.P. (1971) Fundamentals of Ecology. Third Edition, W.B. Saunders Co., Philadelphia

4. S. E. Manahan, Environmental chemistry, 1993, Boca Raton, Lewis publisher

5. Environmental chemistry, Sharma and Kaur, 2016, Krishna publishers

6. Environmental Pollution, Monitoring and control, S.M. Khopker, 2007, New Age International.

7. Environmental chemistry, C. Baird, M. Cann, 5th Edn, 2012, W.H.Freeman publication.

9 G. S. Sodhi Fundamental Concepts of Environmental Chemistry (Third Edition) Narosa (2009).

10. Principles of instrumental analysis: D. A. Skoog, Fifth Edition, Sauns College Publishing (London)

11 Basic concepts of analytical chemistry: S. M. Khopkar, Wiley Eastern (1995)

Semester-VIII: Advanced Materials Chemistry Credits: 04

Code	Type	Title	Credits	Hours	L	T	P
UCHTC81505	Major	Advanced Materials Chemistry	4	4	3	1	0

Detailed Syllabus:

Unit-1: Crystal structure of solids

Fundamental of lattices, unit cell, atomic coordinates, Bravais lattices, crystal direction and planes, types of close packing, packing efficiency, radius ratios; few important crystal structures. Synthesis of Inorganic solids; solid state, solution phase and vapor phase synthesis; precipitation, hydrothermal, sol-gel, surfactant based synthesis. Growth of single crystals. Crystal structure determination by X-ray diffraction, d-spacing formula, symmetrically absent reflections, Multiplicities, Scattering of X-rays by an atom and a crystal. Single crystal and powder diffraction. Electron and neutron diffraction. Concept of reciprocal lattice. Electron microscopy techniques.

Unit-2: Nanomaterial fundamentals

Synthesis: Bottom-up vs. Top-down Methods. Solution phase synthetic methods. Role of surfactant in shape and size control of nanomaterials. Synthesis of nanowires and nanotubes by CVD and MOCVD method.

Nanomaterials Characterization: XRD of nanomaterials, Electron microscopy (SEM, TEM, HRTEM and EDX) of nanomaterials, Scanning probe microscopy. Nanomaterial properties and applications: Magnetic properties of nanoparticles; superparamagnetism, ferromagnetism in antiferromagnetic nanoparticles and single domain to multidomain transition. magnetic nanoparticles as MRI contrast agents.

Unit-3: Frontier areas of polymer science and technology

Conducting polymers: basic principles of conducting polymers, delocalized electronic states of conjugated polymers, polyanilines, polyacetylenes, polythiophene, applications of conducting

polymers.

Biodegradable polymers: Definition classification of natural biodegradable polymers, cellulose, cellulose acetate, cellophane, soy protein, corn, zein protein, wheat gluten protein, synthetic biodegradable polymers, polyhydroxy alkanoates, polycarpolactone, poly(vinyl alcohol), polyacetic acid, application of biodegradable and biomedical polymers, contact lens, dental polymers, artificial heart, kidney, skin, and blood cells.

Fibers: natural fibers, cotton, wool, silk, rayon, artificial fibers, polyamides, acrylic acid, PVC, PVA.

Rubber: Compounding and elastomeric properties, vulcanization, reinforcement.

Recommended books/References:

1. Zhen Guo and Li Tan, *Fundamentals and Applications of Nanomaterials*.2009, Artech House, London Publication.
2. Physical methods for chemistry: R. S. Drago, 1992, Saunders college publication.
3. Polymer science, V. R. Gowariker, N. V.Viswanathan, J. Sreedhar, New Age International (P) Ltd., 2015.
4. P. J. Flory, Principle of polymer chemistry, Cornell University Press.
5. Polymer Science and technology, Plastics, Rubber and composites, P. Ghosh, Tata McGraw Hill.
6. V. Gowriker, N. V. Viswanathan, J. Sreedhar, Polymer Science, New Age Int.Publication, 2019.

Semester-VIII: Advanced Analytical Chemistry Credits: 04

Code	Type	Title	Credits	Hours	L	T	P
UCHTC81506	Major	Advanced Analytical Chemistry	4	4	3	1	0

Detailed Syllabus:

Unit-1: Statistical methods in chemical analysis

Theory of error and treatment of quantitative data, accuracy and precision, ways of expressing accuracy and precision, Normal error curve and its equation. Useful statistical tests with equation, test of significance, the F-test, the students t-test, the Chi-test, the correlation coefficient, confidence limit of the mean, comparison of two standard values, comparison of

two standard values, comparison of standard deviation with average deviation, comparison of mean with true values, regression analysis (least square method).

Unit-2: Polarography

Current-voltage relationship, theory of polarographic waves, instrumentation, qualitative and quantitative applications.

Unit-3: Atomic spectroscopy

Atomic absorption spectroscopy, theory and application (with some examples).

Unit-4: Thermal analysis

Theory, methodology, instruments and applications of theromogravimetric analysis (TGA/DTA), and differential scanning calorimetry (DSC).

Unit-5: Chromatography

Principles of chromatography, paper, column and thin layer chromatography, Gas-liquid chromatography, HPLC.

Unit-6: Analysis of fuel and drugs

Fuel analysis: Solid, liquid and gaseous fuels, ultimate and proximate analysis of solid fuel, Determination of calorific value of solid, liquid and gaseous fuels, Flash point and fire point.

Drug analysis: Classification of drugs, Analysis of some standard drug using various chromatographic techniques.

Recommended books/references:

1. Mendham, J., *A. I. Vogel's Quantitative Chemical Analysis 6th Ed.*, Pearson, 2009.
2. Willard, H.H. *et al.*: *Instrumental Methods of Analysis*, 7th Ed. Wardsworth Publishing California, USA, 1988.
3. Christian, G.D, *Analytical Chemistry*, 6th Ed. John Wiley & Sons, New York, 2004.
4. Harris, D.C.: *Exploring Chemical Analysis*, 9th Ed. New York, W.H. Freeman, 2016.
5. Skoog, D.A. Holler F.J. & Nieman, T.A. *Principles of Instrumental Analysis*
6. Mikes, O. *Laboratory Hand Book of Chromatographic & Allied Methods*, Elles Harwood John Wiley 1979.
7. Ditts, R.V. Analytical Chemistry; Methods of separation, van Nostrand, 1974.
8. Khopkar, S. M., Basic Concepts of Analytical Chemistry, New Age (Second edition) 1998

Semester-VIII: Nuclear and Radiation Chemistry Credits: 04

Code	Type	Title	Credits	Hours	L	T	P

UCHTC81507	Major	Nuclear and Radiation Chemistry	4	4	3	1	0

Detailed Syllabus:

Unit-1:

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

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

Unit-2:

Measurement of radioactivity, idea about accelerator and detectors, Van de Graaaf and linear acceletors, synchrontrons, Geiger-Muller detector, Scintillaton detectors, Type of nuclear reactions, Nuclear fission, Nuclear fusion, Nuclear reactor: classification of reactors, the natural uranium reactor, breeder reactor. Nuclear fusion and stellar energy.

Unit-3:

Radiation chemistry: Elementary ideas of radiation chemistry, radiolysis of water and aqueous solutions, unit of radiation chemical yield (G-value), radiation dosimetry (Fricke's dosimeter), units of radiation energy (Rad, Gray, Rontgen, RBE, Rcm, Sievert).

Unit-4:

Nuclear pollution and Radiological safety: Interaction of radiation with matter, Radiolysis of water, Radiation dosimetry. Radioactive isotopes and their applications, Isotopic dilution analysis, Neutron activation analysis, disposal of nuclear waste, nuclear disaster and its management (nuclear accidents and holocaust – discussion about case studies).

Recommended Books/references:

1. Friendlander G, Kennedy G and Miller J. M. Nuclear and Radiochemistry, Wiley Interscience

2. Harvey, B. G. Introduction to Nuclear Physics & Chemistry, Prentice – Hall,

3. Overman R. T, Basic concept of Nuclear Chemistry, Chapman & Hall.

4. A. N. Nesmeyanov, Radiochemistry, MIR Publication, Moscow.

5. Spinks J. W. T. and Woods R. J. An Introduction to Radiation Chemistry, Wiley

6. Arnikar H. J., Essentials of Nuclear Chemistry, Wiley Eastern, Second Edition.

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

Code	Type	Title	Credits	Hours	L	T	P
UCHTC81508	Major	Organic Spectroscopy	4	4	3	1	0

Detailed Syllabus:

Unit-1: Introduction to spectroscopic techniques: Application of UV – Visible and IR spectroscopy to organic structure elucidation. Electromagnetic spectrum, absorption of energy by organic compounds; Effect of solvent on UV spectrum, red shift & blue shift, Woodward – Fisher rules and theoretical λ max calculations; IR spectrometer instrument & basic principles, Organic functional group identification through IR spectroscopy. IR spectra of alkanes, alkenes and simple alcohols (inter and intramolecular hydrogen bonding), aldehydes, ketones, carboxylic acids and their derivatives (effect of substitution on >C=O stretching absorptions).

(14 Hrs)

Unit-2: 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. **(14 Hrs)**

Unit-3: 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.

(10 Hrs)

Unit-4: 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. **(10 Hrs)**

Recommended Books/References:

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-VIII: Heterocyclic Chemistry ***Credits: 04***

Code	Type	Title	Credits	Hours	L	T	P
UCHTC81509	Major	Heterocyclic Chemistry	4	4	3	1	0

Detailed Syllabus:

Unit-1: Heterocyclic Chemistry

Three-membered rings with one heteroatom: Chemistry of oxiranes, aziridines and episulphides - synthetic approaches and reactivities.

Three-membered heterocycles with two heteroatoms: oxaziranes, diaziridines and diazirines-synthetic approaches and reactivities.

Four-membered heterocycles: oxitanes, azatidanes and thietanes - synthetic approaches and reactivities. natural products:synthesis of Peniciline and cephalosporine.

Five-membered aromatic heterocycles:

1. With one heteroatom: furans, pyrroles and thiophenes - general synthetic approaches, properties and reactivities.

2. With two heteroatoms: oxazoles, isoxazoles, imidazoles, thiazoles, pyrazoles and isothiazoles - general synthetic approaches and reactivities.

3. With three and four heteroatoms: triazoles and tetrazoles - synthetic approaches, properties and reactivity.

Unit-2: Condensed five-membered Heterocycles:

Benzofuran, indoles and benzothiazoles - general synthetic approaches, with greater emphasis on the chemistry of Indoles.

Recommended Books/references:

1. Heterocyclic Chemistry, J.A. Joule, K. Mills, Wiley, 2010.

2. The Essence of heterocyclic Chemistry, A. R. Parikh, H. Parikh, R. Khunt, New Age Int. Publication,

3. Principles of Modern Heterocyclic Chemistry, L. A. Paquette, W. A. Benjamin, New York, 1968.

4. Heterocyclic Chemistry, J.A. Joule and G. F. Smith, van Nostrand, London, 1978.

5. Comprehensive Heterocyclic Chemistry. The structure, reactions, synthesis and use of Heterocyclic compounds, (Ed. A.R. Katritzky and C. W. Rees),. Vol 1-8, Pergamon Press, 1984.

6. Handbook of Heterocyclic Chemistry, A. R. Katritzky, Pergamon Press, 1985.

7. Van der plas, H. C. Ring transformations of Heterocycles, Vols 1 and 2, Academic Press, 1974.

Semester-VIII: Biochemistry Credits: 04

Code	Type	Title	Credits	Hours	L	T	P
UCHTC81510	Major	Biochemistry	4	4	3	1	0

Detailed Syllabus:

Unit-1: Carbohydrates:

Biological importance of carbohydrates, Metabolism, Cellular currency of energy (ATP), Glycolysis, Alcoholic and Lactic acid fermentations, Krebs cycle. **(8 hr)**

Unit-2: Proteins:

Classification, biological importance; Primary, secondary and tertiary structures of proteins: α-helix and β- pleated sheets, Denaturation of proteins. **(8 hr)**

Unit-3: Enzymes:

Nomenclature, Characteristics (mention of Ribozymes), Classification; Active site, Mechanism of enzyme action, Stereospecificity of enzymes,Coenzymes and cofactors, Enzyme inhibitors, Biocatalysis in Green Chemistry" and Chemical Industry **(8 hr)**

Unit-4: Lipids:

Biological importance of triglycerides and phosphoglycerides and cholesterol; Lipid membrane, Liposomes and their biological functions and underlying applications. **(8 hr)**

Unit-5: Structure of DNA/RNA:

Structure of DNA (Watson-Crick model) and RNA, Genetic Code, Biological roles of DNA and RNA: Replication, Transcription and Translation, Introduction to Gene therapy. **(8 hr)**

Recommended Books/References:

1. Berg, J.M., Tymoczko, J.L. and Stryer, L. (2006) Biochemistry. VI the Edition. W.H. Freeman
and Co.

2. Nelson, D. L., Cox, M. M. and Lehninger, A. L. (2009) principles of Biochemistry.IV Edition.
W.H. Freeman and Co.

3. Murray, R.K., Granner, D.K., Mayes, P.A. and Rodwell, V.W. (2009) Harper's Illustrated Biochemistry. XXVIII edition. Lange medical Books/ McGraw-Hill

Semester-VIII: Organometallics and Bioinorganic Chemistry Credits: 04

Code	Type	Title	Credits	Hours	L	T	P
UCHTC81511	Major	Organometallics and Bioinorganic Chemistry	4	4	3	1	0

Detailed Syllabus:

Unit-1: Organometallic Compounds

Definition and classification of organometallic compounds on the basis of bond type. Concept of hapticity of organic ligands. Metal carbonyls: 18 electron rule, electron count of mononuclear, polynuclear and substituted metal carbonyls of 3d series. General methods of preparation (direct combination, reductive carbonylation, thermal and photochemical decomposition) of mono and binuclear carbonyls of 3d series. Structures of mononuclear and binuclear carbonyls of Cr, Mn, Fe, Co and Ni using VBT. pi-acceptor behaviour of CO (MO diagram of CO to be discussed), synergic effect and use of IR data to explain extent of back bonding. Zeise's salt: Preparation and structure, evidences of synergic effect and comparison of synergic effect with that in carbonyls. Metal Alkyls: Important structural features of methyl lithium (tetramer) and trialkyl aluminium (dimer), concept of multicentre bonding in these compounds. Role of triethylaluminium in polymerisation of ethene (Ziegler – Natta Catalyst). Species present in ether solution of Grignard reagent and their structures, Schlenk equilibrium.

Ferrocene: Preparation and reactions (acetylation, alkylation, metallation, Mannich Condensation). Structure and aromaticity. Comparison of aromaticity and reactivity with that of benzene. Definition and Classification with appropriate examples based on nature of metal-carbon bond (ionic, s, p and multicentre bonds). Structures of methyl lithium, Zeiss salt and ferrocene. EAN rule as applied to carbonyls. Preparation, structure, bonding and properties of mononuclear and polynuclear carbonyls of 3d metals. p-acceptor behaviour of carbon monoxide. Synergic effects (VB approach)- (MO diagram of CO can be referred to for synergic effect to IR frequencies). Organometallic compounds of Mg and Li – Use in synthesis of organic compounds.

Unit 2: Bioinorganic chemistry

A brief introduction to bio-inorganic chemistry. Role of metal ions present in biological systems with special reference to Mg^{2+} ions: Role of Mg^{2+} ions in energy production and chlorophyll. Role of Ca^{2+} in blood clotting, stabilization of protein structures and structural role (bones), chelate therapy, metals in diagnosis and medicine, metal complexes for anti-cancer and other therapies.

Recommended books/reference books

1.Lippard, S.J. & Berg, J.M. *Principles of Bioinorganic Chemistry* Panima Publishing Company, 1994.

2. Cotton, F.A. & Wilkinson, G, *Advanced Inorganic Chemistry* Wiley-VCH, 1999

3.Greenwood, N.N. & Earnshaw A. *Chemistry of the Elements*, Butterworth-Heinemann, 1997

4. B. D. Gupta, A. J Elias, Basic Organometallic chemistry, 2nd Edn, University Press, 2013.

Semester-VIII: Introduction to Nanochemistry and Applications Credits: 04

Code	Type	Title	Credits	Hours	L	T	P
UCHTC81512	Major	Introduction to Nanochemistry and Applications	4	4	3	1	0

Detailed Syllabus:

Unit-I: Introduction to nanoscience, nanostructure and nanotechnology (basic idea), Overview of nanostructures and nano-materials, classification, (cluster, colloid, nanoparticles, and nanostructures -Spheroid, Wire, Rod, Tube, and Quantum Dot); Calculation of percentage of surface atom and surface to volume ratio of spherical, wire, rod, and disc shapes nanoparticles.

Unit-II: Size dependent properties of nanomaterials (basic idea with few examples only): Quantum confinement, Electrical, Optical (Surface Plasmon resonance), variation in colors (Blue shift & Red shift), Magnetic, thermal and catalytic properties.

Unit-III: Synthesis of Nanomaterials: Brief introduction about Top-down and Bottom-up approaches & self-assembly techniques of nanoparticles synthesis, Solvothermal process, Examples of preparation of gold and silver metallic nanoparticles, self-assembled nanostructures-controlof nanoarchitecture-one dimensional control. Carbon nanotubes and inorganic nanowires.

Unit-IV: Material characterization techniques (basic idea of use of following instruments in nanomaterial characterization need to be emphasized): Electron microscopic technique, diffraction technique, photoelectron spectroscopy, zeta-potential measurement; Examples of use of nanomaterials in environmental remediation and biology (few practical examples of use of materials can be discussed).

Recommended Books/References books:

1.C. N. R. Rao, A. Muller, A. K. Cheetam, The Chemistry of Nanomaterials: Synthesis, Properties and Applications, Willey-VCH Verlag, Germany, 2005.

2.G. Cao, Nanostructures and Nanomaterials: Synthesis, Properties and Appications, Imperial College Press, London, 2004

3.R. W. Kelsall, I. W. Hameley, M. Geoghegan, Nanoscale Science and Technology, John Wiley & Sons, England, 2005

4.Charles P. Poole and Frank J Owens, *Introduction to nano technology*, Wiley Interscience, 2003.

5. Pradeep, T., A text of book of nanoscience and nanotechnology, Tata McGraw Hill Education Pvt. Ltd., New Delhi, 2012.

Semester-VIII: Advanced Organic Chemistry Credits: 04

Code	Type	Title	Credits	Hours	L	T	P
UCHTC81513	Major	Advanced Organic Chemistry	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: Advanced Stereochemistry:
Relationship between elements of symmetry and chirality. Optical activity in the absence of chiral centre: Axial and planar chirality and helicity. Topicity: Enantiotopic and diastereotopic atoms, ligands and faces. Conformational analysis of cyclic compounds: cyclohexane, mono-substituted cyclohexanes; disubstituted cyclohexanes. Decalins. Principles of asymmetric synthesis, Enantioselectivity and diastereoselectivity. Stereospecific and stereoselective reactions. Chiral auxiliaries. Biomolecule chirality **(16 Hrs)**

UNIT-II: Named Reactions, Rearrangements & Reagents in organic synthesis:
Dicyclohexyl Carbodiimide (DCC), Gilman's reagent, DDQ, Prevost Hydroxylation, Phase transfer catalysts, Phosphorous and Sulphur ylides, Lawson reagents, IBX, Tebbe reagent. Wagner-Meerwein, Demjanov, Benzil-Benzillic acid, Favorskii, Neber, Beckmann, Hofmann, Curtius, Schimidt rearrangements, Mukaiyama aldol reaction, Mitsunobu reaction, Shapiro reaction, Vilsmeier–Haack reaction, Baylis-Hillman reaction, Biginelli reaction. **(16 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 regioselectivity; 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-VIII: Research Project Credits: 12

Code	Type	Title	Credits	Hours	L	T	P
UCHRC81500	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.

Semester-VIII: Literature survey and Seminar Credits: 4

Code	Type	Title	Credits	Hours	L	T	P
UCHSC81500	Major	Literature Survey and Seminar	4	8	0	2	6

Detailed Syllabus:

Students have to consult respective faculty members and select interested topics. More than one student can work under a guide. Guide allotment for the tutorial support for seminar 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 Literature survery report either individually. Students will be periodically assessed for their 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 report on literature survey i.e. small report, presentation, and comprehensive viva carries 60% marks for their Seminar presentation.

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

Semester-I

SEMESTER-I							
S.No.	**Category of Course**	**Course Code**	**Course Title**	**Hours**			**Credits**
				L	**T**	**P**	
1	Minor	UCHTM11100	Inorganic Chemistry-I	3	1	0	4
2	Minor	UCHPM11100	Inorganic Chemistry-I Laboratory	0	0	4	2

Semester-I: Inorganic Chemistry-I Credits: 04

Code	Type	Title	Credits	Hours	L	T	P
UCHTM11100	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 theories of atoms and the concept of wave function.

CLO-2: Understand the periodic properties of s, p block elements

CLO-2: Apply theories to draw the reasonable structure of molecules.

CLO-4: Characterize weak bonding in different molecules and its consequence in biology.

Detailed Syllabus:

Unit-1: Atomic Structure:

Bohr's theory, its limitations and atomic spectrum of hydrogen atom, Sommerfeld theory. Wave mechanics: de' Broglie equation, Heisenberg's Uncertainty Principle and its significance, Schrödinger's time independent wave equation, significance of ψ and ψ^2. Quantum numbers and their significance. Normalized and orthogonal wave functions. Sign of wave functions. Radial and angular wave functions for hydrogen atom. Radial and angular distribution curves. Shapes of s, p, d and f orbitals. Contour boundary and probability diagrams. Pauli's Exclusion Principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations, Variation of orbital energy with atomic number. **(10 Hrs)**

Unit 2: Periodicity of Elements

s, p, d, f block elements, the long form of periodic table. Detailed discussion of the following properties of the elements, with reference to *s* and *p*-block:(a) Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table; (b) Atomic radii (van'der Waals); (c) Ionic and crystal radii; (d) Covalent radii; (e) Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization energy. Applications of ionization enthalpy; (f) Electron gain enthalpy, trends of electron gain enthalpy; (g) Electronegativity, Pauling, Mullikan, Allred-Rachow, Sanderson and Allen scales, electronegativity and bond order, partial charge, hybridization, group electronegativity.

(10 Hrs)

Unit 3: Chemical Bonding

(i) *Ionic bond:* General characteristics, types of ions, size effects, radius ratio rule and its limitations. Packing of ions in crystals. Born-Landé equation with derivation, expression for lattice energy, Madelung constant, Born-Haber cycle, Born-Mayer and Kapustinskii;s modifications on Born-Landé equation. Application of lattice energy, Solvation energy.

(ii) *Covalent bond:* Lewis structure, Valence Shell Electron Pair Repulsion Theory (VSEPR), Shapes of simple molecules and ions containing lone-and bond-pairs of electrons multiple bonding, sigma and pi-bond approach, Valence Bond theory, (Heitler-London approach). Hybridization containing s, p and s, p, d atomic orbitals, shapes of hybrid orbitals, Bents rule, Resonance and resonance energy, Molecular orbital theory. Molecular orbital diagrams of simple homonuclear and heteronuclear diatomic molecules, MO diagrams of simple di- and tri-atomic molecules, e.g., N_2, O_2, C_2, B_2, F_2, CO, NO, and their ions; HCl, BeF_2, CO_2 (idea of s-p mixing and orbital interaction to be given). Covalent character in ionic compounds, polarizing power and polarizability. Fajan rules, polarization. Ionic character in covalent compounds: Bond moment and dipole moment. ionic character from dipole moment and electronegativities.

(**20 Hrs**)

Unit 4: Metallic bonding and Weak chemical forces

(i) *Metallic Bond:* Qualitative idea of free electron model, Semiconductors, Insulators.

(ii) *Weak Chemical Forces:* van'der Waals, ion-dipole, dipole-dipole, induced dipole dipoleinduced dipole interactions, Lenard-Jones 6-12 formula, hydrogen bond, effects of hydrogen bonding on melting and boiling points, solubility, dissolution. (**5 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. Douglas, B.E., McDaniel, D.H., Alexander J.J., *Concepts & Models of Inorganic Chemistry, (Third Edition)* John Wiley & Sons,1999.

5. Housecroft, C. E. and Sharpe, A. G., *Inorganic Chemistry*, 4th Edition, Pearson Edu, Ltd, 2018.

6. Rodger, G. E., *Inorganic and Solid State Chemistry*, Cengage Learning, 2002.

7. Mingos, D. M. P., *Essential Trends in Inorganic Chemistry*, Oxford University Press, 1998.

8. Wulfsberg G., *Inorganic Chemistry*, Viva Students Edition, 2002.

Semester-I: Inorganic Chemistry-I Laboratory ***Credits: 02***

Code	Type	Title	Credits	Hours	L	T	P
UCHPM11100	Minor	Inorganic Chemistry-I 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. TITRIMETRIC ANALYSIS

4. Calibration and use of apparatus.
5. Preparation of solutions of different Molarity/Normality of titrants.
6. Use of primary and secondary standard solutions.

II. ACIDIMETRY

4. Estimation of citric acid in Lemon
5. Estimation of sodium carbonate and sodium bicarbonate present together in a mixture

III. PERMANGANOMETRY

6. Estimation of oxalic acid
7. Estimation of FAS

IV. DICHROMETRY

8. Estimation of Fe (II) with $K_2Cr_2O_7$ using internal (diphenylamine, anthranilic acid) and external indicator.

V. IODOMETRY

9. Estimation of sodium thiosulphate

10. Estimation of iodine content in iodised salt

VI. COMPLEXOMETRY

11. Estimation of Zn^{2+}

12. Estimation of temporary and permanent hardness of water

VII. GRAVIMETRY

13. Estimation of barium as barium chromate

14. Estimation of nickel as Ni-DMG

References:

1. V. Venkateswaran, R.Veerasamy, A.R.Kulandaivelu, Basic principles of practical Chemistry, 2nd Edt, Sultan Chand & sons publisher, 1997.

2. Mendham, J., A. I. Vogel's *Quantitative Chemical Analysis* Sixth Edition, Pearson, 2009.

3. 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	UCHTM21101	Organic Chemistry-I	3	1	0	4
2	Minor	UCHPM21101	Organic Chemistry-I Laboratory	0	0	4	2

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

Code	Type	Title	Credits	Hours	L	T	P
UCHTM21101	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: Understand the basics of organic molecules structure, bonding, reactivity and reaction mechanisms.
CLO-2: Understand the geometry, 3-D structure of organic molecules, identifying chiral centers.
CLO-3: Analyze the Stereochemistry of organic molecules – conformation and configuration, asymmetric molecules.
CLO-4: Understand the difference between nucleophilic substitution and elimination reactions.

Unit 1: Basics of Organic Chemistry

Organic Compounds: Classification, and Nomenclature, Hybridization, Shapes of molecules, Influence of hybridization on bond properties. Electronic Displacements: Inductive, electromeric, resonance and mesomeric effects, hyperconjugation and their applications; Dipole moment; Organic acids and bases; their relative strength. Homolytic and Heterolytic fission with suitable examples. Curly arrow rules, formal charges; Electrophiles and Nucleophiles; Nucleophilicity and basicity; Types, shape and relative stabilities of reaction intermediates (Carbocations, Carbanions, Free radicals and Carbenes).

Organic reactions and their mechanism: Addition, Elimination and Substitution reactions.

(8 hr)

Unit 2: Stereochemistry

Concept of asymmetry, Fischer Projection, Newmann and Sawhorse projection formulae and their interconversions; Geometrical isomerism: cis–trans and, syn-anti isomerism E/Z notations with C.I.P rules. Optical Isomerism: Optical Activity, Specific Rotation, Chirality/Asymmetry, Enantiomers, Molecules with two or more chiral-centres, Distereoisomers, meso structures, Racemic mixtures, Relative and absolute configuration: D/L and R/S designations.

Cycloalkanes and Conformational Analysis

Cycloalkanes and stability, Baeyer strain theory, Conformation analysis, Energy diagrams of cyclohexane: Chair, Boat and Twist boat forms. **(17 hr)**

Unit 3: Chemistry of Aliphatic Hydrocarbons:

A. Carbon-Carbon sigma bonds

Chemistry of alkanes: Formation of alkanes, Wurtz Reaction, Wurtz- Fittig Reactions, Free radical substitutions: Halogenation - relative reactivity and selectivity.

B. Carbon-Carbon pi-bonds

Formation of alkenes and alkynes by elimination reactions, Mechanism of E1, E2, E1cb reactions. Saytzeff and Hofmann eliminations. Reactions of alkenes: Electrophilic additions their mechanisms (Markownikoff/ Anti Markownikoff addition), mechanism of oxymercuration demercuration, hydroboration- oxidation, ozonolysis, reduction (catalytic and chemical), syn and anti-hydroxylation (oxidation). 1, 2- and 1, 4- addition reactions in conjugated dienes and, Diels- Alder reaction; Allylic and benzylic bromination and mechanism, e.g. propene, 1-butene, toluene, ethyl benzene. Reactions of alkynes: Acidity, Electrophilic and Nucleophilic additions. **(14 hr)**

Unit 4: Aromatic Hydrocarbons

Aromaticity: Huckel's rule, aromatic character of arenes, cyclic carbocations/carbanions and heterocyclic compounds with suitable examples. Electrophilic aromatic substitution: halogenation, nitration, sulphonation and Friedel-Craft's alkylation/acylation with their mechanism. Directing effects of substituent groups. **(6 hr)**

Recommended Books/References:

1. Pine S. H. Organic Chemistry, Fifth Edition, McGraw Hill, 2007
2. F. A. Carey, Organic Chemistry, Seventh Edition, Tata McGraw Hill. 2008
3. Clayden, J. et al., Organic Chemistry, 2nd Ed., Oxford University Press, 2001.
4. Hornback, J. M., Organic Chemistry, 2nd Ed., Cengage Learning, 2006.
5. Morrison, R. M. and Boyd, R. N., Organic Chemistry, 6th Ed., Pearson Education, 2008.
6. Smith, M. B. and March, J., Advanced Organic Chemistry, 6th Ed., John Wiley and Sons, 2007.
7. Carey, F. A, Sundberg, R. J., Advanced Organic Chemistry, Parts A and B, Springer, 2007.
8. Kalsi, P.S., (2010). *Stereochemistry: Conformation and Mechanism*, New Age International (p) Ltd. New Delhi.
9. Nasipuri, D. (Latest edition). *Stereochemistry of Organic Compounds: Principles & Applications*, New Age International Publishers.
10. Bruice Paula, Y., (2015). *Organic Chemistry*, 7th Edition, Pearson Edition.
11. Solomons, T.W G., Fryhle, B. Craig. *Organic Chemistry*, John Wiley & Sons, Inc, 2009.

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

Code	Type	Title	Credits	Hours	L	T	P
UCHPM21101	Major	Organic Chemistry-I Laboratory	2	4	0	0	4

Syllabus:

1. Checking the calibration of the thermometer.
2. Purification of organic compounds by crystallization using the following solvents:

a. Water b. Alcohol c. Alcohol-Water

3. Determination of the melting points of given organic compounds and unknown organic compounds (using Kjeldahl method and electrically heated melting point apparatus).
4. Effect of impurities on the melting point – mixed melting point of two unknown organic compounds.
5. Determination of boiling point of liquid compounds. (boiling point lower than and more than 100 °C by distillation and capillary method).

5.Chromatography:

a. Separation of a mixture of two amino acids by ascending and horizontal paper chromatography

b. Separation of a mixture of two sugars by ascending paper chromatography

c. Separation of a mixture of *o*-and *p*-nitrophenol or o-and p-aminophenol by thin layer chromatography (TLC).

Reference Books:

1. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry*, Pearson Education, 2009.
2. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. *Practical Organic Chemistry, 5th Ed.*, Pearson, 2012.
3. Svehla, G. Vogel's *Qualitative Inorganic Analysis*, Pearson Education, **2012**.
4. Mendham, J. Vogel's *Quantitative Chemical Analysis*, Pearson, **2009**.
5. 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	Minor	UCHTM31102	Physical Chemistry-I	3	1	0	4
2	Minor	UCHPM31102	Physical Chemistry-I Laboratory	0	0	4	2

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

Code	Type	Title	Credits	Hours	L	T	P
UCHTM31102	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 role of gases and different laws governing them.
CLO-2: Understand the Liquid state and its physical properties related to temperature and pressure variation.
CLO-3: Understand the properties of liquid as solvent in reactions.
CLO-4: Understand the lattice parameters – its calculation, application of symmetry, solid characteristics of simple salts.
CLO-5: Apply ionic equilibria concepts to solve problems in solutions.

Detailed Syllabus:

Unit 1: Gaseous state:

Behavior of real gases: Deviations from ideal gas behavior, compressibility factor, and its variation with pressure for different gases. Causes of deviation from ideal behavior. van der Waals equation of state, its derivation and application in explaining real gas behaviour; van der Waals equation expressed in virial form, Boyle temperature. Isotherms of real gases and their comparison with van der Waals isotherms, continuity of states, critical state, critical and van der Waals constants, law of corresponding states.

Kinetic molecular model of a gas: postulates and derivation of the kinetic gas equation; collision frequency; collision diameter; mean free path and viscosity of gases, including their temperature and pressure dependence, relation between mean free path and coefficient of viscosity, calculation of σ from η; variation of viscosity with temperature and pressure. Maxwell distribution and its use in evaluating molecular velocities (average, root mean square

and most probable) and average kinetic energy, law of equipartition of energy, degrees of freedom and molecular basis of heat capacities. (**15 Hrs**)

Unit 2: Liquid state

Structure and physical properties of liquids; vapour pressure, surface tension, viscosity, and their dependence on temperature, Effect of addition of various solutes on surface tension, cleansing action of detergents. Structure of water. (**5 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; dissociation constants of mono-, di- and tri-protic acids.

Salt hydrolysis, hydrolysis constants, degree of hydrolysis and pH for different salts. Buffer solutions; Henderson equation, buffer capacity, buffer range, buffer action, applications of buffers in analytical chemistry, Solubility and solubility product.

Brönsted-Lowry concept of acid-base reactions, solvated proton, relative strength of acids, types of acid-base reactions, levelling solvents, Lewis acid-base concept, Classification of Lewis acids. Hard and Soft Acids and Bases (HSAB) Application of HSAB principle. Qualitative treatment of acid – base titration curves (calculation of pH at various stages). Theory of indicators; selection of indicators and their limitations. Multistage equilibria in polyelectrolytes. (**15 Hrs**)

Unit 4: Solid state

Nature of the solid state, law of constancy of interfacial angles, law of rational indices, Miller indices, elementary ideas of symmetry, symmetry elements and symmetry operations, qualitative idea of point and space groups, seven crystal systems and fourteen Bravais lattices; X-ray diffraction, Bragg's law, a simple account of rotating crystal method and powder pattern method. Analysis of powder diffraction patterns of NaCl, CsCl and KCl. Various types of defects in crystals, Glasses and liquid crystals. (**10 Hrs**)

Suggested Books

1. Ball, D. W. *Physical Chemistry* Thomson Press, India, **2007**.
2. Mortimer, R. G. *Physical Chemistry* 3rd Ed. Elsevier: NOIDA, UP, **2009**.
3. G. M. Barrow, Tata McGraw Hill (Fifth Edition), **2007**.
4. Puri, B. R, Sharma, L.R, Pathania, M.S., Principles of Physical Chemistry, Vishal Publishing Co., 47th Edition, **2020**

5. Physical chemistry by G. M. Barrow, Mc Graw Hill. NewYork
6. Kapoor K. L., A Textbook of Physical Chemistry, Volume 1 to Volume 6, McGraw Hill Education (India) Private Limited, **2015**
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.**

Semester-III: Physical Chemistry-I Laboratory Credits: 02

Code	Type	Title	Credits	Hours	L	T	P
UCHPM31102	Minor	Physical Chemistry-I Laboratory	2	4	0	0	4

Detailed Syllabus

I. Surface tension measurements.

13) Determine the surface tension by (i) drop number (ii) drop weight method.
14) Study the variation of surface tension of detergent solutions with concentration.

II. Viscosity measurements using Ostwald's viscometer.

15) Determination of viscosity of solutions of a given polymer
16) Determination of viscosity ethanol and/or sugar at room temperature.
17) Viscosity of sucrose solution with the concentration of solute.
18) Determination of concentration of glycerol using viscosity measurements

III. pH metry

19) Effect on pH of addition of HCl/NaOH to solutions of acetic acid, sodium acetate and their mixtures.
20) Preparation of buffer solutions of different pH using Sodium acetate-acetic acid and measurement of pH using pH meter
21) Preparation of buffer solutions of different pH using ammonium chloride-ammonium hydroxide and measurement of pH using pH meter
22) pH metric titration of any given strong acid vs. strong base
23) pH metric titration of any given weak acid vs. strong base.
24) Determination of dissociation constant of a weak acid.

Reference Books:

1. Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry,* R. Chand & Co.: New Delhi (2011).

2. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry 8th Ed*.; McGraw-Hill: New York (2003).
3. Halpern, A. M. & McBane, G. C. *Experimental Physical Chemistry 3rd Ed.;* W.H. Freeman & Co., New York (2003).
4. Athawale V. D. amd Mathur P. *Experimental Physical Chemistry*, New Age International, 2001.
5. Viswanathan, B., Raghavan, P.S., *Practical Physical Chemistry*, Viva Books Private Ltd, 2012
6. Maity, S.K., Ghosh, N.K., *Physical Chemistry Practicals*, New Central Book Agency Ltd, 1st Edition, 2012
7. A.Findlay, Practical Physical Chemistry (Longmans, Green and Co).
8. J.M.Wilson, K.J.Newcombe, A.R.Denko, R.M.W.Richett, Experiments in Physical Chemistry, (Pergamon Press).
9. Garland, C.W., Nibler, J.W., Shoemaker, D.P., Experiments in Physical Chemistry, McGraw-Hill Higher Education, 8th Edition, 2009

Semester-IV

SEMESTER-IV							
S.No.	**Category of Course**	**Course Code**	**Course Title**	**Hours**			**Credits**
				L	**T**	**P**	
1	Minor	UCHTM41200	Organic Chemistry-II	3	1	0	4
2	Minor	UCHPM41200	Organic Chemistry-II Laboratory	0	0	4	2
3	Minor	UCHTM41201	Physical Chemistry-II	3	1	0	4
4	Minor	UCHPM41201	Physical Chemistry-II Laboratory	0	0	4	2

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

Code	Type	Title	Credits	Hours	L	T	P
UCHTM41200	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: Understand the chemistry of various functional groups.
CLO-2: Understand the role of organometallic compounds in organic synthesis
CLO-3: Use reagents in various organic transformation reactions.
CLO-4: Understand the named reactions and their mechanisms.

Detailed Syllabus:

Unit-1: Chemistry of Halogenated Hydrocarbons:

Alkyl halides: Methods of preparation, nucleophilic substitution reactions – S_N1, S_N2 and S_Ni mechanisms with stereochemical aspects and effect of solvent etc.; nucleophilic substitution vs. elimination.

Aryl halides: Preparation, including preparation from diazonium salts. nucleophilic aromatic substitution; S_NAr, Benzyne mechanism.

Relative reactivity of alkyl, allyl/benzyl, vinyl and aryl halides towards nucleophilic substitution reactions.

Organometallic compounds of Mg and Li and their use in synthesis. **(12 hr)**

Unit-2: Alcohols, Phenols, Ethers and Epoxides

Alcohols: preparation, properties and relative reactivity of 1°, 2°, 3° alcohols, Bouvaelt-Blanc Reduction; Preparation and properties of glycols: Oxidation by periodic acid and lead tetraacetate, Pinacol-Pinacolone rearrangement.

Phenols: Preparation and properties; Acidity and factors effecting it, Ring substitution reactions, Reimer–Tiemann and Kolbe's–Schmidt Reactions, Fries and Claisen rearrangements with mechanism.

Ethers and Epoxides: Preparation and reactions with acids. Reactions of epoxides with alcohols, ammonia derivatives and LiAlH4 **(7 hr)**

Unit-3: Carbonyl Compounds

Structure, reactivity and preparation; Nucleophilic additions, Nucleophilic addition-elimination reactions with ammonia derivatives with mechanism; Mechanisms of Aldol and Benzoin condensation, Knoevenagel condensation, Claisen-Schmidt, Perkin, Cannizzaro and Wittig reaction, Beckmann and Benzil-Benzilic acid rearrangements, haloform reaction and Baeyer Villiger oxidation, α-substitution reactions, oxidations and reductions (Clemmensen, Wolff-Kishner, $LiAlH_4$, $NaBH_4$, MPV, PDC and PGC); Addition reactions of unsaturated carbonyl compounds: Michael addition. Active methylene compounds: Keto-enol tautomerism. Preparation and synthetic applications of diethyl malonate and ethyl acetoacetate.

(14 hr)

Unit-4: Carboxylic Acids and their Derivatives

Preparation, physical properties and reactions of monocarboxylic acids: Typical reactions of dicarboxylic acids, hydroxy acids and unsaturated acids: succinic/phthalic, lactic, malic, tartaric, citric, maleic and fumaric acids; Preparation and reactions of acid chlorides, anhydrides, esters and amides; Comparative study of nucleophilic substitution at acyl group - Mechanism of acidic and alkaline hydrolysis of esters, Claisen condensation, Dieckmann and Reformatsky reactions, Hofmann bromamide degradation and Curtius rearrangement. **(10 hr)**

Unit-4: Sulphur containing compounds

Preparation and reactions of thiols, thioethers and sulphonic acids. **(2 hr)**

Recommended Books/references:

1. Solomons, T.W. G., Fryhle, B. Craig. *Organic Chemistry*, John Wiley & Sons, Inc, 2009.

2. McMurry, J. E. *Fundamentals of Organic Chemistry*, Seventh edition Cengage Learning, 2013.

3. P. Sykes, *A Guide Book to Mechanism in Organic Chemistry*, 6th Edition, Orient Longman, New Delhi, 1997.

4. Morrison R. T. and Boyd R. N. Organic Chemistry, Sixth Edition Prentice Hall India, 2003.

5. Smith, M. B., March J., (Latest Ed.) *March's Advanced Organic Chemistry*, John Wiley and Sons, 6th edition, New York.

Semester-IV: Organic Chemistry-II Laboratory ***Credits: 02***

Code	Type	Title	Credits	Hours	L	T	P
UCHPM41200	Minor	Organic Chemistry-II Laboratory	2	4	0	0	4

Detailed Syllabus:

(List of experiments given are suggestive. One experiment from each group to be demonstrated)

I. Identification of elements (N, S, and halogen) and Functional group tests for alcohols, phenols, carbonyl, carboxylic acid and amine group of compounds.

II. Organic preparations:

15. Acetylation of one of the following compounds: amines (aniline, *o*-, *m*-, *p*-toluidines and *o*-, *m*-, *p*-anisidine) and phenols (β-naphthol, vanillin, salicylic acid) by any one method: (Using conventional method.and Using green chemistry approach)

16. Benzolyation of one of the amines (aniline, *o*-, *m*-, *p*- toluidines and *o*-, *m*-, *p*-anisidine) and one of the phenols (*β*-naphthol, resorcinol, *p*-cresol) by Schotten-Baumann reaction.
17. Oxidation of ethanol/ isopropanol (Iodoform reaction).
18. Bromination (any one)
    a) Acetanilide by conventional methods
    b) Acetanilide using green approach (Bromate-bromide method)
19. Nitration: (any one)
    a) Acetanilide/nitrobenzene by conventional method
    b) Salicylic acid by green approach (using ceric ammonium nitrate).
20. Selective reduction of *meta* dinitrobenzene to *m*-nitroaniline.
21. Reduction of *p*-nitrobenzaldehyde by sodium borohydride.
22. Hydrolysis of amides and esters.
23. Semicarbazone of any one of the following compounds: acetone, ethyl methyl ketone,
24. cyclohexanone, benzaldehyde.
25. *S*-Benzylisothiouronium salt of one each of water soluble/ insoluble acids (benzoic acid, oxalic acid, phenyl acetic acid and phthalic acid).
26. Aldol condensation with either conventional or green method.
27. Benzil-Benzilic acid rearrangement.
28. Collected solid samples may be used for recrystallization, melting point and TLC.

Recommended Books/References:

1. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry*, Pearson Education, 2009.
2. Furniss, B.S., Hannaford, A.J., Smith, P.W.G. & Tatchell, A.R. *Practical Organic Chemistry, 5th Ed.* Pearson, 2012.
3. Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis,* University Press, 2000.
4. Ahluwalia, V.K. & Dhingra, S. *Comprehensive Practical Organic Chemistry: Qualitative Analysis,* University Press, 2000.

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

Code	Type	Title	Credits	Hours	L	T	P
UCHTM41201	Minor	Physical Chemistry-II	4	4	3	1	4

Course Learning Outcomes (CLOs)

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

CLO-1: Understand various laws of thermodynamics and theories of dilute solutions.
CLO-2: Apply the concept of heat of reactions in calculating bond energy, enthalpy, etc.
CLO-3: Understand the concept of entropy and the calculation of entropy using laws of thermodynamics.
CLO-4: Apply thermodynamics to partial molar quantities.
CLO-5: Recognize the problems in thermodynamics, thermochemistry and dilute solutions.

Detailed Syllabus:

Unit-1: Introduction to thermodynamics:

Intensive and extensive variables; state and path functions; isolated, closed and open systems; zeroth law of thermodynamics. *First law:* Concept of heat, *q*, work, *w*, internal energy, *U*, and statement of first law; enthalpy, *H*, relation between heat capacities, calculations of *q*, *w*, *U* and *H* for reversible, irreversible and free expansion of gases (ideal and van der Waals) under isothermal and adiabatic conditions. **(10 hr)**

Unit 2: Thermochemistry:

Heats of reactions: standard states; enthalpy of formation of molecules and ions and enthalpy of combustion and its applications; calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data, effect of temperature (Kirchhoff's equations), pressure on enthalpy of reactions. **(5 hr)**

Unit 3: Second Law

Concept of entropy; thermodynamic scale of temperature, statement of the second law of thermodynamics; molecular and statistical interpretation of entropy. Calculation of entropy change for reversible and irreversible processes. **(5 hr)**

Unit 4: Third law of thermodynamics:

Third Law of thermodynamics, residual entropy, calculation of absolute entropy of molecules **(5 hr)**

Unit 5: Free Energy Functions

Gibbs and Helmholtz energy; variation of S, G, A with T, V, P; Free energy change and spontaneity. Relation between Joule-Thomson coefficient and other thermodynamic parameters; inversion temperature; Gibbs-Helmholtz equation; Maxwell relations; thermodynamic equation of state. **(5 hr)**

Unit 6: Partial molar quantities:

Partial molar quantities, dependence of thermodynamic parameters on composition; Gibbs-Duhem equation, chemical potential of ideal mixtures, change in thermodynamic functions in mixing of ideal gases. **(5 hr)**

Unit 7: Dilute solutions

Dilute solutions; lowering of vapour pressure, Raoult's and Henry's Laws and their applications. Excess thermodynamic functions. Thermodynamic derivation using chemical potential to derive relations between the four colligative properties: [(i) relative lowering of vapour pressure, (ii) elevation of boiling point, (iii) Depression of freezing point, (iv) osmotic pressure] and amount of solute. Applications in calculating molar masses of normal, dissociated and associated solutes in solution. **(10 hr)**

Recommended Books/References:

12. Atkins P. and De Paula, J. *Physical Chemistry* Tenth Ed., OUP, 2014.
13. Castellan, G. W. *Physical Chemistry 4th Ed.,* Narosa, 2004.
14. Engel, T. and Reid, P. *Physical Chemistry 3rd Ed.,* Prentice Hall, 2012.
15. McQuarrie, D. A. and Simon, J. D. *Molecular Thermodynamics* Viva Books, 2004.
16. Roy, B. N. Fundamentals of Classical and Statistical Thermodynamics Wiley, 2001
17. *Commonly Asked Questions in Thermodynamics.* CRC Press, 2011.
18. Levine, I .N. *Physical Chemistry* 6th Ed., Tata Mc Graw Hill, 2010.
19. Metz, C.R. *2000 solved problems in chemistry,* Schaum Series, 2006.
20. Rajaram J, Kuriacose J. C., Chemical Thermodynamics: Classical, Statistical and Irreversible, Pearson Education India, 1st Edition, 2013.
21. Puri, B. R, Sharma, L.R, Pathania, M.S., Principles of Physical Chemistry, Vishal Publishing Co., 47th Edition, **2020**
22. Kapoor K. L., A Textbook of Physical Chemistry, Volume 1 to Volume 6, McGraw Hill Education (India) Private Limited, **2015**

Semester-IV: *Physical Chemistry-II Laboratory* ***Credits: 02***

Code	Type	Title	Credits	Hours	L	T	P
UCHPM41201	Minor	Physical Chemistry-II Laboratory	2	4	0	0	4

Detailed Syllabus:

I. Phase equilibrium

1) Determination of critical solution temperature and composition of the phenol-water system

and to study the effect of impurities on it.

2) Study of two component simple eutectic system

II. Study the equilibrium of the following reactions by the distribution method:

3) I_2 (aq) + I^- → I_3^-(aq)

4) Cu^{2+}(aq) + $n$$NH_3$ → $Cu(NH_3)_n$

III. Study the kinetics of the following reactions.

5) Acid hydrolysis of methyl acetate with hydrochloric acid.

6) Saponification of ethyl acetate.

7) Determination of rate constant of reaction between potassium persulfate and potassium iodide by titration.

IV. Adsorption

8) Verification of Freundlich adsorption isotherm

9) Verification of Langmuir isotherm for adsorption on acidic acid or organic dyes on activated charcoal.

V. Thermodynamics based experiments

10) Heat of solution of oxalic acid from solubility measurements

11) Heat of neutralisation of a given strong acid by a strong base

12) Partition coefficient for the distribution of iodine between water and CCl_4

Recommended Books/References:

1. Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry*, R. Chand, New Delhi, 2011.
2. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry*, Eighth Edition, McGraw-Hill, 2003.
3. Halpern, A. M. and McBane, G. C. *Experimental Physical Chemistry*, Third Edition, W, H. Freeman, 2003.
4. Viswanathan, 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, 1st Edition, 2012

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
UCHTD11100	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
UCHTD21101	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
UCHTD31102	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: Food Chemistry ***Credits: 03***

Code	Type	Title	Credits	Hours	L	T	P
UCHCS21100	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-II: Mathematics for Chemists ***Credits: 03***

Code	Type	Title	Credits	Hours	L	T	P
UCHCS11101	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-III: Quality Control Chemist ***Credits: 03***

Code	Type	Title	Credits	Hours	L	T	P
UCHTS10102	Skill Enhancement	Quality Control Chemist	3	4	2	0	2

	Course (SEC)						

Detailed Syllabus:

As per NSQF, Government of India.