Course Structure and Syllabus

M.Sc. Chemistry

(SEMESTER: I - IV)

Session: 2017-18

Centre for Chemical Sciences
School of Basic and Applied Sciences
Central University of Punjab
Mansa Road
Bathinda – 151001

Centre for Chemical Sciences
M.Sc. Chemistry

SEMESTER 1

S. No.	Paper Code	Course Title	Course Type	L	T	P	Cr
1	CHL.501	Fundamental Biology (Non-medical group)	FC	2	-	-	2
	CHL502	Fundamental Mathematics (Medical group)					
2	CHL.503	Analytical Chemistry and Instrumental Methods	CC	3	-	-	3
3	CHL.504	Inorganic Chemistry-1	CC	3	-	-	3
4	CHL.506	Organic Chemistry-I	CC	3	-	-	3
5	CHL.508	Physical Chemistry-I	CC	3	-	-	3
6	CHL.509	Quantum Chemistry	EC	4	-	-	4
7	CHP.505	Practical Inorganic Chemistry-1	CC	-	-	4	2
8	CHP.507	Practical Organic Chemistry-I	CC	-	-	4	2
9	XXX	Inter-Disciplinary Course (ID) (Opt any one from other Departments)	EC	2	-	-	2
		Total		**20**	**0**	**8**	**24**

FC: Foundation Course, **CC**: Core Course, **EC**: Elective Course
L: Lectures T: Tutorial P: Practical Cr: Credits

Examination Pattern A: Continuous Assessment
Based on Objective Type Tests (10 Marks)
Term paper (10 Marks)
Assignment(s) (5 Marks)
Examination Pattern B: Pre-Scheduled Mid Semester Test-1
Based on Subjective Type Test (25 Marks, 1 hr)
Examination Pattern C: Pre-Scheduled Mid Semester Test-2
Based on Subjective Type Test (25 Marks, 1hr)
Examination Pattern D: End-Term Exam (Final)
Based on Objective Type Tests (25 Marks, 1hr)

SEMESTER 2

S. No.	Paper Code	Course Title	Course Type	L	T	P	Cr
1	CHL.521	Inorganic Chemistry-II	CC	3	-	-	3
2	CHL.523	Organic Chemistry-II	CC	3	-	-	3
3	CHL.524	Physical Chemistry-II	CC	3	-	-	3
4	CHL.526	Spectral Analysis	EC	3	-	-	3
5	CHL.527	Molecular Spectroscopy	CC	4	-	-	4
6	CHP.522	Practical Inorganic Chemistry-II	CC	-	-	4	2
7	CHP.525	Practical Physical Chemistry- II	CC	-	-	4	2
8	CHS.599	Seminar	FC	-	2	-	2
9	XXX	Inter-Disciplinary Course (ID) (Opt any one from other Departments)	EC	2	-	-	2
		Total		**18**	**2**	**8**	**24**

FC: Foundation Course, **CC**: Core Course, **EC**: Elective Course

L: Lectures T: Tutorial P: Practical Cr: Credits

Examination Pattern A: Continuous Assessment

Based on Objective Type Tests (10 Marks)

Term paper (10 Marks)

Assignment(s) (5 Marks)

Examination Pattern B: Pre-Scheduled Mid Semester Test-1

Based on Subjective Type Test (25 Marks, 1 hr)

Examination Pattern C: Pre-Scheduled Mid Semester Test-2

Based on Subjective Type Test (25 Marks, 1hr)

Examination Pattern D: End-Term Exam (Final)

Based on Objective Type Tests (25 Marks, 1hr)

SEMESTER 3

S. No.	Paper Code	Course Title	Course Type	L	T	P	Cr
1	CHL.601	Inorganic Chemistry-III	CC	3	-	-	3
2	CHL.602	Organic Chemistry-III	CC	3	-	-	3
3	CHL.604	Material Chemistry	CC	4	-	-	4
4	CHL.606	Bioinorganic and Biophysical Chemistry	FC	4	-	-	4
5	CHL.607	Inorganic Photochemistry	EC	3	-	-	3
6.	CHP.603	Practical Organic Chemistry-III	CC	-	-	4	2
7.	CHS.605	Practical Physical Chemistry- III	CC	-	-	4	2
8.	CHL.608	Current Trends in Organic Synthesis	EC	3	-	-	3
	CHL.609	Supramolecular Chemistry					
	Total			**20**	**0**	**8**	**24**

FC: Foundation Course, **CC**: Core Course, **EC**: Elective Course
L: Lectures T: Tutorial P: Practical Cr: Credits
Examination Pattern A: Continuous Assessment Based on Objective Type Tests (10 Marks)
Term paper (10 Marks)
Assignment(s) (5 Marks)
Examination Pattern B: Pre-Scheduled Mid Semester Test-1
Based on Subjective Type Test (25 Marks, 1 hr)
Examination Pattern C: Pre-Scheduled Mid Semester Test-2
Based on Subjective Type Test (25 Marks, 1hr)
Examination Pattern D: End-Term Exam (Final)
Based on Objective Type Tests (25 Marks, 1hr)

SEMESTER 4

S. No.	Paper Code	Course Title	Course Type	L	T	P	Cr
1	CHL.621	Polymer and Solid State Chemistry	CC	4	-	-	4
Opt any one of the following courses:							
2	CHL.622	Advanced Organic Synthesis	EC	4	-	-	4
	CHL.623	Chemistry of Natural Products					
	CHL.624	Organotransition Metal Chemistry					
3	CHD.600	Project	EC	-	-	-	16
		Total		**8**			**24**

Examination Pattern A: Continuous Assessment Based on Objective Type Tests (10 Marks)
Term paper (10 Marks)
Assignment(s) (5 Marks)

Examination Pattern B: Pre-Scheduled Mid Semester Test-1
Based on Subjective Type Test (25 Marks, 1 hr)

Examination Pattern C: Pre-Scheduled Mid Semester Test-2
Based on Subjective Type Test (25 Marks, 1hr)

Examination Pattern D: End-Term Exam (Final)
Based on Objective Type Tests (25 Marks, 1hr)

Course Title: Fundamental Biology (Non-medical group)

L	T	P	Credits
2	0	0	2

Paper Code: CHL.501

Total Contact Hours: 36

Learning objective: To impart knowledge of molecular structure and interactions present in various bio-molecules that assist in functioning and organization of biological cell.

Unit 1 **9 Hrs**

Introduction: Cell structure and functions, thermodynamics and kinetics of biological processes, ATP. water – physical properties and structure of water molecules, Interactions in aqueous solutions, Role of water in life, pH, Biological buffers, solution equilibria, Henderson-Hasselbalch equation, Hofmeister series, Chaotropic and kosmotropic ions/co-solvents.

Unit 2 **9 Hrs**

Amino Acids and Peptides: Classification and properties of amino acids, peptide and polypeptides, primary structures, structure of peptide bond, synthesis of peptides, N-terminal, C-terminal and sequence determination.

Carbohydrates: Biologically important monosaccharides, disaccharides and polysaccharides, glycoproteins, role of sugars in biological recognition.

Unit 3 **9 Hrs**

Proteins: Secondary structure of proteins with emphasize on supramoelcular characteristics of α-helix, β-sheets, supersecondary structure and triple helix structure of collagen, tertiary structure of protein-folding, quaternary structure of protein, protein misfolding and conformational diseases.

Catalysis and binding in enzymes, ligand-protein interactions, membranes, ribosomes and multienzyme complexes as supramolecular complexes.

Unit 4 **9 Hrs**

Nucleic Acids: Purine and pyrimidine bases, nucleotides, nucleosides, base pairing via H-bonding, structure of ribonucleic acids (RNA) and deoxyribonucleic acids (DNA), double helix model of DNA, different types of RNA and their functions, the chemical basis for heredity, overview of replication of DNA, transcription, translation and genetic code, genome sequencing and PCR techniques.

Lipids: Lipid classification, lipid bilayers, liproproteins-composition. high density (HDL) and low-density (LDL) lipoproteins and function, membrane proteins - integral membrane proteins, lipid linked proteins, peripheral proteins, overview of membrane structure and assembly, liposomes, their biological functions.

Course Outcome:

After this course completion, the students will acquire knowledge of

1. Molecular structure and interactions present in proteins, nucleic acids, carbohydrates and lipids.
2. Organization and working principles of various components present in living cell.
3. Physical principles of structure, function, and folding of biomolecules.

SUGGESTED READINGS

1. Voet, D.J., Voet, J.G., Pratt, C.W., Principles of Biochemistry, 3rd edition, 2008, John Wiley,.
2. Berg, J.M., and Tymoczko, J.L., Stryer, L., Biochemistry, 6th edition, 2007, W.H. Freeman,.
3. Garrett, R.H., Grisham, C.M., Biochemistry, Brooks/Cole, 4th edition, 2014, Cengage Learning,.
4. Conn, E.E., and Stump, F., Outlines of Biochemistry, 5th edition, 2006, John Wiley.

Course Title: Fundamental Mathematics (Medical group)
Paper Code: CHL.502
Total Contact Hours: 36

L	T	P	Credits
2	0	0	2

Learning objective: To provide students with knowledge, abilities and insight in mathematics so that they can understand, correlate and quantify the physical principles of chemical system.

Unit 1 **9 Hrs**

Trigonometry and Algebra

Trigonometric functions of sum and differences of angles, addition and subtraction formulas. Quadratic equations and their solutions: binomial theorem, binomial expansion, finding middle term, general term. **Complex Algebra:** complex numbers, the graphical interpretation of complex numbers, characterizations of the exponential function, the trigonometric functions of complex argument ($e^{i\theta}$, $e^{-i\theta}$).

Unit 2 **9 Hrs**

Differential Calculus and Matrix Algebra

Functions, limits, derivative, physical significance, basic rules of differentiation, maxima and minima, exact and inexact differentials, partial differentiation.

Addition and multiplication; inverse, adjoint and transpose of matrices, matrix equation, Introduction to vector spaces, matrix eigen values and eigen vectors, diagonalization, determinants (examples from Huckel theory).

Unit 3 **9 Hrs**

Integral Calculus

Basic rules for integration, integration by parts, partial fraction and substitution, definite integrals, evaluation of definite and some standard integrals related to chemistry

Unit 4 **9 Hrs**

Elementary Differential Equations

Variables-separable and exact, first-order differential equations, homogenous, exact and linear equations. Applications to chemical kinetics, quantum chemistry, etc. solutions of differential equations by the power series method, spherical harmonics, second order differential equations and their solutions.

Course Outcome:

1. The completion of this course will enable the students to solve the complex problems in quantum chemistry, statistical thermodynamics, molecular spectroscopy, chemical kinetics, group theory, etc in the latter stage of M.Sc. chemistry programme.

SUGGESTED READINGS

1. Steiner, E. The Chemistry Mathematics, 2nd edition, 2008, Oxford University Press.
2. Doggett, G. and Sucliffe, B.T. Mathematics for Chemistry, 1st edition, 1995, Longman.
3. Daniels, F. Mathematical Preparation for Physical Chemistry, 2003, McGraw Hill.
4. Hirst, D.M. Chemical Mathematics, Longman.
5. Barrante, J. R. Applied Mathematics for Physical Chemistry, 3rd edition, 2008, Prentice Hall.
6. Tebbutt P. Basic Mathematics for Chemists, 1st edition, 1998, John Wiley.

Course Title: Analytical Chemistry and Instrumental Methods
Paper Code: CHL.503
Total Contact Hours: 54

L	T	P	Credits
3	0	0	3

Learning objective: To impart knowledge of various analytical and instrumental methods for chemical characterization and analysis.

Unit 1 **10 Hrs**

Errors in Quantitative Analysis: Accuracy, precision, sensitivity, specificity, standard deviation, classification of errors and their minimization, significant figures, standard reference materials.

Quantitative Analysis: Concepts important to quantitative analysis, classification of methods for quantitative analysis, choice of method for analysis, theory of volumetric and gravimetric methods of analysis.

Thermogravimetry: TGA, DTA, DSC - Instrumentation, methodology, applications.

Unit 2 **8 Hrs**

Analytical Spectroscopy: Principle, applications and limitations of spectrophotometery, Beer-Lambert law, analysis of mixtures, sources and treatment of interferences and detection limits to be considered in each of the techniques, fluorescence spectrometry, nephelometry, turbidimetry, atomic absorption spectrometry (AAS); flame AAS, electrothermal AAS (ETAAS). Wavelength dispersive (WDXRF) and energy dispersive (EDXRF), X-ray fluorescence.

Unit 3 **18 Hrs**

Potentiometry – General principles, calomel electrodes, Ag/AgCl electrodes, membrane electrodes – ion selective electrodes, glass electrodes, liquid membrane electrodes, Clark's electrode, biosensors.

Amperometry/Coulometry: Basic principles, constant current and constant potential coulometry. coulometric titrations.

Voltammetry: Principles, voltammograms, equation of voltammogram, different waveforms–linear scan, square scan and triangular scan, cyclic voltammetry.

Unit 4 **18 Hrs**

Chromatography: Partition and distribution, principles of chromatography, plate and rate theory. retention time and retention factor, resolution and separation factor; general idea about adsorption, partition and column chromatography, paper and thin layer chromatography, gas chromatography (GC) and high performance liquid chromatography (HPLC) - instrumentation, methodology and applications. UPLC, SFC LC, hyphenated techniques, LC-MS and LC MS/MS.

Course Outcome: The students will acquire knowledge of

1. Various analytical methods and their applications
2. Various instrumental methods and their applications.
3. Further the student should be able to figure out the analytical process and instrumental method to be advised for a particular problem in hand

SUGGESTED READINGS

1. Skoog, D.A., Holler, F.J., and Crouch, S.R. Principles of Instrumental Analysis, 6th Edition, 2007, Thomson Learning.

2. Willard, H. H., Merritt Jr. L., Dean, J.A. and Settle, F.A. Instrumental Methods of Analysis, 7th edition, 2007, CBS Publishers.
3. Bassett, J., Denney, R.C., Jeffery, G.H., and Mendham, J. Vogel's Textbook of Quantitative Chemical Analysis, 6th Edition, 2009, Pearson Education.
4. Skoog, D.A., West, D.M., Holler, F.J., and Crouch, S.R. Fundamentals of Analytical Chemistry, 9th edition, 2013, Brooks/Cole.
5. Christian, G.D. Analytical Chemistry, 6th edition, 2004, John Wiley and Sons Inc.
6. Bard A.J. and Faulkner, I.R. Electrochemical Methods, 2nd edition, Wiley, New York, 2000.
7. Rouessac, F. and Rouessac, A. Chemical Analysis: Modern Instrumentation Methods and Techniques, 2013, John Wiley & Sons.
8. Danzer, K. Analytical Chemistry: Theoretical and Metrological Fundamentals. 2007, Springer Science & Business Media.

Course Title: Inorganic Chemistry - I
Paper Code: CHL.504
Total Contact Hours: 54

L	T	P	Credits
3	0	0	3

Learning objective: To introduce theories, reaction mechanism and stability of the coordination complexes, and their magnetic and electronic properties.

Unit 1 **10 Hrs**

Metal-Ligand Equilibria in Solution

Stepwise and overall formation constant and their interaction, trends in stepwise constants,factors affecting the stability of metal complexes with reference to the nature of metal ion and ligand, chelate effect and its thermodynamic origin, determination of binary formation constants by spectrophotometry and potentiometric (pH) methods.

Unit 2 **15 Hrs**

Reaction Mechanisms of Transition Metal Complexes

Introduction,potential energy diagram and reactivity of metal complexes, ligand substitution reactions, substitution reactions mechanisms, labile and inert metal complexes, acid hydrolysis, factors affecting acid hydrolysis, base hydrolysis, conjugate base mechanism, anation reaction, substitution reactions in square planar complexes, trans effect, mechanism of the substitution reaction reactions without metal ligand bond cleavage, electron transfer processes outer and inner sphere, Berry pseudorotation.

Unit 3 **15 Hrs**

Ligand field theory and molecular orbital theory; nephelauxetic series, structural distortion and lowering of symmetry, electronic, steric and Jahn-Teller effects on energy levels, conformation of chelate ring, structural equilibrium, magnetic properties of transition metal ions and free ions presentive, effects of L-S coupling on magnetic properties, temperature independent paramagnetism(TIP) in terms of crystal field theory CFT and molecular orbital theory (MOT), quenching of orbital angular momentum by crystal fields in complexes in terms of termsplitting. effect of spin-orbit coupling and A, E & T states mixing.

Unit 4 **14 Hrs**

Crystal Fields Splitting

Spin-spin, orbital-orbital and spin orbital coupling, LS and J-J coupling schemes, determination of all the spectroscopic terms of p^n, d^n ions, determination of the ground state terms for pn, dn, fn ions using L.S. scheme, determination of total degeneracy of terms, order of interelectronic repulsions and crystal field strength in various fields, spin orbit coupling parameters (λ) energy separation between different j states, the effect of octahedral and tetrahedral fields on S, P, D and F terms. splitting patterns of and G, H and I terms. Strong field configurations, transition from weak to strong crystal fields, selection rules of electronic transitions in transition metal complexes, relaxation of the selection rule in centrosymmetric and non-centrosymmetric molecules, Orgel diagrams, Tanabe Sugano diagrams, calculation of 10Dq and B with use of Orgel and Tanabe Sugano diagrams, variation of the Racah parameter, spectrochemical series, band intensities, factors influencing band widths.

Course Outcome: The completion of this course will enable the students toacquire knowledge of

1. Reaction mechanism, formation constant and stability of the coordination complexes.
2. Interpretation of the electronic and magnetic properties.

SUGGESTED READINGS

1. Cotton, F.A. and Wilkinson G. Advanced Inorganic Chemistry, 6th edition, 2007, John Wiley& Sons.
2. Huheey, J. E. Inorganic Chemistry: Principles of Structure and Reactivity, 4thedition, 2006, Dorling Kindersley (India) Pvt. Ltd.
3. Greenwood, N.N. and Earnshaw, A. Chemistry of the Elements, 2ndedition, 2005 (reprinted),Butterworth-Heinemann, A division of Read Educational & Professional Publishing Ltd.
4. Lever, A.B.P. Inorganic Electronic Spectroscopy, 2ndedition, 1984, Elsevier Science Publishers B.V.
5. Carlin, R. L. and Van Duyneveldt, A.J.Magnetic Properties of Transition Metal Compounds, Inorganic Chemistry Concepts 2, SpringerverlagNew York Inc., 1977.
6. Miessler,G. L.andTarr, D. A. Inorganic Chemistry,4thedition, 2011, Pearson Education.
7. Figgis,B.N. Introduction to Ligand Field, 1966Wiley Eastern.
8. Drago,R.S. Physical Method in Chemistry, 1965, W.B. Saunders Company.
9. Shriver, D.F.; Atkins, P.W. Inorganic Chemistry, 5thedition, 2010, Oxford University Press.
10. Earnshaw, A. Introduction to Magnetochemistry, 1968, Academic Press.
11. Dutta, R.L.; Syanal, A. Elements of Magnetochemistry, 2ndedition, 1993, Affiliated East West Press.
12. Drago, R. S. Physical Methods for Chemists, 2ndedition, 1992, Saunders College Publishing.

Course Title: Organic Chemistry-I
Paper Code: CHL.506
Total Contact Hours: 54

L	T	P	Credits
3	0	0	3

Learning objective: To impart advanced knowledge of stereochemistry of organic compounds and mechanism of substitution, elimination and addition reactions.

Unit 1 **16 Hrs**

Stereochemistry: Elements of symmetry, chirality, projection formulae, configurational and conformational isomerism in acyclic and cyclic compounds; stereogenicity, stereoselectivity, enantioselectivity, diastereoselectivity, racemic mixture and their resolution, configurational notations of simple molecules, D/L, R/S, *E*/*Z* and *cis*/*trans* configurational notations, *threo* and *erythro* isomers, methods of resolution, optical purity, enantiotopic and diastereotopic atoms, groups and faces, stereospecific and stereoselective synthesis, asymmetric synthesis, optical activity in the absence of chiral carbon (biphenyls, allenes and spiranes), chirality due to helical shape, stereochemistry of the compounds containing nitrogen, sulphur and phosphorus, conformational analysis of cyclic compounds such as cyclopentane, cyclohexane, cyclohexanone derivatives, decalins, 1,2-; 1,3-, 1,4-disubstituted cyclohexane derivatives and D-Glucose, effect of conformation on reactivity, conformation of sugars.

Unit 2 **14 Hrs**

Aliphatic nucleophilic substitution reaction: The S_N2, S_N1, mixed S_N2 and S_N1 and SET mechanism, the S_Ni mechanism. nucleophilic substitution at an allylic, aliphatic and vinylic carbon. reactivity effects of substrate structure, attacking nucleophile, leaving group and reaction medium, ambident nucleophile, regioselectivity, competition between S_N2 and S_N1 mechanisms, Vilsmeier–Haack reaction.

Aromatic nucleophilic substitution: The S_NAr, bimolecular displacement mechanism and benzyne mechanism, reactivity effect of substrate structure, leaving group and attacking nucleophile.

Aromatic electrophilic substitution: The arenium ion mechanism, orientation and reactivity, energy profile diagrams, *ortho/para* ratio, ipso attack, orientation in other ring systems, quantitative treatment of reactivity in substrates and electrophiles, Diazonium coupling.

Unit 3 **12 Hrs**

Elimination reactions: E2, E1 and E1cB mechanisms and their spectrum, orientation of the double bond, effects of substrate structures, attacking base, the leaving group and the medium, mechanism and orientation in pyrolytic elimination.

Addition to carbon-carbon multiple bonds: Mechanistic and stereochemical aspects of addition reactions involving electrophiles, nucleophiles and free radicals, addition of halogen polar reagents to alkenes, Regio- and chemoselectivity, orientation and reactivity, hydroboration, epoxidation and hydroxylation.

Unit 4 **12 Hrs**

Addition to carbon-hetero multiple bonds: Reactivity of carbonyl group, homologation and dehomologation of carbonyl compounds, Arndt-Eistert synthesis, nucleophilic addition of hetero-atoms (N,O,S), conjugate addition reactions, acylation of carbonyl carbon, carboxylic acids and derivatives, decarboxylation reactions, addition of Grignard reagent, organozinc and organolithium reagents to carbonyl and unsaturated carbonyl compounds, mechanism of condensation reactions involving enolates- Aldol, Knoevenagel, Claisen, Mannich, Benzoin, Perkin and Stobbe reactions, hydrolysis of esters and amides, ammonolysis of esters.

Course Outcome: Students will acquire the knowledge of

1. Conformational analysis of cyclic and acyclic compounds, chirality and reactivity.
2. Mechanistic aspects in nucleophilic and electrophilic substitution.
3. Mechanistic aspects in addition and elimination reactions.

SUGGESTED READINGS

1. Clayden, J., Greeves, N., Warren, S. and Wothers, P. Organic Chemistry, 2nd edition, 2012, Oxford University Press.
2. Finar, I.L. Organic Chemistry Volume 1, 6th edition, 2012, Pearson Education UK.
3. McMurry J. Organic Chemistry**,** 8th edition, 2011 Asian Book Pvt. Ltd, New Delhi
4. Smith, M. B. March's Advanced Organic Chemistry: Reactions, Mechanisms and Structure, 7th Edition, 2013, John Wiley & Sons.
5. Ahluwalia, V. K. and Parashar R. K. Organic Reaction Mechanism**,** 4th edition, 2011, Narosa Publishing House (P) Ltd., New Delhi.
6. Bansal, R. K. A text book of Organic Chemistry, 5th edition, 2010, New Age International (P) Ltd., New Delhi.
7. Bansal R.K. Organic Reaction Mechanism, 2010, New Age International (P) Ltd., New Delhi.
8. Kalsi, P.S. Organic Reactions and Their Mechanisms. 3rd edition, 2010, New Age International, New Delhi.
9. Kalsi, P.S. Stereochemistry: Conformation and Mechanism, 2010, New Age International Ltd, New Delhi.
10. Lowry, T. H. and Richardson K. S. Mechanism and Theory in Organic Chemistry, 3rd edition, 1998, Addison-Wesley Longman Inc., New York.
11. Morrison, R.T. and Boyd, R.N. Organic Chemistry, 6th edition, 2011, Prentice- Hall of India, New Delhi.
12. Mukherjee, S.M. and Singh, S.P. Reaction Mechanism in Organic Chemistry. 3rd edition, 2009, Macmillan India Ltd., New Delhi.
13. Robert, J. D. and Casereo, M.C. Basic principle of Organic Chemistry**,** 2nd edition, 1977, Addison-Wesley.
14. Solomon, T.W.G, Fryhle, C.B. and Snyder, S. A.Organic Chemistry. 11th edition, 2013, John Wiley and Sons, Inc.
15. Sykes, P. A Guide Book to Mechanism in Organic Chemistry, 6th edition, 1997, Prentice Hall.
16. Eliel, E. L. and Wilen, S. H. Stereochemistry of Organic Compounds, 1994, John Wiley & Sons.

Course Title: Physical Chemistry-I
Paper Code: CHL.508
Total Contact Hours: 54

L	T	P	Credits
3	0	0	3

Learning objective: To impart knowledge of advanced classical and statistical thermodynamics.

Unit 1 **10 Hrs**

Thermodynamics: Concepts involved in first, second and third law of thermodynamic, Helmholtz and Gibbs Energies, Maxwell relations, equilibrium constant, temperature-dependence of equilibrium constant, Van't Hoff equation.

Unit 2 **10 Hrs**

Partial Molar Properties and Fugacity: Partial molar properties. Chemical potential of a perfect gas, dependence of chemical potential on temperature and pressure, Gibbs- Duhem equation, real gases, fugacity, its importance and determination, standard state for gases.

Solid-Liquid Solutions: Solutions of nonelectrolytes and electrolytes. Colligative properties of solutions, such as osmotic pressure, depression of the freezing point and elevation of the boiling point.

Unit 3 **12 Hrs**

Thermodynamics of Simple Mixtures: Thermodynamic functions for mixing of perfect gases. chemical potential of liquids. raoult's law, thermodynamic functions for mixing of liquids (ideal solutions only). Real solutions and activities. Clausius-clapeyron equation and its application to solid-liquid, liquid-vapour and solid-vapour equilibria.

Unit 4 **22 Hrs**

Statistical Thermodynamics: Thermodynamic probability and entropy, maxwell-boltzmann, bose-einstein and fermi-dirac statistics. partition function, molar partition function, thermodynamic properties in term of molecular partition function for diatomic molecules, monoatomic gases, rotational, translational, vibrational and electronic partition functions for diatomic molecules, calculation of equilibrium constants in term of partition function. monoatomic solids, theories of specific heat for solids.

Course Outcome: The students will acquire knowledge of

1. Classical thermodynamics and understanding thermodynamic phenomenon in a chemical system
2. Statistical thermodynamics and understanding thermodynamic properties in terms of partition functions,
3. Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac statistics, theories of specific heat for solids.

SUGGESTED READINGS

1. Barrow, G. M. Physical Chemistry, 5th Edition, 2007, Tata McGraw-Hill.
2. Kapoor, K. L. Text Book of Physical Chemistry, Volume 2-3,5, 5th/3rd Edition, 2011, Macmillan.
3. Atkins, P. and De Paula, J. Atkins' Physical Chemistry. 9th Edition, 2009, Oxford University Press.
4. McQuarrie, D. A. and Simon, J. D. Physical Chemistry: A Molecular Approach, 1st edition, 1998, Viva Books.
5. Moore, J. W. and Pearson, R. G. Kinetics and Mechanism, 3rd edition, 1981, John Wiley and Sons.
6. Silbey, R. J. Alberty, R. A. and Bawendi, M. G. Physical Chemistry, 4th Edition, 2004, Wiley-Interscience Publication.
7. Engel, T., Reid, P. and Hehre, W. Physical Chemistry, 3rd Edition, 2012, Pearson Education.
8. Puri, B.R., Sharma L.R. and Pathania, M.S. Principles of Physical Chemistry, 46th Edition, 2013, Vishal Publishing Company.

9. Rastogi, R. P. and Mishra, R. R. An Introduction to Chemical Thermodynamics 6th edition, 2013, Vikas Publishing
10. Rajaram, J. and Kuriacose, J. C. Chemical Thermodynamics, Classical, Statistical and Irreversible Thermodynamics, 2013, Pearson Education.
11. Laurendeau N. M. Statistical Thermodynamics: Fundamentals and Applications, 2005, Cambridge University Press.
12. Nash, L. K. Elements of Statistical Thermodynamics, 2nd Edition, 2012, Dover Publication Inc.
13. Hill, T. L. An Introduction to Statistical Thermodynamics, 1986, Dover Publications Inc.

Course Title: Quantum Chemistry
Paper Code: CHL.509
Total Contact Hours: 72

L	T	P	Credits
4	0	0	4

Learning objective: To acquire knowledge of the quantum chemical description of chemical bonding, reactivity and their applications in molecular spectroscopy and inorganic chemistry.

Unit 1 **18 Hrs**

Fundamental Background: Postulates of quantum mechanics, eigen values and eigen functions, operators, Schrodinger equation-particle in a box (1D, 3D) and its application, one-dimensional harmonic oscillator and rigid rotor, particle in a ring, hydrogen atom.

Unit 2 **18 Hrs**

Approximate Methods: Perturbation theory for non-degenerate and degenerate states and its applications. The variation theorem and its application.

Unit 3 **18 Hrs**

Angular Momentum: Ordinary angular momentum, eigen functions and eigen values for angular momentum, addition of angular momenta, spin, antisymmetry and Pauli exclusion principle.

Electronic Structure of Atoms: Electronic configuration, Russell-Saunders terms and coupling schemes, magnetic effects: spin-orbit coupling and Zeeman Splitting.

Unit 4 **18 Hrs**

Born-Oppenheimer Approximation: LCAO-MO and VB treatments of the H_2^+ and H_2, hybridization and valence MOs of H_2O and NH_3. Huckel Theory of acyclic and cyclic conjugated systems, bond order and charge density calculations.

Course Outcome: The students will acquire knowledge of

1. Schrodinger equation for a particle in a box and quantum chemical description.
2. Electronic and Hamiltonian operators for molecules.
3. Quantum chemical description of angular momentum and term symbols for a one and many-electron systems.
4. Born-Oppenheimer approximation, the Pauli principle, Hund's rules, Hückel theory and the variation principle.

SUGGESTED READINGS

1. Levine, I.N. Quantum Chemistry, 5th edition, 2000, Pearson Educ., Inc. New Delhi.
2. Chandra, A.K. Introductory Quantum Chemistry, 4th Edition, 1994, Tata Mcgraw Hill.
3. Prasad, R.K., Quantum Chemistry, 4th Edition, 2009, New Age Science.
4. McQuarrie, D. A. and Simon, J. D. Physical Chemistry: A Molecular Approach, 1stedition, 1998, Viva Books.
5. Murrell, J.N., Kettle S.F.A. and Tedder, J. M. Valence Theory, 2nd edition, 1965, John Wiley.
6. Lowe, J. P. and Peterson, K. Quantum Chemistry, 3rd Edition, 2006, Academic Press.

Course Title: Practical Inorganic Chemistry-I
Paper Code: CHP.505
Contact Hours: 72

L	T	P	Credits
0	0	4	2

Learning objective: To impart knowledge of various techniques for analysis of inorganic compounds.

Experiments:

Introduction to good laboratory practices in chemistry.

Gravimetric Estimation

1. Determination of Ba^{2+} as its sulphate/chromate.
2. Estimation of lead as its lead sulfate.
3. Estimation of Nickel (II) as its nickel dimethyl glyoximate.
4. Estimation of Cu^{2+}as cuprous thiocyanate.

Precipitation Titrations

5. $AgNO_3$ standardization by Mohr's method.
6. Volhard's method for Cl^- determination.

Oxidation-Reduction Titrations

7. Standardization of $KMnO_4$with sodium oxalate and determination of Ca^{2+} ion.
8. Standardization of ceric sulphate with Mohr's salt and determination of Cu^{2+}, NO_2 and $C_2O_4^{-2}$ ions.
9. Standardization of $K_2Cr_2O_7$ with Fe^{2+} and determination of Fe^{3+} (Ferric alum)
10. Standardization of hypo solution with potassium iodate / $K_2Cr_2O_7$ and determination of available Cl_2 in bleaching powder, Sb^{3+} and Cu^{2+}.
11. Determination of hydrazine with KIO_3 titration.

Spectrophotometeric determination: NO_3^- in water sample, $K_2Cr_2O_7$ in the presence of $KMnO_4$ and Fe(III) using 8-hydroxyquinoline.

Flame photometric determination: Li, Na, K and Ca.

Atomic Absorption Spectrometry: Estimation of metals in brass, soil and groundwater.

Course outcome: The students will acquire knowledge of

1. Volumetric and gravimetric analysis of cations and anions.
2. Standardization and titrations of various inorganic compounds.

SUGGESTED READINGS

1. Pass, G. and Sutcliffe H. Practical Inorganic Chemistry, 1st edition, 1979, Chapman and Hall Ltd.
2. Jolly, W.L. Synthetic Inorganic Chemistry, 2nd edition, 1961, Prentice Hall, Inc.,.
3. Nakamoto, K. Infrared and Raman Spectra of Inorganic and Coordination Compounds: Part A and B, 5thedition, 1997, John Wiley and Sons,.
4. Mendham, J., Denney, R.C., Barnes, J.D. and Thomas, M. Vogel's Textbook of Quantitative Chemical Analysis, 6th edition, 2000, Pearson Education Ltd.
5. Svehla, G. and Sivasankar, B. Vogel's Qualitative Inorganic Analysis (revised), 7th edition, 1996, Pearson Education Ltd.
6. Skoog, D.A., Holler, F.J., and Crouch, S.R., Principles of Instrumental Analysis, 6th Edition, 2007 Thomson Learning.

Course Title: Practical Organic Chemistry-I
Paper Code: CHP.507
Total Contact Hours: 72

L	T	P	Credits
0	0	4	2

Learning objective: To develop experimental skills of various separation and purification techniques and understand various concept of stereochemistry through molecular models.

Experiments

Safety and Handling of hazardous chemicals:

(i) Good laboratory practices, handling and disposal of hazardous chemicals.
(ii) Awareness about different types of glassware, heating devices, how to conduct organic reaction etc.

A. Techniques:

Chromatography: Thin layer chromatography (TLC): Monitoring the progress of chemical reactions, R_f values: identification of unknown organic compounds by comparing the R_f values with known standards. Column chromatography.

Purification Techniques: crystallization, distillation, sublimation and fractional distillation. Determination of melting point and mixed melting point.

B. Single Stage Synthesis: Synthesis of compounds and their purification, aspects such as conversion, theoretical yield and percentage yield should be paid attention. (Attempt any seven)

1 Synthesis of chalcones *via* Claisen-Schmidt condensation.
2 Reduction of benzophenone to benzhydral using $NaBH_4$.
3 Conversion of benzaldehyde to cinnamic acid (Knoevenagel condensation)
4 Conversion of benzaldehyde to dibenzylidene acetone (Aldol condensation)
5 Preparation of Grignard reagent.
6 Synthesis of alcohol *via* addition of Grignard reagent to an aldehyde.
7 To prepare phenylpropene *via* dehydration of corresponding phenylpropanol.
8 Preparation of bromohydrin from phenylpropene.
9 To prepare ethyl cinnamate *via* acid catalyzed esterification of cinnamic acid.
10 Conversion of phthalic anhydride to phthalimide
11 Conversion of acetanilide to *p*-bromoacetanide
12 Conversion of *p*-bromoacetanide to *p*-bromoaniline
13 Synthesis of Phenytoin

C. Demonstration of Stereochemical aspects of the compounds through molecular models.

D. ChemDraw-Sketch: Draw the structure of simple aliphatic, aromatic, heterocyclic organic compounds with substituents. Get the correct IUPAC name and predict the UV, IR and ^{1}H-NMR signal analysis.

Course Outcome: The students will acquire knowledge of

1. Good laboratory practices including safe handling of hazardous chemicals, laboratory glassware and equipment(s).
2. Various techniques such as thin layer chromatography, column chromatography besides extraction/workup of reaction mixture, distillation, and crystallization.
3. Importance of reaction conditions for a particular reaction and their mechanism.

4. Stereochemical aspects of the compounds through molecular model and drawing of organic structure through ChemDraw.

SUGGESTED READINGS

1. Harwood, L.M.and Moody, C.J. Experimental Organic Chemistry, 1st edition, 1989, Blackwell Scientific Publishers.
2. Vogel, A.I. Textbook of Practical Organic Chemistry, 6th edition,1978, ELBS, Longman Group Ltd.
3. Mann, F.G. and Saunders, B.C. Practical Organic Chemistry, 4th edition, New Impression, 1975, Orient Longman Pvt. Ltd.
4. Leonard, J. and Lygo, B. Advanced Practical Organic Chemistry, 1995, Chapman and Hall,.
5. Armarego, W. L. and Chai, C. Purification of Laboratory Chemicals, 2012, Butterworth-Heinemann.
6. Young, J. A. Improving Safety in the Chemical Laboratory: A Practical Guide. 2nd Edition, 1991, Wiley Publishing.

Course Title: Inorganic Chemistry-II
Paper Code: CHL.521
Total Contact Hours: 54

L	T	P	Credits
3	0	0	3

Learning objective: To introduce the concepts and importance of symmetry and group theory in solving chemical problems and clusters of boranes, orgnaometallics, inorganic chains, rings and cages.

Unit 1 **12 Hrs**

Symmetry

Symmetry elements, symmetry operations and their matrix representation, group postulates and types, multiplication tables, point group determination,

Unit2 **12 Hrs**

Group theory

Determination of reducible and irreducible representations, character tables, construction of character tables for C_2v, C_3v, use of symmetry in obtaining symmetry of orbitals in molecules.

Unit3 **14 Hrs**

MetalComplexes

Organic-transition metal chemistry, complexes with π-acceptor and σ-donor ligands, 18-electron and 16-electron rules, isolobal analogy, structure and bonding.Metal carbonyls, structure and bonding, vibrational spectra of metal carbonyls for bonding and structure elucidation, important reaction of metal carbonyls. Preparation, bonding structure and important reactions of transition metal nitrosyl, dinitrogen and dioxygencomplexes, tertiary phosphine as ligand.metallocenes, metal cluster compounds, metal-metal bond, metal carbenes, carbonyl and non-carbonyl clusters, fluxional molecules, application of orgnaometallic compounds as catalysts in organic synthesis.

Unit4 **16 Hrs**

Inorganic chains, rings and cages

a) **Chains:** Catenation, heterocatenation, isopolyanions and heteropolyanions.
b) **Rings:** Borazines, phosphazenes, other heterocyclic inorganic ring systems, homocyclic inorganic systems.
c) **Cages:** Cage compounds having phosphours, oxygen, nitrogen and sulphur: boron cage compounds, boranes, carboranes and metallocenecarboranes.

Course Outcome: The students will acquire knowledge of

1. Concepts to realize point group withinchemical structure, character tables and projection operator techniques.
2. Application of symmetry and group theory in spectroscopy.
3. Structural properties of organometallic complexes and their uses.

SUGGESTED READINGS

1. Cotton, F.A.; Wilkinson Advanced Inorganic Chemistry, 6th edition, 2007, John Wiley& Sons.
2. Huheey, J. E. Inorganic Chemistry: Principles of Structure and Reactivity, 4th edition, 2006, Dorling Kindersley (India) Pvt. Ltd.
3. Greenwood, N.N. and Earnshaw, A. Chemistry of the Elements, 2nd edition, 2005 (reprinted), Butterworth-Heinemann, A division of Read Educational & Professional Publishing Ltd.
4. Lever, A.B.P. Inorganic Electronic Spectroscopy, 2nd edition, 1984, Elsevier Science Publishers B.V.

5. Carlin, R. L. and Van Duyneveldt, A.J. Magnetic Properties of Transition Metal Compounds, Inorganic Chemistry Concepts 2, Springerverlag New York Inc., 1977.
6. Shriver, D.F.; Atkins, P.W. Inorganic Chemistry, 5th edition, 2010, Oxford University Press.
7. Earnshaw, A. Introduction to Magnetochemistry, 1968, Academic Press.
8. Dutta, R.L.; Syanal, A. Elements of Magnetochemistry, 2nd edition, 1993, Affiliated East West Press.
9. Drago, Russell S. *Physical Methods for Chemists*, 2nd edition, 1992, Saunders College Publishing

Course Title: Organic Chemistry-II
Paper Code: CHL.523
Total Contact Hours: 54

L	T	P	Credits
3	0	0	3

Learning objective: To impart knowledge of pericyclic and photochemical reactions, Molecular rearrangements and aromaticity.

Unit 1 **12 Hrs**

Reactive intermediates: Generation, structure and reactions of carbocation, carbanion, free radicals, carbenes, nitrenes and benzynes. Neighbouring group participation, classical and non-classical carbocations, phenonium ions and norbornyl system.

Aromaticity: Aromaticity in benzenoid and non-benzenoid compounds, Huckel's rule, energy level of π-molecular orbitals, annulenes, azulenes, antiaromaticity.

Unit 2 **12 Hrs**

Photochemistry: Jablonski diagram, singlet and triplet states, photosensitization, quantum efficiency, photochemistry of carbonyl compounds, Norrish type-I and type-II cleavages, Paterno-Buchi reaction, Photoreduction, Di π – methane rearrangement.

Photochemistry of aromatic compounds, Photo-Fries reactions of anilides, Photo-Fries rearrangement, Barton reaction, Singlet molecular oxygen reactions.

Unit 3 **16 Hrs**

Pericyclic chemistry:

Introduction, Phases, nodes and symmetry properties of molecular orbitals in ethylene, 1,3-butadiene, 1,3,5- hexatriene, Allyl cation, allyl radical, pentadienyl cation and pentadienyl radical.

Electrocyclic reactions: Conrotation and disrotation, 4n and 4n+2 systems. Woodward-Hoffmann rules. (i) Symmetry properties of HOMO of open chain partner (ii) Conservation of orbital symmetry and correlation diagrams.

Cycloaddition reactions: Suprafacial and antarafacial interactions. $\pi^2 + \pi^2$ and $\pi^4 + \pi^2$ cycloadditions and stereochemical aspects. Diels-Alder reaction. Woodward-Hoffmann Selection rules. Explanation for the mechanism by (i) Conservation of orbital symmetry and correlation diagrams (ii) FMO theory

Sigmatropic reactions: [1,j] and [i,j] shifts; suprafacial and antarafacial, selection rules for [lj} shifts; Cope and Claisen rearrangements; explanation for the mechanism by (i) symmetry properties of HOMO (ii) Introduction to cheletropic reactions and the explanation of mechanism by FMO theory.

Unit 4 **14 Hrs**

Rearrangements: General mechanistic considerations-nature of migration, migratory aptitude, mechanistic study of the following rearrangements: Pinacol-pinacolone, Wagner-Meerwein, Benzil-Benzillic acid, Favorskii, Neber, Beckmann, Hofmann, Curtius, Schmidt, Baeyer-Villiger, Shapiro reaction, Carroll, Claisen, Cope, Gabriel–Colman, Smiles and Sommelet–Hauser rearrangements.

Selective Name Reactions: Sharpless asymmetric epoxidation, dihydroxylation, Ene/Alder-ene reaction, Dakin reaction, Reformatsky, Robinson annulation, Michael addition, Stork-enamine, Hofmann-Loffler Fretag, Shapiro reaction, Chichibabin reaction.

Course Outcome: The students will acquire knowledge of

1. Basic principles of photochemical reactions, photochemistry of carbonyl and aromatic compounds.

2. Various thermally or photochemically driven pericyclic reactions and explanation for their stereochemical aspects.
3. Various molecular rearrangements and their application in organic synthesis for the conversion of different functional group.
4. Aromaticity and antiaromaticity in carbocyclic and heterocyclic compounds.

SUGGESTED READINGS

1. Acheson, R.M. An introduction to the Chemistry of Heterocyclic Compounds, 3rd edition, 1976 Wiley India Pvt. Ltd.
2. Clayden, J., Greeves, N., Warren, S. and Wothers, P. Organic Chemistry, 2nd edition, 2012, Oxford University Press.
3. Ahluwalia, V. K. and Parasar R. K. Organic Reaction Mechanism**,** 4th edition, 2011, Narosa Publishing House (P) Ltd., New Delhi.
4. Bansal, R. K. A Textbook of Organic Chemistry, 5th edition, 2010, New Age International (P) Ltd., New Delhi.
5. Bansal R.K. Organic Reaction Mechanism,2010, New Age International (P) Ltd., New Delhi.
6. Bansal, R.K. Hetrocyclic Chemistry, 5th edition, 2010, New Age International (P) Ltd., New Delhi.
7. Carey B. F. A., Sundberg R.J., Advanced Organic Chemistry Part A, 4th edition, 2002, Kluwer Academic Publishers.
8. Carey B. F. A., Sundberg R.J., Advanced Organic Chemistry Part B, 5th edition, 2007, Springer Science and Business Media Ltd.
9. Finar, I.L. Organic Chemistry Volume 1, 6th edition, 2012, Pearson Education UK.
10. Gilchrist, T.L. (1997). Heterocyclic Chemistry, 3rd edition, 1997, Addison Wesley Longman Publishers, US.
11. Gupta R.R., Kumar M. and Gupta V. Heterocyclic Chemistry-II Five Membered Heterocycles Vol. 1-3, 2010, Springer Verlag, India.
12. Joule, J.A. and Mills, K. Heterocyc1ic Chemistry, 5th edition,2010, Blackwell Publishers, New York.
13. Kalsi, P.S. Organic Reactions and Their Mechanisms. 3rd edition, 2010, New Age International, New Delhi.
14. Lowry, T. H. and Richardson K. S. Mechanism and Theory in Organic Chemistry, 3rd edition, 1998, Addison-Wesley Longman Inc., New York.
15. Morrison, R.T. and Boyd, R.N. Organic Chemistry, 6th edition, 2011, Prentice- Hall of India, New Delhi.
16. Mukherjee, S.M. and Singh, S.P. Reaction Mechanism in Organic Chemistry. 3rd edition, 2009, Macmillan India Ltd., New Delhi.
17. Katritzky, A. R., Ramsden, C. A., Joule, J. A. and Zhdankin V. V. Handbook of Heterocyclic Chemistry, 3rd edition, 2010, Elsevier UK.
18. Smith, M. B. March's Advanced Organic Chemistry: Reactions, Mechanisms and Structure, 7th Edition, 2013, John Wiley & Sons.
19. Sykes, P. A Guide Book to Mechanism in Organic Chemistry, 6th edition, 1997, Prentice Hall.
20. Norman, R.O.C. and Coxon, J.M. Principles of Organic Synthesis, 3rd edition, 1998, Nelson Thornes, Blackie Academic & Professional.

Course Title: Physical Chemistry-II
Paper Code: CHL.524
Total Contact Hours: 54

L	T	P	Credits
3	0	0	3

Learning objective: To impart knowledge of applications of electrochemistry, reaction kinetics, surface reaction, adsorption and catalysis.

Unit 1 **14 Hrs**

Electrochemistry: Nernst equation, electrochemical cells, concentration cells with and without liquid junction, application of electrochemical cell, thermodynamics of reversible electrodes and reversible cells. activity-coefficients, mean activity coefficients; Debye-Huckel treatment of dilute electrolyte solutions, derivation of Debye-Huckel limiting law, extended Debye-Huckel law, conductometric titrations.

Unit 2 **14 Hrs**

Reaction Kinetics: Introduction, rates of chemical reactions, mechanisms of chemical reactions and steady state approximation, laws of photochemistry, kinetics of photochemical reactions, collision and transition state theories, stearic factor, treatment of unimolecular reactions, ionic reactions: salt effect.

Unit 3 **14 Hrs**

Fast Reaction: Introduction to time-resolved techniques for absorption and emission measurements, relaxation method, study of kinetics of fast reactions by millisecond stopped-flow, nanosecond flash photolysis techniques, detection and kinetics of reactive intermediates, measurement of fluorescence and phosphorescence lifetimes, photoinduced electron transfer rates.

Unit 4 **12 Hrs**

Adsorption and Catalysis: Adsorption of solids, Gibbs adsorption isotherm, BET adsorption isotherm, Langmuir and Fredulich Isotherms. Homogeneous catalysis and heterogeneous catalysis, enzyme catalysis. Kinetics of catalytic reactions.

Course Outcome: The students will acquire knowledge of

1. Redox processes in electrochemical systems, Debye-Huckel theory and determination of activity and activity coefficient.
2. Mechanism for chemical reactions for optimizing the experimental conditions,
3. Kinetics of fast reactions by ultrafast methods and techniques
4. Application of homogeneous and heterogeneous catalysis in chemical synthesis
5. Importance of adsorption process and catalytic activity at the solid surfaces

SUGGESTED READINGS

1. Barrow, G. M. Physical Chemistry, 5th Edition, 2007, Tata McGraw-Hill.
2. Kapoor, K. L. Text Book of Physical Chemistry, Volume 1, 4, 5th Edition, 2011, MACMILLAN Publisher.
3. Atkins, P. and De Paula, J. Atkins' Physical Chemistry. 9th Edition, 2009, Oxford University Press.
4. McQuarrie, D. A. and Simon, J. D. Physical Chemistry: A Molecular Approach, 1stedition, 1998, Viva Books,.
5. Moore, J. W. and Pearson, R. G. Kinetics and Mechanism, 3rd edition, 1981, John Wiley and Sons.

6. Silbey, R. J. Alberty, R. A. and Bawendi, M. G. Physical Chemistry, 4th Edition, 2004, Wiley-Interscience Publication.
7. Engel T., Reid, P. and Hehre, W. Physical Chemistry, 3rd Edition, 2012, Pearson Education.
8. Puri, B.R. Sharma L.R. and Pathania M.S. Principles of Physical Chemistry, 46th Edition, 2013, Vishal Publishing Company.
9. Laidler, K. J. Chemical Kinetics, 3rd Edition, 1987, Pearson Education Ltd.
10. Engel T. and Reid, P. Thermodynamics, Statistical Thermodynamics, & Kinetics, 3rd edition, 2013, Pearson Education.
11. Lakowicz, J. R. Principles of Fluorescence Spectroscopy, 3rd edition, 2006, Springer.
12. Raj, G. Surface Chemistry (Adsorption), 4th Edition, 2002, Goel Publishing House.

Course Title: Spectral Analysis
Paper Code: CHL.526
Total Contact Hours: 54

L	T	P	Credits
3	0	0	3

Learning objective: To introduce the principles of various spectroscopic techniques such as UV, IR, NMR and Mass spectroscopy and illustrate their application for structural elucidation of organic molecules.

Unit 1 **14 Hrs**

UV-Visible spectroscopy: Principle of UV-Visible spectroscopy, role of solvents, chromophores and their interaction with UV-visible radiation. Woodward-Fieser rule.

Infrared Spectroscopy: Infrared radiation and its interaction with organic molecules, vibrational mode of bonds, effect of hydrogen bonding and conjugation on absorption bands, interpretation of IR spectra. FTIR.

Unit 2 **14 Hrs**

Nuclear magnetic resonance spectroscopy: Introduction, chemical shift, isotopic nuclei, reference standards and solvents. **^{1}H- NMR** spectra: spin spin coupling, coupling constants, integration of signals, interpretation of spectra, decoupling, double resonance and shift reagent methods, long range coupling, resonance of other nuclei e.g. ^{19}F, ^{15}N, ^{31}P.

Unit 3 **13 Hrs**

^{13}C NMR: Introduction, nuclear overhauser enhancement (NOE), DEPT techniques, Principle of 2-D NMR, Correlation spectroscopy (COSY), Homo COSY (^{1}H-^{1}H COSY), Hetro COSY (^{1}H-^{13}C COSY, HMQC), long range ^{1}H-^{13}C COSY (HMBC), NOESY, ^{13}C NMR spectra, their interpretation and application.

Unit 4 **13 Hrs**

Mass spectrometry: Basic principles and brief outline of instrumentation, Ion formation, molecular ion, metastable ion, McLafferty rearrangement, nitrogen rule, fragmentation process in relation to molecular structure and functional groups. relative abundance of isotopes, chemical ionization, FAB, ESI and MALDI other recent advances in mass spectrometry.

Course Outcome: The students will be able to

1. Describe the general principles of spectroscopy (UV, IR, NMR & MS) and various chromatographic techniques
2. Solve the structural problems based on UV-Vis, IR, ^{1}H NMR, ^{13}C NMR and mass spectral data.

SUGGESTED READINGS

1. Banwell, C.N. and McCash, E. M. Fundamentals of Molecular Spectroscopy, 2000, Tata McGraw-Hill, New Delhi.
2. Dyer, J.R. Application of Absorption Spectroscopy of Organic Compounds, 2009, Phi Learning.
3. Kalsi, P.S. Spectroscopy of Organic Compounds, 2004, New Age International Ltd.
4. Kemp, W.Organic spectroscopy, 1991, ELBS London.
5. Khopkar, S.M. Basic Concepts of Analytical Chemistry**,**2007, New Age International Pvt Ltd.
6. Melinda, J.D. Introduction to solid NMR Spectroscopy**,** 2010, Wiley India Pvt Ltd
7. Mendham, J., Denney, R.C., Barnes, J. D. and Thomas, M. J. K. Vogel's Textbook of Quantitative Chemical Analysis**,**2003, Pearson Education Pvt. Ltd., New Delhi.

8. Pavia, D.L., Lampman, G. M., Kriz, G. S. And Vyavan, J. R. Introduction to Spectroscopy,4th Edition, 2010, Harcourt College, NY.
9. Popov, A.I.; Halenga, K. Modern NMR techniques and their Applications in Chemistry,1991, Marcel Deckker.
10. Silverstein, R.M., Webster, F. X., Kiemle, D. J. And Bryce, D. L. Spectrometric Identifications of Organic Compounds, 8th Edition, 2014, John Wiley.
11. Skoog, D.A., Holler, F.J., and Crouch, S.R., Principles of Instrumental Analysis, 6th Edition, 2007 Thomson Learning.
12. Willard, H.H., Merritt Jr. L., Dean, J.A. and Settle, F.A., Instrumental Methods of Analysis, 7thedition, 2007, CBS Publishers.
13. Williams, D.H.; Fleming, I. Spectroscopy Methods in Organic Chemistry, 6th Edition, 2008, Tata McGraw-Hill Publishing Co. Ltd., New Delhi.

Course Title: Molecular Spectroscopy
Paper Code: CHL.527
Total Contact Hours: 72

L	T	P	Credits
4	0	0	4

Learning objective: To impart the knowledge of electronic, rotation, vibration, laser, NMR, FTIR spectroscopy and their applications.

Unit 1 **18 Hrs**

Electronic Spectroscopy: Principle of UV-Visible spectroscopy, Electronic transition, energy of electronic transition, selection rules, the Franck-Condon principle.

Microwave Spectroscopy: Classification of molecules, rigid rotor model, effect of isotopic substitution on the transition frequencies, intensities, non-rigid rotor, Stark effect, applications.

Unit 2 **18 Hrs**

Vibrational Spectroscopy: Instrumentation and applications of Infrared Spectroscopy, Simple harmonic oscillator, Vibrational energies of diatomic molecules, Anharmonicity, Vibration-rotation spectroscopy, P, Q, R branches, Vibrations of polyatomic molecules, Group frequencies, Overtones, Hot bands, Applications.

Raman Spectroscopy - Classical and quantum theories of Raman Effect, pure rotational, vibrational and vibrational-rotational raman spectra, mutual exclusion principle, coherent anti stokes raman spectroscopy.

Unit 3 **18 Hrs**

Nuclear Magnetic Resonance (NMR) Spectroscopy: Basic principles, instrumentation, magnetization vector and relaxation, nmr transitions, bloch equation, relaxation effects and mechanism, shielding and deshielding of magnetic nuclei, chemical shift, spin-spin interactions and coupling constant 'J', double resonance and spin tickling, effect of quadrapole nuclei, nuclear overhauser effect (NOE), multiple pulse methods, nmr in medical diagnostics.

Unit 4 **18 Hrs**

Lasers and Laser Spectroscopy: Principles of laser action, pulsed lasers, Q-switching, harmonic generation, examples of lasers: He-Ne, Nd-YAG, dye lasers, femtosecond spectroscopy.

Photoelectron spectroscopy: The photoelectric effect, UV photoelectron spectroscopy UPES, X-ray photoelectron spectroscopy XPES, electron binding energy, ESCA, Auger electron spectroscopy.

Course Outcome: The students will acquire knowledge of

1. Microwave, Infrared-Vibration-rotation Raman and infra-red Spectroscopy and their applications for chemical analysis
2. Electronic spectroscopy of different elements and simple molecules.
3. Nuclear Magnetic and Electron Spin Resonance Spectroscopy for organic compounds analysis, medical diagnostics.

SUGGESTED READINGS

1. Hollas, J. M. Modern Spectroscopy, 4th edition, 2004, John Wiley & Sons, Ltd.
2. Barrow, G. M. Introduction to Molecular Spectroscopy, 1988, McGraw-Hill International.

3. Banwell C. N. and McCash, E.M. Fundamentals of Molecular Spectroscopy, 4th edition, 1994, Tata McGraw Hill, New Delhi.
4. Lakowicz, J. R. Principles of Fluorescence Spectroscopy, 3rd edition, 2006, Springer.
5. Carrington A. and Mc Lachlan, A. D. Introduction to Magnetic Resonance, 1979, Chapman and Hall, London.
6. Harris, R. K. Nuclear Magnetic Resonance Spectroscopy, 1986, Addison-Wesley Longman Ltd, London.
7. Windawi, H. and Floyd, F.L.H. Applied Electron Spectroscopy for Chemical Analysis, Chemical Analysis, Vol. 63: A Series of Monographs on Analytical Chemistry and Its Applications Series, 1982, John Wiley.
8. Chang,R. Basic Principles of Spectroscopy, 1971, McGraw-Hill.
9. Ghosh, P.K. Introduction to Photoelectron Spectroscopy, Chemical Analysis Vol. 67: A Series of Monographs on Analytical Chemistry and Its Applications Series, 1983, John Wiley& Sons, New York.
10. Gunther, H. NMR Spectroscopy: Basic Principles, Concepts, and Application in Chemistry, 3rd Edition, 2013, Wiley Publishing.
11. Carrington, A. and MacLachalan, A.D. Introduction to Magnetic Resonance, 1967, Harper and Row, New York, USA.
12. Barrow, G. M. Physical Chemistry, 5th Edition, 2007, Tata McGraw-Hill.
13. Kapoor, K. L. Text Book of Physical Chemistry, Volume 1, 4, 5th Edition, 2011, MACMILLAN,.
14. Atkins, P. and De Paula, J. Atkins' Physical Chemistry. 9th Edition, 2009, Oxford University Press.
15. McQuarrie, D. A. and Simon, J. D. Physical Chemistry: A Molecular Approach, 1stedition, 1998, Viva Books.
16. Silbey, R. J. Alberty, R. A. and Bawendi, M. G. Physical Chemistry, 4th Edition, 2004, Wiley-Interscience Publication.

Course Title: Practical Inorganic Chemistry -II

L	T	P	Credits
0	0	4	2

Paper Code: CHL.522

Total Contact Hours: 72

Learning objective: To teach the synthesis of inorganic complexes and their characterization with instrumental techniques.

1. Preparation of Chloropentaammine cobalt (III) Chloride and its IR measurements.
2. Preparation of $[Co(en)_2Cl_2]$ Cl, Na_2 $[Fe(CN)_5$ $NH_3]$. H_2O, $[UO_2$ $(NO_3)_2$ $Py_2]$, Cu_2 $(CH_3COO)_4$ $(H_2O)_2$.
3. Preparation of $Hg[Co(CNS)_4]$ and used as standard for the magnetic moment measurement
4. Preparation of cis-and trans-K $[Cr$ $(C_2O_4)_2$ $(H_2O)_2$ and its IR study.
5. Preparation of bis(2,4-pentanedione)vanadium(IV) acetate and its piperidine or pyridine complex. Study of both the complexes with the help of infrared, UV-vis spectroscopy and magnetic susceptibility.
6. Preparation of lead tetraacetate.
7. Preparation and separation of isomers of $K_3[Fe(C_2O_4)_3]$, Cu(II) and Ni(II) complexes of Schiff base

Course Outcome: The students will acquire knowledge of

1. Preparation and purification of different inorganic complexes.
2. Application of UV-Vis, FT-IR, Magnetic moment measurement, Conductivity measurements, NMR and Thermogravimetric analysis for characterization of coordination complexes.

SUGGESTED READINGS

1. Pass, G. and Sutcliffe H. Practical Inorganic Chemistry, 1st edition, 1979, Chapmann and Hall Ltd.
2. Jolly, W.L. Synthetic Inorganic Chemistry, 2nd edition, 1961, Prentice Hall, Inc.,.
3. Nakamoto, K. Infrared and Raman Spectra of Inorganic and Coordination Compounds: Part A and B, 5th edition, 1997, John Wiley and Sons,.
4. Mendham, J., Denney, R.C., Barnes, J.D. and Thomas, M. Vogel's Textbook of Quantitative Chemical Analysis, 6th edition, 2000, Pearson Education Ltd.
5. Kolthoff, I.M. and Sandell, E.B. Text Book of Quantitative Inorganic Analysis, Revised Edition, 1968, London Macmillan and Co. Ltd.
6. Marr, G. and Rockett, B.W. Practical Inorganic Chemistry, 1972, John Wiley & Sons.
7. Jolly, W.L. The Synthesis and Characterization of Inorganic Compounds. 1970, Prentice Hall Press.

Course Title: Practical Physical Chemistry-II
Paper Code: CHL.525
Total Contact Hours: 72

L	T	P	Credits
0	0	4	2

Learning objective: To impart knowledge and hand-on experiences of different analytical techniques for chemical analysis

1. Determination of strength of a given base by titrating with an acid conductometrically.
2. Determination of solubility and solubility product of sparingly soluble salts (e.g., $PbSO_4$, $BaSO_4$) conductometrically.
3. Determination standard electrode potential of Fe^{2+}/Fe^{3+} system by potentiometer using potassium permanganate solution.
4. Determination of pK_a of acetic acid and glycine by pH meter using NaOH.
5. Determination of relative and absolute viscosity of a given liquid.
6. Determination of surface tension of alcohols.
7. Determination of refractive indices of given liquids.
8. Determination of concentrations of heme proteins using spectrophotometer
9. Preparation of buffers and measurement of their pH
10. Verification of the Lambert Beer's law.
11. Structural analysis of amino acids and proteins using FTIR and CD spectrometer.
12. Determination of the T_m values of DNA and proteins.
13. Study of the thermal/cold denaturations of proteins using UV-visible and CD spectroscopic techniques.
14. Molecular weight of a non-electrolyte by cryoscopy method.
15. Determination of stability constant of Fe(III)-salicyclic acid complex by spectrophotometer.

Course Outcome: The students will acquire knowledge of development of experimental skills on conductivity meter, potentiometer, pH meter, viscometer, refractometer, spectrophotometer, CD and FTIR for different applications.

SUGGESTED READINGS

1. Nad, A. K., Mahapatra, B. and Ghoshal, A. An Advanced Course in Practical Chemistry, 2014, New Central Book Agency (P) Ltd.
2. Maity S. and Ghosh, N. Physical Chemistry Practical, 2012, New Central Book Agency (P) Ltd.
3. Elias, A. J. Collection of Interesting General Chemistry Experiments, 2008, Universities Press.
4. Khosla, B.D., Garg, V.C., and Gulati A.R., Senior Practical Physical Chemistry, 2007, S. Chand& Sons.
5. Yadav, J.B. Advanced Practical Physical Chemistry, 2008, Krishna Prakasan Media.
6. Das, R.C. and Behra, B. Experimental Physical Chemistry, 1983, Tata McGraw-Hill.
7. James, A.M. and Prichard, F.E. Practical Physical Chemistry, 3rd edition, 1974, Longman, Harlow.
8. Ghosh, J.C., Experiments in Physical Chemistry, 1990, Bharati Bhavan.

Course Title: Seminar
Paper Code: CHS.599
Total Contact Hours: 36

L	T	P	Credits
0	2	0	2

Learning objective: The course would develop scientific aptitude, critical thinking, research writing and research presentation.

The seminar must include discussion on topics such as awareness about weapons of mass destruction (chemical, biological, radiological, and nuclear weapons), disarmament, peaceful uses of chemistry, International Regulation of Biological and Chemical or Weapons of Mass Destruction.

Course Outcome: The student would be able to

1. Investigate various aspects related to the chemistry problem.
2. Appreciate the literature and its relevance to his topic of interest
3. Technical write and presentation the chemical problem in hand.
4. Should generate interest in current topics of research and commercial worth of chemistry.

Course Title: Inorganic Chemistry-III
Paper Code: CHL.601
Total Contact Hours: 54

L	T	P	Credits
3	0	0	3

Learning objective: To aware the knowledge of coordination chemistry and properties of f-block elements, and spectroscopic techniques to analyse the inorganic compounds.

Unit 1 **20 Hrs**

Lanthanides, actinides and super-heavy elements

Coordination chemistry, magnetic and spectral properties, comparison of general properties of lanthanides and actinides, comparison with d-block elements, organo lanthanides and actinides, analytical application of lanthanides and actinides-lanthanides as shift reagents and high temperature super conductors.

Unit 2 **10 Hrs**

Nuclear Magnetic Resonance (NMR) and Electron Spin Resonance (ESR) Spectroscopy:

NMR: The contact and pseudo contact shifts, factors affecting nuclear relaxation, some applications including biochemical systems , an overview of NMR of metal nuclides with emphasis on ^{195}Pt and ^{119} Sn NMR.

ESR: Hyperfine coupling, spin polarization for atoms and transition metal ions, spin orbit coupling and significance of *g*-tensors, application of transition metal complexes (having one unpaired electron) including biological systems.

Unit 3 **12 Hrs**

Mossbauer Spectroscopy

Basic principles, spectral parameters and spectrum display, application of the technique to the studies of (1) bonding and structures of Fe^{2+} and Fe^{3+} compounds including those of intermediate spin , (2) Sn^{2+} and Sn^{4+} compounds- nature of M-L bond, coordination number, structure and (3) detection of oxidation state and non-equivalent MB atoms.

Unit 4 **12 Hrs**

Nuclear Chemistry: Classification of nuclides, nuclear stability, atomic energy, types of nuclear reactions-fission and fusion, nuclear decay laws, radioanalytical techniques.

Course Outcome: The students will acquire knowledge of

1. Details on f-block elements properties
2. Structural support to inorganic compounds through spectroscopic techniques

SUGGESTED READINGS

1. Drago, Russell S. Physical Methods for Chemists, 2nd edition, 1992, Saunders College Publishing.
2. Ebsworth, E.A.V., Rankin, D.W.H. and Cracock, S. Structural Methods in Inorganic Chemistry, 1st edition, 1987, ELBS.
3. Cotton, F.A. and Lippard, S.J. Progress in Inorganic Chemistry, Vol. 8, Vol. 15, Wiley Internationals.
4. Lever, A.B.P. Inorganic Electronic Spectroscopy, 2nd edition, 1984, Elsevier Science Publishers B.V.
5. Parish, R.V. NMR, NQR, EPR and Mossbauer Spectroscopy in Inorganic Chemistry, 1st edition, 1990, Ellis Harwood.
6. Silverstein, R.M. Bassler, G.C. and Morrill, T.C. Spectrometric Identification of Organic Compounds, 6th edition, 2002, John Wiley.
7. Abraham, R.J., Fisher, J. and Loftus, P. Introduction to NMR Spectroscopy, Wiley.

8. Dyer, J.R. Application of Spectroscopy of Organic Compounds, Prentice Hall..
9. Carlin, R.I. Transition Metal Chemistry, Vol. 3, Marcell Dekker Publication
10. Martin, M.L., Delpeuch, J.J. and Martin, G.J. Practical NMR Spectroscopy, Heyden.
11. Williams, D.H. and Fleming, I. Spectroscopic Methods in Organic Chemistry, Tata McGraw-Hill.
12. Greenwood, N. N. and Earnshaw, A. Chemistry of the Elements, 1984.

Course Title: Organic Chemistry-III
Paper Code: CHL.602
Total Contact Hours: 54

L	T	P	Credits
3	0	0	3

Learning objective: To impart knowledge of certain topics in Chemistry such as structure and reactivity, retrosynthetic analysis, reagents for oxidation and reduction and heterocyclic chemistry.

Unit 1 **12 Hrs**

Reaction mechanism, structure and reactivity: Types of mechanisms, types of reactions, kinetic and thermodynamic control, Hammond's postulate, Curtin-Hammett principle, potential energy diagrams, transition states and intermediates, methods of determining mechanisms, isotopes effects, effect of structure on reactivity; resonance, inductive, electrostatic and steric effect, the Hammett equation and linear free energy relationship, substituent and reaction constants, Taft equation.

Unit 2 **14 Hrs**

Retrosynthesis: Synthon, synthetic equivalent, functional group interconversion (FGI), functional group addition, functional group elimination, criteria for selection of target, linear and convergent synthesis, retrosynthetic analysis involving chemoselectivity, reversal of polarity (umpolung), importance of the order of events in organic synthesis. One group and two group c-x disconnections in 1,2-, 1,3-, &1,4, two group c-c disconnections, Diels-alder reaction, control in carbonyl condensation, 1,5-difunctionalised compounds.

Unit 3 **14 Hrs**

Metal and non-metal mediated oxidation and reductions: Mechanism, selectivity, stereochemistry and applications of oxidation reactions, Oppenauer oxidation, oxidation reactions using DDQ, NBS, $Pb(OAc)_4$, Selenium dioxide, PCC, PDC, Cr and Mn reagents, Periodic acid, OsO_4, Swern oxidations, hydroboration, epoxidations using peracids.

Mechanism, selectivity, stereochemistry and applications of catalytic hydrogenations using Pd, Pt and Ni catalysts, Clemmensen reduction, Wolff-Kishner reduction, Meerwein-Pondorff-Verley reduction, dissolving metal reductions, metal hydride reductions using $NaBH_4$, $LiAlH_4$, DIBAL. Wilkinson's catalysis, boron in reduction, Birch reduction.

Unit 4 **14 Hrs**

Heterocyclic Chemistry: Systematic nomenclature (Hantzsch-Widman system) for monocyclic, fused and bridged heterocycles, aromatic heterocycle, non-aromatic heterocycle: bond angle and torsional strains and their consequences in small ring heterocycles, conformation of six-membered heterocycles and their synthesis

Three-membered and four-membered heterocycles: Synthesis and reactions of aziridines, oxiranes, thiranes, azetidines, oxetanes and thietanes.

Five membered heterocycles containing two heteroatoms (S,N,O): Diazoles (imidazole, pyrazole), triazoles, oxazoles and thiazoles.

Benzo-fused five-membered and six membered heterocycles: IUPAC Nomenclature, indoles, benzofurans and benzimidazoles.

Six-membered heterocycles: Synthesis and reactions of coumarins, chromones, pyridine, pyrimidine *etc*.

Course Outcome: The students will acquire knowledge of:

1. Various reaction mechanisms including effect of structure on reactivity besides kinetic and thermodynamic controlled reactions.

2. Designing a retrosynthetic approach for the synthesis of a target molecule.
3. Oxidation and reduction reagents and their application for functional group conversion in organic synthesis.
4. Nomenclature, synthesis and reactivity of smaller, five and six membered heterocyclic compounds.

SUGGESTED READINGS

1. Acheson, R.M. An Introduction to the Chemistry of Heterocyclic Compounds, 3rd edition, 1976 Wiley India Pvt. Ltd.
2. Ahluwalia, V. K. and Parasar R. K. Organic Reaction Mechanism**,** 4th edition, 2011, Narosa Publishing House (P) Ltd., New Delhi.
3. Bansal, R. K. A text book of Organic Chemistry, 5th edition, 2010, New Age International (P) Ltd., New Delhi.
4. Bansal R.K. Organic Reaction Mechanism,2010, New Age International (P) Ltd., New Delhi.
5. Bansal, R.K. Hetrocyclic Chemistry, 5th edition, 2010, New Age International (P) Ltd., New Delhi.
6. Carey B. F. A., Sundberg R.J., Advanced Organic Chemistry Part A, 4th edition, 2002, Kluwer Academic Publishers.
7. Carey B. F. A., Sundberg R.J., Advanced Organic Chemistry Part B, 5th edition, 2007, Springer Science and Business Media Ltd.
8. Finar, I.L. Organic Chemistry Volume 1, 6th edition, 2012, Pearson Education UK.
9. Gilchrist, T.L. Heterocyclic Chemistry, 3rd edition, 1997, Addison Wesley Longman Publishers, US.
10. Gupta R.R., Kumar M. and Gupta V. Heterocyclic Chemistry-II Five Membered Heterocycles Vol. 1-3, 2010, Springer Verlag, India.
11. Joule, J.A. and Mills, K. Heterocyc1ic Chemistry, 5th edition, 2010, Blackwell Publishers, New York.
12. Kalsi, P.S. Organic Reactions and Their Mechanisms. 3rd edition, 2010, New Age International, New Delhi.
13. Kalsi, P. S. Stereochemistry: Conformation and Mechanism, 7th edition, 2008, New Age International (P) Ltd., India.
14. Lowry, T. H. and Richardson K. S. Mechanism and Theory in Organic Chemistry, 3rd edition, 1998, Addison-Wesley Longman Inc., New York.
15. Morrison, R.T. and Boyd, R.N. Organic Chemistry, 6th edition, 2011, Prentice- Hall of India, New Delhi.
16. Mukherjee, S.M. and Singh, S.P. Reaction Mechanism in Organic Chemistry. 3rd edition, 2009, Macmillan India Ltd., New Delhi.
17. Katritzky, A. R., Ramsden, C. A., Joule, J. A. andZhdankin V. V. Handbook of Heterocyclic Chemistry, 3rd edition, 2010, Elsevier UK.
18. Smith, M. B. March's advanced organic chemistry: reactions, mechanisms, and structure, 7th Edition, 2013, John Wiley & Sons.
19. Warren, S., Organic synthesis: The Synthon Approach 2010, John wiley& Sons, New York.
20. Warren, S. And Wyatt, P. Designing Organic synthesis: A Disconnection Approach. 2nd Edition, 2010, John Wiley & Sons, New York.
21. Corey, E.J. and Cheng X.-M. The Logic of Chemical Synthesis, 1989, John Wiley & Sons.

Course Title: Material Chemistry
Paper Code: CHL.604
Total Contact Hours: 72

L	T	P	Credits
4	0	0	4

Learning objective: To impart knowledge of materials, their characteristics and physical functions

Unit 1: 18 Hrs

Magnetic Materials (Ferrites) Introduction, structure and classification, hard and soft ferrites, synthesis of ferrites by various methods (precursor and combustion method), characterization of ferrites by Mossbauer spectroscopy, significance of hysteresis loop and saturation magnetization in ferrites, magnetic properties of ferrites, applications of ferrites.

Glasses, Ceramics, Composites and Nanomaterials

Glassy state, glass formers and glass modifiers, applications. ceramic structures, mechanical properties, clay products. microscopic composites; dispersion-strengthened and particle-reinforced, fibre-reinforced composites, macroscopic composites, nanocrystalline phase, preparation procedures, special properties, applications.

Unit 2: 24 Hrs

Mesmorphic behaviour, thermotropic liquid crystals, positional order, bond orientational order, nematic and smectic mesophases; smectic - nematic transition and clearing temperature -homeotropic, planar and schlieren textures, twisted nematics, chiral nematics, molecular arrangement in smectic A and smectic C phases, optical properties of liquid crystals. dielectric susceptibility and dielectric constants. lyotropic phases and their description of ordering in liquid crystals.

Thin Films and Langmuir- Blodgett Films

Prepartion techniques; evaporation/sputtering, chemical process, sol gel etc. Langmuir – Blodgett (LB) films, growth technique, photolithography, properties and applications of thin and LB films

Materials for Solid State Devices

Rectifiers, transistors, capacitors –IV-V compounds, low–dimensional quantum structure; optical properties.

Unit 3: 12 Hrs

Types of ionic conductors, mechanism of ionic conduction, interstitial jumps (Frenkel); vacancy mechanism, diffusion superionic conductors; phase transitions and mechanism of conduction in superionic conductors, examples and applications of ionic conductors.

Molecular Conductor: Oligo (phenylene vinylene)s, oligo(phenylene ethynylene)s, oligo (eneyne)s, oligo(thiophene vinylene), oligo (thiphene ethynylene) etc. and their applications.

Unit 4: 18 Hrs

Fullerenes, Carbon Nanotubes and Graphene: Types and Properties, methods of preparation and separation of carbon nanotubes, applications of fullerenes, CNTs and graphene.

Nonlinear optical materials: Non-linear optical effects, second and third order – molecular hyperpolarisability and second order electric suspceptibility – materials for second and third harmonic generation.

Course Outcome: The students will acquire knowledge of

1. Inorganic, organic and mixed materials
2. Characterization of these materials
3. The relationship between material structure and physical attributes associated with them.

SUGGESTED READINGS

1. Ashcroft, N.W. and Mermin, N.D. Solid State Physics, 1976, Saunders College.
2. Callister, W.D. and Rethwisch, D. G. Material Science and Engineering, An Introduction, 9th Edition, 2014, Willey.
3. Anderson, J.C. Leaver, K.D. Alexander J.M. and Rawlings, R.D. Material Science, 5th Edition, 2003, Nelson and Thornes.
4. Keer, H.V. Principle of the Solid State, 1993, New Age International.

Course Title: Bio-inorganic and Biophysical Chemistry
Paper Code: CHL.606
Total Contact Hours: 72

L	T	P	Credits
4	0	0	4

Learning objective: To provide knowledge of structure, function, and physicochemical properties of biomolecules.

Unit 1 **18 Hrs**

Inorganic Chemistry of Enzymes - I

Metalloporphyrings: hemoglobin and myoglobin, nature of heme-dioxygen binding, model systems, cooperativity in hemoglobin, physiology of myoglobin and hemoglobin, structure and function of haemoglobin and myoglobin. Other iron-prophyrin biomolecules, peroxidases and catalases, cytochromes, cytochrome P450 enzymes, other natural oxygen carriers, hemerythrins, electron transfer. Biochemistry of iron, iron storage and transport, the Fenton reaction, free radical chemistry and metal poisoning, ferritin, transferrin, bacterial iron transport.

Unit 2 **18 Hrs**

Inorganic Chemistry of Enzymes - II

Metallothioneins: ferridoxins, carboxypeptidase, carbonicanhydrase, blue copper proteins, superoxide dismutase, hemocyanines, photosynthesis, respiration and photosynthesis; chlorophyll and photosynthetic reaction center.

Enzymes: Structure and function, inhibition and poisoning vitamin B_{12} and B_{12} coenzymes metallothioneins, nitrogen fixation, in-vitro and in-vivo nitrogen fixation, bio-inorganic chemistry of Mo and W.

Unit 3 **18 Hrs**

Metal Ions in Biological Systems

Role of metal ions in replication and transcription process of nucleic acids. Biochemistry of calcium as hormonal messenger, muscle contraction blood clotting, neurotransmitter, calcification reclaiming of barren land. metals in the regulation of biochemical events.

Metal complexes for therapeutic uses (cisplatin, carboplatin, non platinum metal complexes).

Unit 4 **18 Hrs**

Biophysical Chemistry

Principles of biophysical chemistry (pH, buffer, reaction kinetics, thermodynamics, colligative properties), structure and physical properties of amino acids, physical principle of structure, function, and folding of proteins, conformations of proteins (Ramachandran plot, secondary, tertiary and quaternary structure; domains; motif and folds), determination of protein structures by spectroscopic methods (CD, FTIR, NMR), thermodynamics of protein folding by spectroscopic and calorimetric methods, ultrafast folding dynamics study by laser flash photolysis, protein conformational study by NMR and fluorescence spectroscopy, measurement of hydrodynamic radii by dynamic light scatter

Course Outcome: The students will acquire knowledge of

1. Structure and biological functions of proteins and enzymes.
2. The role of metals in biology
3. Factors that govern the thermodynamic stability, folding, and dynamics of proteins.

4. Kinetics, thermodynamics, and mechanism of protein folding.

SUGGESTED READINGS

1. Huheey, J. E.,Keiter,E. A. AndKeiter, R.L. Inorganic Chemistry Principles of Structure and Reactivity, 4th edition, 2006, Haper Collins.
2. Douglas, B., McDaniel,D. AndAlexander, J. Concepts and Models of Inorganic Chemistry, 3rd edition, 2006, John Wiley and Sons.
3. Cotton, F.A. andWilkinson, G. Advanced Inorganic Chemistry: A Comprehensive Text, John Wiley, 5th edition.
4. Elschenbroich,Ch. and Salzer,A. Organometallics. A Concise Introduction, 2nd edition, 1992, Wiley-VCH.
5. Atkins, P., Overtone, T., Rourke, J., Weller, J. And Armstrong, F. Shriver and Atkin'sInorganic Chemistry, 5thedition, 2010, Oxford University Press.
6. Cowan, J.A. Inorganic Biochemistry: An Introduction, 2nd edition, 1997, Wiley – VCH,.
7. Lippard,S. J. Progress in Inorganic Chemistry,Vols. 18, 1991, Wiley-Interscience.
8. Lippard,S. J. Progress in Inorganic Chemistry,Vols. 38, 1991, Wiley-Interscience.
9. Lesk, A.M., Introduction to Protein Science: Architecture, Function, and Genomics, 2nd edition, 2010, Oxford University Press.
10. Cantor, C.R. and Schimmel, P.R., Biophysical Chemistry, 1980, Freeman.
11. Van Holde, K.E., Johnson, W.C. and Ho, P.S., Principles of Physical Biochemistry, 2nd Edition, 2006, Pearson Education.
12. Harding, S.E. and Chowdhry, B. Z. Protein-Ligand Interactions, 2001, Oxford University Press.

Course Title: Inorganic Photochemistry
Paper Code: CHL.607
Total Contact Hours: 54

L	T	P	Credits
3	0	0	3

Learning objective: To acquire knowledge of Inorganic photochemistry and photophysical principles, their applications on simple and macromolecules.

Unit 1 **14 Hrs**

Basics of Photochemistry: Absorption, excitation, laws of photochemistry, quantum yield, lifetime of excited states, photochemical stages-primary and secondary process, electronic transitions, Jablonski diagram and photophysical processes, radiative transitions, absorption and emission, phosphorescence, intersystem crossing, mechanisms of singlet-triplet conversion (spin-orbit coupling), examples of ISC between states of different configurations, radiative rates, radiationless transitions, internal conversion, energy gap.

Unit 2 **12 Hrs**

Photochemical Mechanism: Properties of excited states- structure, dipole moment, acid-base strength, reactivity; photochemical kinetics- calculation of rates of radiative process; bimolecular deactivation-quenching; excited states of metal complexes comparison with organic compounds, electronically excited states of metal complexes, charge transfer excitation.

Unit 3 **14 Hrs**

Ligand Field Photochemistry: Photosubstitution, photooxidation and photoreduction, ground state and excited state, energy content of the excited state, development of redox potentials of the excited states; redox reactions by excited metal complexes- energy transfer (FRET & SET), exciplex formation,

Redox Processes: Conditions of the excited states to be useful redox reactants, excited electron transfer, photochemical reactions of Cr, Fe and Ru complexes, role of spin-orbit coupling in the lifetime of the complexes, application of redox process for catalytic purposes, transformation of low energy reactants into high energy products, chemical energy into light; sensitization and metal complex sensitizers; inorganic photochemistry in biological process and their model studies, solar-energy conservation and storage.

Unit 4 **14 Hrs**

Applications of Photochemistry: Measurement of fluorescence and phosphorescence and lifetimes, introduction to time-resolved techniques for absorption and emission measurements, detection and kinetics of reactive intermediates, photochromic reactions and memory devices, sensors, switches and molecular machines, TiO_2 photocatalysis, flash photolysis.

Course Outcomes: The student will have knowledge of

1. Inorganic photochemistry and photophysical principles.
2. Identification and characterization of transient intermediates by ultrafast modern techniques.
3. Theory of photoreaction.
4. Application of photochemistry and photophysical principles on simple and macromolecules.

SUGGESTED READINGS

1. Lakowicz, J. R. Principles of Fluorescence Spectroscopy, 3rd edition, 2006, Springer.

2. Adamson, A. W. and Fleischauer, P. D. Concepts of Inorganic Photochemistry. 1975, Wiley International.
3. Rohatgi-Mukherjee, K. K. Fundamentals of Photochemistry. 2nd Edition, 1986, New Age International.
4. Kryukov, A. I., and S. Yakuchmii. Fundamentals of Photochemistry of Coordination Compounds, 1990.
5. Kavarnos, G. J. Fundamentals of Photoinduced Electron Transfer, 1993, Wiley-VCH publishers Inc., New York.
6. Valeur, B. Molecular Fluorescence: Principles and Applications, 2002, Wiley-VCH Verlag GmbH, Weinheim.
7. Turro, N. J. Ramamurthy, V. and Scaiano, J. C. Modern Molecular Photochemistry of Organic Molecules, 2010, University Science, Books, CA.
8. Ninomiya, I. and Naito, T. Photochemical Synthesis, 1989, Academic Press, New York.

Course Title: Current Trends in Organic Synthesis
Paper Code: CHL.608
Total Contact Hours: 54

L	T	P	Credits
3	0	0	3

Learning objective: To update the knowledge in organic chemistry to an advanced level suited for the industrial tailored synthetic approaches

Unit 1 **14 Hrs**

Free radical reactions

Types of free radical reactions, free radical substitution mechanism at an aromatic substrate, free radical rearrangement, neighbouring group assistance, reactivity for aliphatic and aromatic substrates at a bridgehead, Reactivity in the attacking radicals, the effect of solvents on reactivity, allylic halogenation (NBS), auto-oxidation. Coupling of alkynes and arylation of aromatic compounds by diazonium salts.

Free radicals theory of aging and role of antioxidants.

Unit 2 **13 Hrs**

Enolate Chemistry: Regio- and stereo-selectivity in enolate generation. "O" versus "C" alkylation, effect of solvent, counter cation and electrophiles; symbiotic effect; thermodynamically and kinetically controlled enolate formations; various transition state models to explain stereoselective enolate formation; enamines and metallo-enamines; regioselectivity in generation, application in controlling the selectivity of alkylation.

Unit 3 **14 Hrs**

Protection and deprotection of various functional groups:

Protection of alcohols by ether, silyl ethers and ester formations and their deprotection, protection of carbonyls by acetal and ketal formation and their deprotection, protection of 1, 2 diols- by acetal, ketal and carbonate formation and their deprotection, protection of amines by acetylation, benzylation, benzyloxy carbonyl, t-butoxycarbonyl (Boc), fmoc, triphenyl methyl groups and their deprotection, protection of carboxylic acids by ester formation and their deprotection

Unit 4 **13 Hrs**

New synthetic reactions: Baylis-Hillman reaction, Biginelli reaction, Mukaiyama aldol reaction, Mitsunobu reaction, McMurrey reaction, Julia-Lythgoe olefination, and Peterson's stereoselective olefination, Buchwald-Hartwig coupling, Eishenmosher-Tanabe fragmentation and Shapiro reaction, Stork-enamine reaction, Aza-Cope, Aza-Wittig reaction, Ugi reaction, Robinson–Gabriel synthesis, Strecker amino acid synthesis Vilsmeier–Haack reaction,

Course Outcome: The student would acquire the knowledge of

1. Regioselective and enantioselective C-C bond
2. Judicious use of Protection and deprotection based synthesis.
3. Reaction of commercial importance and their control.

SUGGESTED READINGS

1. Finar, I.L., Organic Chemistry Vol. 1, 6th edition, 2012, Pearson Education, UK.
2. Finar, I.L., Organic Chemsitry Vol. 2: Stereochemistry and the Chemistry of Natural Products, 6th edition, 2012, Pearson Education, UK.
3. Fleming I. Pericyclic Reactions, 1999, Oxford University Press.
4. Fleming I. Molecular Orbitals and Organic Chemical Reactions, 2011, John Wiley & Sons.
5. Li, J. J. Name Reactions: A collection of Detailed Reaction Mechanisim,5th edition, 2014, Springer-Verlag.

6. Kalsi, P.S. Organic Reactions and Their Mechanisms, 3rd edition, 2010, New Age International Pub., New Delhi.
7. Kalsi, P.S. Stereochemistry: Conformation and Mechanism, 6th edition, 2008, New Age International (p) Ltd., New Delhi.
8. Lowry, T. H. and Richardson K. S. Mechanism and Theory in Organic Chemistry, 3rd edition, 1998, Addison-Wesley Longman Inc., New York.
9. McMurry J. Organic Chemistry, 8th edition, 2011 Asian Book Pvt. Ltd, New Delhi
10. Morrison, R.T. and Boyd, R.N. Organic Chemistry, 6th edition, 2011, Prentice- Hall of India, New Delhi.
11. Mukherjee, S.M. and Singh, S.P. Reaction Mechanism in Organic Chemistry. 3rd edition, 2009, Macmillan India Ltd., New Delhi.
12. Bruckner, R. Advanced organic chemistry: Reaction Mechanism, 2001, Academic Press.
13. Smith, M. B. March's advanced organic chemistry: reactions, mechanisms, and structure, 7th Edition, 2013, John Wiley & Sons.
14. Solomon, T.W.G., Fryhle, C.B. and Snyder, S. A. Organic Chemistry. 11th edition, 2013, John Wiley and Sons, Inc.
15. Sykes, P. A Guide Book to Mechanism in Organic Chemistry, 6th edition, 1997, Prentice Hall.
16. Carruthers, W. Some Modern Methods of Organic Synthesis, 4th edition, 2004, Cambridge Uni. Press, UK.

Course Title: Supramolecular Chemistry

L	T	P	Credits
3	0	0	3

Paper Code: CHL.609

Total Contact Hours: 54

Learning objective: To impart knowledge of molecular interactions apart from bonding. Use of such interactions in template host and their designing for complimentary target guest and devising supramolecules which could be applied as organic materials, sensors, and devices.

Unit 1 **14 Hrs**

Introduction: Definition and development of supramolecular chemistry, nature of binding interactions in supramolecular structures: ion-ion, ion-dipole, dipole-dipole, h-bonding, cation-π, anion- π, π - π and vanderwaal interactions, supramolecular chemistry in life, ionophores, porphyrin and other tetrapyrrollic macrocycles, coenzymes, neurotransmitters, DNA and biochemical self-assembly. classification of supramolecular host-guest compounds, pre- organization and complementarily, receptors, nature of supramolecular interactions.

Unit 2 **14 Hrs**

Cation and Anion Binding: Host-guest chemistry: synthesis and structure of crown ethers, lariat ether and podands, cryptands, spherands, calixarenes, cylcodextrins, cyclophanes, carcerands and hemicarcerands. Concepts of selectivity, macrocyclic, macrobicyclic and template effects, soft ligands, carbon donor and π- acid ligands, siderophores.

biological anion receptors, concepts on anion host design, from cation to anion hosts- a simple change in pH, guanidinium- based receptors, neutral receptors, organometallic receptors, coordination interactions.

Unit 3 **13 Hrs**

Molecular self-assembly: Supramolecular polymers: definition, types of intermolecular interactions and their energetics. self-assembly molecules: design, synthesis and properties of the molecules, self-assembly by H-bonding, catenanes, rotaxanes, molecular knot bromenean rings dendrimers and supramolecular gels. relevance of supramolecular chemistry to mimic biological system. thermodynamics and kinetic stability of supramolecular systems and their applications. fullerness as hosts or guests and as superconducting intercalation compounds and their applications.

Unit 4 **13 Hrs**

Supramolecular and Molecular Devices: Supramolecular photochemistry, molecular electronic devices: molecular electronic devices, molecular wires, molecular rectifiers, molecular switches and molecular logic gates, machines based on catenanes and rotaxanes organics for photonics and electronics.

Course Outcome: The students will acquire knowledge of

1. Various supramolecular aspects of interaction between two chemical systems.
2. Devising supramolecular systems based on complementarity and preorganizational requirements of host.

SUGGESTED READINGS

1. Steed J.W and Atwood, J.L Supramolecular chemistry, 2nd Edition, John Wiley & Sons, Ltd. New York.
2. Lehn, J. M., Supramolecular Chemistry-Concepts and Perspectives, Wiley –VCH (1995).
3. P.D., Beer, Gale, P. A., and Smith, D. K., Supramolecular Chemistry, 1999, Oxford University Press.
4. Martin, N. and Nierengarten J.-F. Supramolecular Chemistry of Fullerenes and Carbon Nanotubes, 2012, Wiley-VCH.

5. Vicens, J. and Harrowfield J. Calixarenes in the Nanoworld, 2007, Springer.
6. Schalley, C. A. Analytical Methods in Supramolecular Chemistry, 2nd Edition, Volume 1 & 2, 2012, Wiley-VCH

L	T	P	Credits
0	0	4	2

Course Title: Practical Organic Chemistry-III
Paper Code: CHP.603
Total Contact Hours: 72

Learning objective: To provide knowledge of various methodologies for synthesis of target molecules and characterization by spectroscopy techniques.

Experiments:

- **Solvent Drying**: Use of sodium metalfor drying of toluene and precautions while quenching the residual sodium. Drying of DCM using P_2O_5 and safe disposal of residual P_2O_5.

1. **Exercises of structure elucidation of unknown compounds *via* combined spectral interpretation of ^{1}H, ^{13}C NMR, IR, UV and Mass along with 2-D NMR spectra.**

2. **Synthesis**: Separation and purification of organic compounds by column chromatography, percentage yield calculation (Any six)
    1. Preparation of allylic alcohols *via* Baylis-Hillman reaction using DABCO as a catalyst under neat condition and their characterization through various spectroscopic techniques.
    2. To study Buchwald-Hartwig reaction of aryl halide with an amine using Cu-based catalyst.
    3. Synthesis of triazole *via* reaction of phenylacetylene with azide in water (Huisgen cycloaddition).
    4. Synthesis of stilbenes *via* Heck coupling Strategy.
    5. To study decarboxylation of Ferulic acid under microwave irradiation.
    6. Regioselective reduction of α,β-unsaturated carbonyl compound under microwave irradiation.
    7. Synthesis of imidazolium and pyridinium based ionic liquids.
    8. To study dehydration of benzylic alcohols using imidazolium based ionic liquid.
    9. To synthesize 2-phenyl-1,3,4-oxadiazole from benzhydrazide.
    10. To synthesize substituted benzodiazepine from chalcone*via* reflux conditions.
    11. To synthesize *p* -nitrobenzaldehyde oxime from *p*-nitrobenzaldehyde.
    12. Synthesis of isooxazoline from prior synthesized oxime.
    13. Synthesise of benzothiazole starting from 2-aminothiophenol.
    14. To study amination of benzothiazole with various amines.
    15. To synthesize acylidine analogue of Meldrum acid.

Course Outcome: The students will acquire knowledge of

1. Drying of various solvents using sodium metal and P_2O_5 and their disposal.
2. Structure elucidation of unknown compounds*via* interpretation of the spectra (NMR, IR, UV & MS**)**
3. Various reactions conditions including modern coupling strategies and their implications.

SUGGESTED READINGS

1. Harwood, L.M. and Moody, C.J. Experimental Organic Chemistry, 1st edition, 1989, Blackwell Scientific Publishers.
2. Vogel, A.I. Textbook of Practical Organic Chemistry, 6th edition,1978, ELBS, Longman Group Ltd.
3. Mann, F.G. and Saunders, B.C. Practical Organic Chemistry, 4th edition, New Impression, 1975, Orient Longman Pvt. Ltd.
4. Viswas, A. And Tewari, K.S. A Textbook of Organic Chemistry, 3rdedition, 2009Vikas Publishing House.
5. Leonard, J. and Lygo, B. Advanced Practical Organic Chemistry, 1995, Chapman and Hall,.
6. Armarego, W. L. and Chai, C. Purification of Laboratory Chemicals, 2012, Butterworth-Heinemann.
7. Young, J. A. Improving safety in the chemical laboratory: a practical guide. 2nd Edition, 1991, Wiley Publishing.

Course Title: Practical Physical Chemistry-III
Paper Code: CHP.605
Total Contact Hours: 72

L	T	P	Credits
0	0	4	2

Learning objective: To provide training and hand-on experiences of different analytical techniques for chemical analysis and verifications of physical and chemical properties.

Experiments:

1. To verify Freundlich and Langmuir adsorption isotherms for adsorption of acetic acid on activated charcoal.
2. Determination of partition coefficient of benzoic acid between organic solvent and water.
3. Determination of partition coefficient of iodine between water and octanol and determination of equilibrium constant of tri-iodide.
4. Determination of rate constant of hydrolysis of an ester and to study the effect of ionic strength on reaction rate.
5. To study kinetics of inversion of cane sugar by optical rotation measurement.
6. Determination of activation energy of a reaction by spectrophotometer.
7. Energy of activation of acid catalyzed hydrolysis of methyl acetate.
8. Kinetics of acid-catalysed reaction between acetone-iodine
9. Determination of order of $S_2O_8^{2-} + I^- \rightarrow SO_4^{2-} + I_2$ reaction
10. Determination of energy of activation of $S_2O_8^{2-} + I^- \rightarrow SO_4^{2-} + I_2$ reaction
11. Studies on the effect of variation of ionic strength on the rate of $S_2O_8^{2-} + I^- \rightarrow SO_4^{2-} + I_2$ reaction
12. Determination of the rate constant for the oxidation of iodide ions by hydrogen peroxide studying the kinetics as an iodine clock reaction.

Course Outcome: The students will acquire knowledge of

1. Experimental techniques for controlling the chemical reactions.
2. Measurement of various physical and chemical properties.
3. Applying related experiments for their research work.

SUGGESTED READINGS

1. Nad, A. K., Mahapatra, B. and Ghoshal, A. An Advanced Course in Practical Chemistry, 2014, New Central Book Agency (P) Ltd.
2. Maity S. and Ghosh, N. Physical Chemistry Practical, 2012, New Central Book Agency (P) Ltd.
3. Elias, A. J. Collection of Interesting General Chemistry Experiments, 2008, Universities Press.
4. Khosla, B.D., Garg, V.C., and Gulati A.R., Senior Practical Physical Chemistry, 2007, S. Chand & Sons.
5. Yadav, J.B. Advanced Practical Physical Chemistry, 2008, Krishna Prakasan Media.
6. Das, R.C. and Behra, B. Experimental Physical Chemistry, 1983, Tata McGraw-Hill.
7. James, A.M. and Prichard, F.E. Practical Physical Chemistry, 3rd edition, 1974, Longman, Harlow.
8. Ghosh, J.C., Experiments in Physical Chemistry, 1990, Bharati Bhavan.

Course Title: Polymer and Solid State Chemistry
Paper Code: CHL.621
Total Contact Hours: 72

L	T	P	Credits
4	0	0	4

Learning objective: To impart knowledge of polymers, solid state chemistry and nanomaterials.

Unit 1 **18 Hrs**

Polymers: Importance of polymers, basic concepts: monomers, repeat Units, degree of polymerization. linear, branched and network polymers, classification of polymers. polymerization: condensation, addition, radical chain-ionic, co-ordination and copolymerization, polymerization conditions and polymer reactions, polymerization in homogeneous and heterogeneous systems.

Application of Polymers: Phenol-formaldehyde, urea-formaldehyde, melamine-formaldehyde, epoxy resins and curing agents, polyamides: nylon-6, nylon-6,6,

Unit 2 **18 Hrs**

Polymer Characterization: Polydispersion-average molecular weight concept, number, weight and viscocity average molecular weights, polydispersity and. molecular weight distribution, the practical significance of molecular weight, measurement of molecular weights, light scattering, osmotic and ultracentrifugation methods, analysis and testing of polymers, chemical analysis of polymers, thermal analysis and physical testing-tensile strength.

Unit 3 **18 Hrs**

Solid State Structure: Primitive lattice vectors, reciprocal lattice, crystal systems and symmetry, bravais lattices, lattice energy, crystal structure of diamond, NaCl, KCl, CsCl, TiO_2, etc,
Defects: Intrinsic and extrinsic defects, point, line and plane defects, vacancies, Schottky defects, Frenkel defects, Thermodynamic and structural aspects.
Diffraction Methods: Basic concepts of X-ray, electron and neutron diffraction methods, structure of simple lattices and X-ray intensities, structure factor and its relation to intensity and electron density, phase identification, X-ray structure analysis, XRD and its applications, polymorphism and cocrystallization.

Unit 4 **18 Hrs**

Semiconductor and Superconductors: Band theory, band gap, metals and semiconductors, intrinsic and extrinsic semiconductors, p-n junctions and other applications

Magnetic Optical Properties*:* Classification of magnetic materials, Langevin diamagnetism, magnetic domains and hysteresis, optical reflectance, Raman scattering in crystals, photoconduction, lasers, photovoltaic and photocatalytic effects.

Nanomaterials: Nanoparticles: zero dimensional nanostructure, homogeneous and heterogeneous nucleation, metallic nanoparticles- synthesis and applications; nanowires and nanorods: one dimensional nanostructures, spontaneous growth, VLS, electro spinning, lithography; thin film: two dimensional nanostructure- preparation techniques; Langmuir-Blodgett (LB) film growth techniques, photolithography properties and applications.

Course Outcome: After completion of this course, the students will acquire knowledge of

1. Different mechanisms of polymerization, number, weight and viscosity average molecular weights with various techniques
2. Processing of thermoplastic and thermosetting polymers, concept of conducting polymers and their applications.
3. Physicochemical properties, defects in solid, diffraction techniques, electrical and magnetic properties of materials.

SUGGESTED READINGS

1. Gowariker, V. R., Viswanathan, N. V. and SreedharJ. Polymer Science, 1st Edition, 1986, New Age International Pvt. Ltd., New Delhi.
2. Odian, G., Principles of Polymerization, 4th Edition, 2007, John Wiley & Sons.
3. Peacock, A. and Calhoun, A. Polymer Chemistry-Properties and Applications, 2006, Carl Hanser Verlag GmbH & Company KG.
4. Chandra, R. and Adab, A., Rubber and Plastic Waste, 1994, CBS Publishers & Distributors, New Delhi.
5. Bahadur, P., and Sastry, N. V., Principles of Polymerisation, 2nd Edition, 2006, Narosa Publishing House, New Delhi .
6. Keer, H.V. Principle of the Solid State, 1993, New Age International.
7. Ashcroft, N.W. and Mermin, N.D. Solid State Physics, 1976, Saunders College.
8. Callister, W.D. and Rethwisch, D. G. Material Science and Engineering, An Introduction, 9th Edition, 2014, Willey.
9. Anderson, J.C. Leaver, K.D. Alexander J.M. and Rawlings, R.D. Material Science, 5th Edition, 2003, Nelson and Thornes.

Course Title: Advanced Organic Synthesis
Paper Code: CHL.622
Total Contact Hours: 72

L	T	P	Credits
4	0	0	4

Learning objective: To impart knowledge of various important topics in organic synthesis such as asymmetric synthesis, reagents including organometallic reagents and some important reactions of ylides.

Unit 1 **14 Hrs**

Asymmetric synthesis: Chiral pools, chiral catalysis: chiral auxiliaries, methods of asymmetric induction – substrate, reagent and catalyst controlled reactions; determination of enantiomeric and diastereomeric excess; enantio-discrimination. resolution – optical and kinetic, chemo- regio- and stereoselective transformations, organocatalysis and biocatalysis

Unit 2 **18 Hrs**

Reaction of ylides: Phosphorus ylide; structure and reactivity, stabilized ylides, effects of ligands on reactivity, Witting, Wittig-Horner and Wadsworth, Emmons reactions-mechanistic realization; E/Z selectivity for olefin formation, Schlosser modification: Sulphur ylides; stabilized and non-stabilized ylides: thermodynamically and kinetically controlled reactions with carbonyl compounds, regio- and stereo-selective reactions.

Unit 3 **20 Hrs**

Organometallic compounds

Organoboranes: Preparation of organobornaes viz hydroboration with BH_3-THF, dicylohexyl borane, disiamyl borane, thexyl borane, 9-BBN and disopincamphlyel borane, functional group transformations of organo boranes: oxidation, protonolysis and rearrangements. formation of carbon-carbon-bonds *viz* organo boranes carbonylation. Organolithium, organozinc and organocopper compounds, organosilicon compounds for organic synthesis, organopalladium and organostannous (applications in coupling reactions).

Unit 4 **20 Hrs**

Reagents in organic synthesis: Gilman'sreagent, Lithiumdiisopropylamide(LDA), 1,3-Dithiane (Umpolung reagent), Trimethylsilyliodide, Bakers yeast, Prevost Hydroxylation, Phase transfer catalysts: quaternary ammonium and Phosphonium salts, Crown ethers, Merrifield resin, Fenton's reagents, Ziegler-Natta catalyst, Lawsson reagents, K-selecteride and L-selecteride, Sodium cyanoborohydride, IBX, Sodium triacetoxyborohydride, Fetizon reagent, Dioxiranes, Ceric ammonium nitrate, Tebbe reagent, Corey-Nicolaou reagent, Mosher's reagent, use of Os, Ru, and Tl reagents.

Course Outcomes: The students will acquire knowledge of

- Asymmetric synthesis and chiral resolution.
- Various reagents including organomettalic compounds, experimental conditions and their applications in organic synthesis/industry.
- Some important reactions utilizing phosphorus and sulphur ylides.

SUGGESTED READINGS

1. Claydon, J., Gleeves, N., Warren, S. and Wother, P. Organic chemistry, 2001, Oxford University Press, UK.
2. Fieser and Fieser, Reagents for organic synthesis, Vol 1-26, 3rd edition, 2011, Wiley Interscience.
3. Finar, I.L. Organic Chemistry, 6th edition, 2012, Pearson Education, UK.

4. Li, J.J.Name Reactions: A Collection of Detailed Reaction Mechanism 4th edition, 2009 Springer.
5. Smith, M. B. March's advanced organic chemistry: reactions, mechanisms, and structure. 7th Edition, 2013, John Wiley & Sons.
6. Reich, H.J. and Rigby, M.Handbook of Reagents for Organic Synthesis Acidic and Basic Reagents VoI. IV, 1999, Wiley-Interscience.
7. Warren, S. Organic synthesis: The Synthon Approach. 2010, John Wiley & Sons, New York,
8. Warren, S. and Wyatt, P. Designing Organic synthesis: A Disconnection Approach. 2nd Edition, 2010, John Wiley & Sons, New York.
9. Corey E.J. and Cheng, X.-M. The Logic of Chemical Synthesis, 1989, John Wiley & Sons.
10. Fuhrhop J.-H. and Penzlin, G. Organic Synthesis: Concepts methods, StartingMaterials, 2nd edition,1994, Verlag chemie.
11. Davies S. G., Organotransition Metal Chemistry: Application to OrganicSynthesis, 1994, Pergamon Press.
12. Morrison J. D. (eds) Asymmetric Synthesis, Vol. 1 to 5, 1992, Academic Press.
13. Aitken R.A. and Kilenyi S.N., Asymmetric Synthesis, 1992, Springer Publishers.
14. Proctor G. Asymmetric Synthesis, 1996, Academic Press.

Course Title: Chemistry of Natural Products
Paper Code: CHL.623
Total Contact Hours: 72

L	T	P	Credits
4	0	0	4

Learning objective: The course provides a brief introduction, classification, occurrence and biosynthesis of various natural products.

Unit 1 **18 Hrs**

Terpenoids and Carotenoids: Classification, nomenclature, occurrence, isolation, general methods of structure determination, isoprene rule. Structure determination, stereochemistry, biosynthesis and synthesis of the following representative molecules: Geraniol, Menthol and β-Carotene

Unit 2 **18 Hrs**

Alkaloids: Nomenclature and physiological action, isolation, general methods of structure elucidation, degradation, classification based on nitrogen heterocyclic ring, structure, stereochemistry, synthesis of the following: Ephedrine, Nicotine and Morphine.

Unit 3 **18 Hrs**

Steroids: Occurrence, nomenclature, basic skeleton and stereochemistry, structure determination and synthesis of cholesterol, partial synthesis of testosterone and progesterone, chemical tests for steroids

Unit 4 **18 Hrs**

Plant pigments: Occurrence, nomenclature and general methods of structure determination. isolation and synthesis of anthocyanins

Carbohydrates: Introduction of sugars, structures of triose, tetrose, pentose, hexose, stereochemistry and reactions of glucose, conformation and anomeric effects in hexoses

Course Outcome: The students will be able to:

1. Become familiar with various types of natural products and their importance.
2. Identify various types of natural products including their properties, occurrence, structure and biosynthesis.

SUGGESTED READINGS

1. Bhat, S.V., Nagasampagi, B.A., Meenakshi, S.Natural Product Chemistry & Applications, 2009, Narosa Publishing House, New Delhi.
2. Bhat, S.V., Nagasampagi, B.A., Sivakumar, M. Chemistry of Natural Products2005, Narosa Publishing House, New Delhi.
3. Brahamchari, G. Natural Product: Chemistry, Biochemistry and Pharmacology 2009, Narosa Publishing House, New Delhi.
4. Cseke, L.J. Natural Products from plants 2nd edition, 2009, CRC Press, Taylor and Francis US.
5. Dewick, P.M. Medicinal Natural Products: A Biosynthetic Approach 3nd edition, 2009, Willey & Sons,UK.
6. Finar, I.L. Organic Chemistry: Stereochemistry and the Chemistry of Natural Products. 6th edition, 2006, Dorling Kindersley Pvt. Ltd., India.
7. Peterson, F. and Amstutz, R. Natural Compounds as drugs, 2008, Birkhauser Verlay.
8. Thomson, R.H. The Chemistry of Natural Products, 1st edition, 2008, Springer,.

Course Title: Organotransition Metal Chemistry
Paper Code: CHL.624
Total Contact Hours: 72

L	T	P	Credits
4	0	0	4

Learning objective: The course provides advanced knowledge of organotransition metal chemistry

Unit 1 **18 Hrs**

Compounds of Transition Metal-Carbon Multiple Bonds

Alkylidenes, alkylidynes, low valent carbenes and carbynes-synthesis, nature of bond, structural characteristics, nucleophilic and electrophilic reaction on the ligands, role in organic synthesis

Unit 2 **18 Hrs**

Transition Metal Complexes

Transition metal complexes with unsaturated organic molecules, alkenes, alkynes, allyl, diene, dienyl, arene and trienyl complexes, preparations, properties, nature of bonding and structural features importantreactions relating to nucleophilic and electrophilic attack on ligands and to organic synthesis, metallocenes.

Unit 3 **18 Hrs**

Alkyls and Aryls of Transition Metals

Types, routes of synthesis, stability and decomposition pathways, organocopper in organic synthesis.

Fluxional organometallic compounds

Fluxionality and dynamic equilibria in compounds such as η^2 olefin, η^2 allyl and dienyl complexes.

Unit 4 **18 Hrs**

Homogeneous Catalysis

Stoichiometric reaction for catalysis, homogeneous catalytic hydrogenation, Zeigler-Natta polymerization of olefins, catalytic reactions involving carbon monoxide such as hydrocarbonylation of olefins (oxo reaction) oxopalladation reactions, activation of C-H bond.

Course Outcome: The students will acquire knowledge of

1. Transition metal complexes and compounds of transition metal-carbon multiple bonds
2. Alkyls and aryls of transition metals and fluxional organometallic compounds
3. Homogeneous catalysis and their applications.

SUGGESTED READINGS

1. Collman, J.P.; Norton, J.R.; Hegsdus, L.S.; Finke, R.G. Principles and Application of Organotransition Metal Chemistry, 1987, University Science Books.
2. Crabtree, R.G. The Organometallic Chemistry of the Transition Metals, 5th edition, 2011, John Wiley.
3. Mehrotra R. C. and Singh, A. Organometallic Chemistry, 2nd edition, 2005, New Age International.
4. Cotton, F.A. and Wilkinson, G. Advanced Inorganic Chemistry, 6th edition, 1999, John Wiley.
5. Pearson, A.J. Metallo-Organic Chemistry, 1985, Wiley.

Interdisciplinary Courses Offered by Centre for Chemical Sciences

ID Courses offered by the faculty of Centre for Chemical Sciences (For students of other Centres)											
1	CHL.511	Basics perspective in Inorganic Chemistry	2	-	-	2	10	15	15	10	50
2	CHL.512	Introduction to Green Chemistry and Sustainability	2	-	-	2	10	15	15	10	50
3	CHL.513	Chemistry of Nanomaterials and Fabrication	2	-	-	2	10	15	15	10	50

Course Title: Basic Perspectives in Inorganic Chemistry
Paper Code: CHL.511
Total Contact Hours: 36

L	T	P	Credits
2	0	0	2

Learning objective: To introduce the knowledge of d-block elements, coordination chemistry, ions role in biology, metals in aqueous environment, and hydrogen energy.

Unit 1 **8 Hrs**

Chemistry of d-block elements. coordination chemistry, models and stereochemistry, theories, spectra and bonding.

Unit 2 **10 Hrs**

Ions role in bioscience: ionophores, pophyrin and other tetrapyrrollic macromolecules, coenzymes, neurotransmitters, metal binding to dna.

Unit 3 **10 Hrs**

Metals in aqueous environment – introduction, environmental chemistry, environmental composition, chemical processes, complexes, metal speciation of calcium, copper and mercury, their behaviour in hydrosphere.

Unit 4 **8 Hrs**

Hydrogen Energy. introduction, synthesis and structures of metal hydrides, coordination modes of hydrogen atom, hydrogen storage, H_2 evolution under solar energy, thermal energy and acidifications.

Course Outcome: The completion of this course will enable the students to acquire knowledge of

1. The coordination chemistry of d-group elements and coordination of ions within living organisms.
2. Environmental chemistry and metal hydrides as hydrogen energy source.

SUGGESTED READINGS

1. Cotton, F.A.; Wilkinson Advanced Inorganic Chemistry, 6th edition, 2007, John Wiley& Sons.
2. Huheey, J. E. Inorganic Chemistry: Principles of Structure and Reactivity, 4th edition, 2006, Dorling Kindersley (India) Pvt. Ltd.
3. Greenwood, N.N. and Earnshaw, A. Chemistry of the Elements, 2nd edition, 2005 (reprinted), Butterworth-Heinemann, A division of Read Educational & Professional Publishing Ltd.
4. Lippard, S.J. and Berg, J.M., Principles of Bioinorganic Chemistry. 1994, University Science Books.
5. Van-Loon G.W. and Duffy S.J. Environmental Chemistry: A Global Perspective, 3rd Edition, 2011, Oxford University Press.
6. Rao C.S. Environmental Pollution Control Engineering, 2nd Edition, 2006, New Age International Publishers, New Delhi,
7. Peruzzini, M. and Poli, R. Recent Advances in Hydride Chemistry, 2005, Elsevier Science B.V., Amsterdam.

Course Title: Introduction to Green Chemistry and Sustainability
Paper Code: CHL.512
Total Contact Hours: 36

L	T	P	Credits	Marks
2	0	0	2	100

Learning objective: To introduce basic concepts of green chemistry and their importance for sustainable development.

Unit 1 **10 Hrs**

Introduction:
Adverse effect of some of the current chemical practices on health and environment, concept and need of green chemistry, basic principles of green chemistry with examples– atom economy, wastage minimization, selection of starting materials etc. limitations/obstacle in the persuit of the goals of green chemistry, types of solvent.

Unit 2 **14 Hrs**

Emerging non-conventional techniques:
Microwave heating as energy efficient source, sono-chemistry and green chemistry, ionic liquids**:** use ofionic liquids as solvent as well as catalyst, recyclability of ionic liquids. solvent free conditions.

Unit 3 **12 Hrs**

Value addition of abundantly available precursors:
Need for the use of renewable precursors over petroleum based feedstocks, biomass conversion (carbohydrates, lignocellulose biomass) into value added molecules.

Course Outcome: The students will be acquainted with

1. Modern concepts and tools of green chemistry and their importance in sustainable development.
2. Utilization of abundantly available precursors for the production of value added chemicals.

SUGGESTED READINGS

1. Anastas, P.T. and Warner J. C. Green chemistry, Theory and Practical. 1st edition, 2000, Oxford University Press, US.
2. Ahluwalia, V.K and Kidwai, M. New Trends in Green Chemistry, 2004, Springer.
3. Malhotra, S. V. Ionic Liquids in Organic Synthesis, 2007, Oxford University Press, US.
4. Ahluwalia, V.K.Green Chemistry: Greener Alternatives to Synthetic Organic Transformations, 2011, Alpha Science International Limited.
5. Klass, D. Biomass for Renewable Energy, Fuels, and Chemicals, Elsvier, 1998

Course Title: Chemistry of Nanomaterials and Fabrication
Paper Code: CHL.513
Total Contact Hours: 36

L	T	P	Credits	Marks
2	0	0	2	100

Learning objective: To impart the basic and recent knowledge of nanomaterials regarding their fabrication, characterization and applications.

Unit 1 **6 Hrs**

Background to Nanotechnology:

Scientific revolution- Atomic structures-molecular and atomic size-Bohr radius -emergence of nanotechnology-challenges in nanotechnology. definition of a nano system - types of nanocrystals-one dimensional (1D)-two dimensional (2D)-three dimensional(3D) nanostructured materials - quantum dots - quantum wire- multifunctional nanostructures.

Unit 2 **10 Hrs**

Fabrication and Characterization of Nanomaterials:

Top-down and bottom-up approaches: chemical routes for synthesis of nanomaterials: chemical precipitation and coprecipitation; metal nanocrystals by reduction, sol-gel synthesis; microemulsions or reverse micelles, myle formation; solvothermal synthesis; thermolysis routes, microwave heating synthesis; sonochemical synthesis; electrochemical synthesis. physical methods: -inert gas condensation, arc discharge, plasma arc technique, MW plasma, laser pyrolysis, molecular beam epitaxy, chemical vapour deposition method and electro deposition. diffraction analyses, imaging techniques, spectroscopic techniques.

Unit 3 **10 Hrs**

Nanomaterials and properties:

Influence of nucleation rate on the size of the crystals- macroscopic to microscopic crystals and nanocrystals - large surface to volume ratio. Metals (Au, Ag) - metal oxides (TiO2, CeO2, ZnOetc) - semiconductors (Si, Ge, CdS, ZnSe) - carbon nanotubes (CNT) - ceramics and composites - dilute magnetic semiconductor- biological system - DNA and RNA - lipids - size dependent properties - mechanical, physical and chemical properties.

Unit 4 **10 Hrs**

Applications of Nanomaterials:

Photocatalysis- solar cell-water splitting-energy harvesting- LSPR- molecular electronics and nanoelectronics- quantum electronic devices - CNT based transistor and field emission display -biological applications - biochemical sensor-MRI agent - nanomedicine: molecular manufacturing - MEMS - NEMS - Bio-MEMS - protein nanoarrays - nano fluidics and micro fluidics -self-assembly of nanoparticles for biomedical applications-bacterial structures- cubosomes-dendrimers-DNA nanoparticle conjugates-bioactive nanomaterials-Au nanoparticles and CdSe quantum dots - molecular motors -nanoparticle and protein interactions.

Course Outcome: The students will acquire knowledge of

1. Nanotechnology, fabrication and characterization of nanomaterials, properties and applications of nanomaterials.

SUGGESTED READINGS

1. Rao, C. N. R., Müller, A. and Cheetham,A. K. (Eds.) The Chemistry of Nanomaterials:Synthesis, Properties and Applications. 2004, Willy-VCH.
2. Poole, Jr., C. P. and Owens F. J. Introduction to Nanotechnology, 2006, Willy-VCH
3. Mukhopadhyay, S. M. Nanoscale Multifunctional Materials: Science and Applications, 2012, Willy-VCH
4. Kelsall, R. W., Hamley,I. W. and Geoghegan, M. Nanoscale Science and Technology,2005, John Wiley and Sons.