Central University of Punjab, Bathinda

Course Structure and Syllabus

Department of Chemical Sciences
School of Basic and Applied Sciences

M.Sc. Chemistry

Session: 2018-20

SEMESTER 1

S. No.	Paper Code	Course Title	Course Type	L	T	P	Cr
1	CHM.506	Fundamental Biology (Non-medical group)	CF	2	-	-	2
	CHM.507	Fundamental Mathematics (Medical group)					
2	CHM.508	Analytical Chemistry and Instrumental Methods	CF	3	-	-	3
3	CHM.509	Inorganic Chemistry-1	CC	3	-	-	3
4	CHM.510	Organic Chemistry-I	CC	3	-	-	3
5	CHM.511	Physical Chemistry-I	CC	3	-	-	3
6	CHM.512	Quantum Chemistry	CC	3	-	-	3
7	CHM.513	Practical Inorganic Chemistry-I (P)	CC	-	-	4	2
8	CHM.514	Practical Organic Chemistry-I (P)	CC	-	-	4	2
9	XXX	Inter-Disciplinary Course (ID) (Opt any one from other Departments)	EC	2	-	-	2
10.	CHM.541	Seminar	EC	-	-	-	1
		Total		**20**	**0**	**8**	**24**

CC: Core Course, **EC**: Elective Course, **CF**: Compulsory Foundation, **EF**: Elective Foundation

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

Mode of Transaction: Lecture, Demonstration, Lecture cum demonstration, Dialogue Mode, Experimentation, Problem solving, Seminar.

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SEMESTER 2

S. No.	Paper Code	Course Title	Course Type	L	T	P	Cr
1	CHM.521	Inorganic Chemistry-II	CC	3	-	-	3
2	CHM.522	Organic Chemistry-II	CC	3	-	-	3
3	CHM.523	Physical Chemistry-II	CC	3	-	-	3
4	CHM.524	Spectroscopic Analysis	CF	3	-	-	3
5	CHM.525	Molecular Spectroscopy	CC	3	-	-	3
6	CHM.526	Practical Inorganic Chemistry-II (P)	CC	-	-	4	2
7	CHM.527	Practical Physical Chemistry- II (P)	CC	-	-	4	2
8	CHM.542	Seminar	EC	-	-	-	1
9	XXX	Inter-Disciplinary Course (ID) (Opt any one from other Departments)	EC	2	-	-	2
10.	XXX	Value Added Course	EF	1	-	-	1
		Total		**18**	**1**	**8**	**23**

CC: Core Course, **EC**: Elective Course, **CF**: Compulsory Foundation, **EF**: Elective Foundation

Mode of Transactions: Lecture, Demonstration, Lecture cum demonstration, Experimentation, Problem solving, Brain storming, Tutorial, Case study, Dialogue Mode, Seminar.

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SEMESTER 3

S. No.	Paper Code	Course Title	Course Type	L	T	P	Cr
1.	CHM.551	Inorganic Chemistry-III	CC	3	-	-	3
2.	CHM.552	Organic Chemistry-III	CC	3	-	-	3
3.	CHM.553	Bioinorganic and Biophysical Chemistry	CC	3	-	-	3
4.	CHM.556	Research Methodology	CF	4	-	-	4
5.	CHM.554	Practical Organic Chemistry-III (P)	CC	-	-	4	2
6.	CHM.555	Practical Physical Chemistry- III (P)	CC	-	-	4	2
7.	XXX*	Value Added Course	CF	1	-	-	1
8.	CHM.599	Project	EC	-	-	12	6
	Total			**14**	**-**	**20**	**24**

CC: Core Course, **EC**: Elective Course, **CF**: Compulsory Foundation, **EF**: Elective Foundation

Mode of Transactions: Lecture, Demonstration, Lecture cum demonstration, Experimentation, Problem solving, Brain storming, Tutorial, Case study, Dialogue Mode, Project.

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SEMESTER 4

S. No.	Paper Code	Course Title	Course Type	L	T	P	Cr
1	CHM.571	Polymer and Solid State Chemistry	CC	4	-	-	4
2.	CHM.572	Concepts in Chemistry –I	CC	2	-	-	2
3.	CHM.573	Concepts in Chemistry –II	CC	2	-	-	2
4.	CHM.599	Project	EC	-	-	12	6
Opt any one of the following courses:							
5.	CHM.574	Advanced Organic Synthesis	EC	4	-	-	4
	CHM.575	Chemistry of Natural Products					
	CHM.576	Organotransition Metal Chemistry					
	CHM.577	Environmental Chemistry					
Opt any one of the following courses:							
6.	CHM.578	Inorganic Photochemistry	EC	4	-	-	4
	CHM.579	Current Trends in Organic Synthesis					
	CHM.580	Supramolecular Chemistry					
	CHM.581	Material Chemistry					
		Total		**16**	**-**	**-**	**22**

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CC: Core Course, **EC**: Elective Course, **CF**: Compulsory Foundation, **EF**: Elective Foundation

Mode of Transactions: Lecture, Demonstration, Lecture cum demonstration, Experimentation, Problem solving, Brain storming, Tutorial, Case study, Dialogue Mode, Project.

Course Title: Fundamental Biology (Non-medical group)
Paper Code: CHM.506
Total Contact Hours: 30

L	T	P	Cr
2	0	0	2

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 **7 Hours**

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, Acidic and basic buffers, Biological buffers, solution equilibria, Henderson-Hasselbalch equation, Hofmeister series, Chaotropic and kosmotropic ions/co-solvents.

Unit 2 **7 Hours**

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 **8 Hours**

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

Unit 4 **8 Hours**

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.

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.

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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., Voet, J. G., and Pratt, C. W. (2008). *Principle of Biochemistry*. John Wiley and Sons .
2. Berg, J. M., Stryer, L., and Tymoczko, J. L. (2015). *Stryer Biochemie*. Springer-Verlag.
3. Garrett, R. H., and Grisham, C. M. (2013). *Biochemistry*, Brooks/Cole, Cengage Learning.
4. Conn, E., and Stumpf, P. (2009). *Outlines of Biochemistry*. John Wiley and Sons.

Course Title: Fundamental Mathematics (Medical group)
Paper Code: CHM.507
Total Contact Hours: 30

L	T	P	Cr
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 **7 Hours**

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. Common series and expansions used in chemistry.

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 **8 Hours**

Differential Calculus

Functions, limits, L'Hospital rule and its application, differentiation, physical significance, basic rules of differentiation, maxima and minima, exact and inexact differentials, partial differentiation.

Marix Algebra: 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).

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Unit 3 **8 Hours**

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 **7 Hours**

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. (2008). *The Chemistry Maths Book*. Oxford University Press.
2. Doggett, G., and Sutcliffe, B. T. (1995). *Mathematics for Chemistry*. Longman Pub Group.
3. Daniels, F. (2003). *Mathematical Preparation for Physical Chemistry*. McGraw Hill Publishers.
4. Tebbutt, P. (1998). *Basic Mathematics for Chemists*. Chichester: Wiley.

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Course Title: Analytical Chemistry and Instrumental Methods
Paper Code: CHM.508
Total Contact Hours: 45

L	T	P	Cr
3	0	0	3

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

Unit 1 **11 Hours**

Quantitative Analysis: Linear regression, covariance and correlation coefficient. Standard reference materials, criteria for selection of analytical method. 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 **11 Hours**

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, atomic absorption spectrometry (AAS); flame AAS, electrothermal AAS (ETAAS).

Unit 3 **12 Hours**

Potentiometry – General principles, reference electrodes, ion selective electrodes, ion selective electrode construction, membrane electrode, glass electrodes, liquid membrane electrodes, biosensors ISFET and MOSFETS.

Coulometry: Basic principles of electrogravimetry, ohmic potential, kinetic and concentration polarization, overpotential, constant current and constant potential coulometry. coulometric titrations and application.

Voltammetry: Principles, dropping mercury electrode (DME), polarography, half-wave potential, diffusion current and Illkovic equation, different wave forms–linear scan, square scan and triangular scan, cyclic voltammetry, voltammograms. Anion/cation striping voltametry and its applications.

Unit 4 **11 Hours**

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. SFC LC, hyphenated techniques, LC-MS and LC-MS/MS. Ion exchange resins and extraction, Ion Chromatography, anion supressors and ion speciation analysis.

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. (2017). *Principles of Instrumental Analysis*. Cengage learning.
2. Willard, H. H., Merritt Jr, L. L., Dean, J. A., and Settle Jr, F. A. (1988). *Instrumental Methods of Analysis.* CBS Publishers.

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3. Mendham, J., Denney, R. C., Barnes, J. D., and Thomas, M. J. K. (2008). *Vogel's Textbook of Quantitative Chemical Analysis*, Dorling Kindersley.
4. Skoog, D. A., West, D. M., Holler, F. J., and Crouch, S. (2013). *Fundamentals of Analytical Chemistry*. Nelson Education.
5. Christian, G. D. (1994). *Analytical Chemistry*. John Wiley and Sons, USA, 331.
6. Bard, A. J., and Faulkner, L. R. (2001). *Electrochemical Methods*. John Wiley New York, *669*.
7. Rouessac, F., and Rouessac, A. (2013). *Chemical Analysis: Modern Instrumentation Methods and Techniques*. John Wiley and Sons.
8. Danzer, K. (2007). *Analytical Chemistry: Theoretical and Metrological Fundamentals*. Springer Science and Business Media.

Course Title: Inorganic Chemistry - I
Paper Code: CHM.509
Total Contact Hours: 45

L	T	P	Cr
3	0	0	3

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

Unit 1 **11 Hours**

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 ionand ligand, chelate effect and its thermodynamic origin, determination of binary formationconstants by spectrophotometry and potentiometric (pH) methods.

Unit 2 **11 Hours**

Reaction Mechanisms of Transition Metal Complexes

Introduction, potential energy diagram and reactivity of metal complexes, ligand substitution reactions, 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.

Unit 3 **12 Hours**

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

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equilibrium, magnetic properties of transition metal ions and free ions presentive, effects of L-S coupling on magnetic properties, quenching of orbital angular momentum by crystal fields in complexes in terms of splitting. effect of spin-orbit coupling and A, E and T states mixing.

Unit 4 **11 Hours**

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 p^n, d^n, f^n 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. 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, 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. (1988). *Advanced Inorganic Chemistry* (Vol. 545). New York: Wiley.
2. Huheey, J. E., Keiter, E. A., Keiter, R. L., and Medhi, O. K. (2006). *Inorganic Chemistry: Principles of Structure and Reactivity*. Pearson Education India.
3. Greenwood, N. N., and Earnshaw, A. (2012). *Chemistry of the Elements*. Elsevier.
4. Miessler, G. L. and Tarr, D. A. (2011) *Inorganic Chemistry*, Pearson Education.
5. Atkins, P. (2010). *Shriver and Atkins' Inorganic Chemistry*. Oxford University Press, USA.
6. Dutta, R. L., and Syamal, A. (1993). *Elements of Magnetochemistry*. Affiliated East-West Press.
7. Drago, R. S. (1992) *Physical Methods for Chemists*. Saunders College Publishing.

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Course Title: Organic Chemistry-I
Paper Code: CHM.510
Total Contact Hours: 45

L	T	P	Cr
3	0	0	3

Learning objective: To impart knowledge of structure reactivity relationship, reactive intermediates and mechanism of general organic reactions including substitution, elimination and addition.

Unit 1 **11 Hours**

Reaction mechanism, structure and reactivity: Classification and determination of reaction mechanisms kinetic and thermodynamic control, Hammond's postulate, Curtin-Hammett principle, methods of determining mechanisms, isotope effects, effect of structure on reactivity:Hammett equation, Taft equation.

Reactive intermediates: Generation, structure and reactions of carbocations, carbanions, 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,antiaromaticity, homoaromatic compounds.

Unit 2 **11 Hours**

Aliphatic nucleophilic substitution reaction: The S_N2, S_N1, mixed S_N2 and S_N1 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 betweenS_N2 and S_N1 mechanisms.

Aromatic nucleophilic substitution: The S_N^{Ar}, 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.

Unit 3 **12 Hours**

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 **11 Hours**

Addition to carbon-hetero multiple bonds: Structure and reactivity of carbonyl group towards nucleophilic addition: addition of CN, ROH, RSH, H_2O, hydride ion, ammonia derivatives, $LiAlH_4$, $NaBH_4$, organozinc and organolithium reagents to carbonyl and conjugated carbonyl compounds, Arndt-Eistert synthesis.Mechanism of condensation reactions involving enolates: Aldol, Knoevenagel, Claisen, Dieckmann, Mannich, Benzoin, Perkin and Stobbe reactions.Carboxylic acids and derivatives, hydrolysis of esters and amides, ammonolysis of esters.

Course Outcome: Students will acquire the knowledge of

1. Structure activity relationship and methods for determination of mechanism of various organic reactions.
2. Mechanistic aspects in nucleophilic and electrophilic substitution.
3. Mechanistic aspects in addition and elimination reactions.

SUGGESTED READINGS

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1. Clayden, J., Greeves, N., Warren, S. and Wothers, P. (2012) *Organic Chemistry.* 2012, Oxford University Press.
2. Finar, I. L. (1996). *Textbook of Organic Chemistry*. *ELBS*, Pearson Education UK.
3. McMurry, J. (1996). *Organic Chemistry*, Brooks. Cole, New York, 657.
4. Smith, M. B., and March, J. (2013). *March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure*. John Wiley and Sons.
5. Ahluwalia, V. K., and Parashar, R. K. (2011). *Organic Reaction Mechanisms*. Narosa Publishing House (P) Ltd.
6. Bansal, R. K. (2012). *A Textbook of Organic Chemistry*. New Age International.
7. Bansal R.K. (2010) *Organic Reaction Mechanism.* New Age International (P) Ltd.
8. Kalsi, P.S. (2010) *Organic Reactions and Their Mechanisms.* New Age International, New Delhi.
9. Lowry, T. H. and Richardson K. S. (1998) *Mechanism and Theory in Organic Chemistry,* Addison-Wesley Longman Inc., New York.
10. Morrison, R.T. and Boyd, R.N. (2011) *Organic Chemistry,* Prentice- Hall of India.
11. Mukherjee, S.M. and Singh, S.P. (2009) *Reaction Mechanism in Organic Chemistry.* Macmillan India Ltd., New Delhi.
12. Robert, J. D. and Casereo, M.C. (1977) *Basic Principle of Organic Chemistry***.** Addison-Wesley.

13. Solomon, T.W.G, Fryhle, C.B. and Snyder, S. A. (2013) *Organic Chemistry*. John Wiley and Sons, Inc.
14. Sykes, P. A. (1997) *Guide Book to Mechanism in Organic Chemistry,* Prentice Hall.

Course Title: Physical Chemistry-I

Paper Code: CHM.511

Total Contact Hours: 45

L	T	P	Cr
3	0	0	3

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

Unit 1 **11 Hours**

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, fugacity, its importance and determination, standard state for gases.

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. Activity coefficient; determination of activity and activity coefficients.

Unit 2 **11 Hours**

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.

Phase transition: Phase rule, water, CO_2 phase transition, binary and ternary component phase transitions. Clausius-Clapeyron equation and its application to solid-liquid, liquid-vapour and solid-vapour equilibria.

Unit 3 **12 Hours**

Statistical Thermodynamics: Statistical concepts and examples, Thermodynamic probability and entropy, 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.

Unit 4 **11 Hours**

Theories of Statistical Thermodynamics: Concept of Maxwell-Boltzmann, Bose-Einstein and Dermi-Dirac statistics, Difference between Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac statistics, Applications of Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac statistics., Monoatomic solids, theories of specific heat for solids.

Course Outcome: The students will acquire knowledge of

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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. (2007) *Physical Chemistry*. Tata McGraw-Hill Publishers.
2. Kapoor, K. L. (2011) *Text Book of Physical Chemistry*. 3/5, Macmillan Publishers.
3. Atkins, P. and De Paula, J. (2009) *Atkins' Physical Chemistry*. Oxford University Press.
4. McQuarrie, D. A. and Simon, J. D. (1998) *Physical Chemistry: A Molecular Approach*. Viva Books.
5. Moore, J. W. and Pearson, R. G.(1981) *Kinetics and Mechanism.* John Wiley and Sons.
6. Silbey, R. J. Alberty, R. A. and Bawendi, M. G. (2004) *Physical Chemistry*. Wiley-Interscience Publication.
7. Engel, T., Reid, P. and Hehre, W. (2012) *Physical Chemistry*. Pearson Education.
8. Puri, B.R., Sharma L.R. and Pathania, M.S. (2013) *Principles of Physical Chemistry*. Vishal Publishing Company.
9. Rastogi, R. P. and Mishra, R. R. (2013) *An Introduction to Chemical Thermodynamics.* Vikas Publishing
10. Rajaram, J. and Kuriacose, J. C.(2013) *Chemical Thermodynamics, Classical, Statistical and Irreversible Thermodynamics*. Pearson Education.
11. Laurendeau N. M.(2005) *Statistical Thermodynamics: Fundamentals and Applications*. Cambridge University Press.
12. Nash, L. K. (2012) *Elements of Statistical Thermodynamics*. Dover Publication Inc.
13. Hill, T. L. (1986) *An Introduction to Statistical Thermodynamics*. Dover Publications Inc.

Course Title: Quantum Chemistry
Paper Code: CHM.512
Total Contact Hours: 45

L	T	P	Cr
3	0	0	3

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

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Unit 1 **11 Hours**

Fundamental Background: Review of essential mathematical concepts required for quantum chemistry, Postulates of quantum mechanics, Eigen values and Eigen functions, operators, Schrodinger equation- Free particle and particle in a box and its application (*i.e.,* quantum tunnelling effect), one-dimensional harmonic oscillator and rigid rotor, particle in a ring, particle on a sphere, hydrogen like atoms.

Unit 2 **11 Hours**

Approximate Methods: The variation theorem and its application, linear variation principle, perturbation theory up to second order in energy and its applications.

Unit 3 **12 Hours**

Angular Momentum: Ordinary angular momentum, generalized angular momentum, Eigen functions and Eigen values for angular momentum, Ladder operator, addition of angular momenta, spin, antisymmetry and Pauli exclusion principle, Slatter determinantal wave functions.

Electronic Structure of Atoms: Electronic configuration, term symbols and spectroscopic states, Russell-Saunders terms and J-J coupling schemes, Term separation energies of pn and dn configurations, Magnetic effects: spin-orbit coupling and Zeeman splitting.

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Unit 4 **11 Hours**

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. Introduction to the SCF.

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. (2000) *Quantum Chemistry*. Pearson Education Inc.
2. Chandra, A.K. (1994) *Introductory Quantum Chemistry*. Tata Mcgraw-Hill.
3. Prasad, R.K., (2009) *Quantum Chemistry*. New Age Science.

4. McQuarrie, D. A. and Simon, J. D. (1998) *Physical Chemistry: A Molecular Approach.* Viva Books.
5. Murrell, J.N., Kettle S.F.A. and Tedder, J. M. (1965) *Valence Theory.* John Wiley Publishers.
6. Lowe, J. P. and Peterson, K.(2006) *Quantum Chemistry.* Academic Press.

Course Title: Practical Inorganic Chemistry-I (P)
Paper Code: CHM.513
Contact Hours: 60

L	T	P	Cr
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.

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. (1979) *Practical Inorganic Chemistry.* Chapman and Hall Ltd.

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

Course Title: Practical Organic Chemistry-I (P)
Paper Code: CHM.514
Total Contact Hours: 60

L	T	P	Cr
0	0	4	2

Learning objective: To develop experimental skills of various separation, drying, purification techniques and their application in synthesis.

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.

Solvent Drying: Use of sodium metal for 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.

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.
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 To prepare phenylpropene *via* dehydration of corresponding phenylpropanol.
6 Preparation of bromohydrin from phenylpropene.
7 To prepare ethyl cinnamate *via* acid catalyzed esterification of cinnamic acid.
8 Conversion of phthalic anhydride to phthalimide
9 Synthesis of Phenytoin.
10 Synthesis of alcohol *via* addition of Grignard reagent to an aldehyde.

C. 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. Drying of various solvents using sodium metal and P_2O_5 and their disposal.
3. Various techniques such as thin layer chromatography, column chromatography besides extraction/workup of reaction mixture, distillation and crystallization.
4. Importance of reaction conditions for a particular reaction and their mechanism.

IQAC

SUGGESTED READINGS

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

Course Title: Seminar

Paper Code: CHM.541

Total Contact Hours: 15

L	T	P	Cr
0	1	0	1

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/her topic of interest
3. Technical write and presentation of the chemical problem in hand.
4. Should generate interest in current topics of research and commercial worth of chemistry.

IQAC

SEMESTER 2

Course Title: Inorganic Chemistry-II

Paper Code: CHM.521

Total Contact Hours: 45

L	T	P	Cr
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 **11 Hours**

Symmetry

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

Unit 2 **11 Hours**

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.

Unit 3 **12 Hours**

Metal Complexes

Organic-transition metal chemistry, complexes with π-acceptor and σ-donor ligands, 18-electron and 16-electron rules, isolobal analogy, Synthesis and important reaction of metal carbonyls.Structure and bonding ofmetal carbonyls,metal nitrosyl, dinitrogen and dioxygencomplexes, tertiary phosphine as ligand andvibrational spectra of metal carbonyls for bonding and structure elucidation,

Unit 4 **11 Hours**

Inorganic cages

Metallocenes, metal cluster compounds, metal-metal bond, and non-carbonyl clusters, fluxional molecules. Cage compounds of boron: 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., and Wilkinson, G. (1988). *Advanced Inorganic Chemistry* (Vol. 545). New York: Wiley.
2. Huheey, J. E., Keiter, E. A., Keiter, R. L., and Medhi, O. K. (2006). *Inorganic Chemistry: Principles of Structure And Reactivity*. Pearson Education India.
3. Greenwood, N. N., and Earnshaw, A. (2012). *Chemistry of the Elements*. Elsevier.
4. Lever, A.B.P. (1984) *Inorganic Electronic Spectroscopy*. Elsevier Science Publishers B.V.
5. Atkins, P. (2010). *Shriver and Atkins' Inorganic Chemistry*. Oxford University Press, USA.
6. Dutta, R. L., and Syamal, A. (1993). *Elements of Magnetochemistry*. Affiliated East-West Press.

IQAC

Course Title: Organic Chemistry-II
Paper Code: CHM.522
Total Contact Hours: 45

L	T	P	Cr
3	0	0	3

Learning objective: To impart knowledge of stereochemical aspects of organic compounds, pericyclic, photochemical reactions and molecular rearrangements.

Unit 1 **11 Hours**

Stereochemistry: chirality, projection formulae,configurational and conformational isomerism in acyclic and cyclic compounds; stereogenicity, stereoselectivity, diastereoselectivity, D/L, R/S, *E/Z* and *cis/trans* configurational notations, *threo* and *erythro* isomers, optical purity, enantiotopic and diastereotopic atoms, groups and faces, stereospecific and stereoselective synthesis, optical activity in the absence of chiral carbon (biphenyls, allenes and spiranes), chirality due to helical shape, 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,

Unit 2 **11 Hours**

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 **12 Hours**

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

IQAC

Sigmatropic reactions: [1,j] and [i,j] shifts; suprafacial and antarafacial, selection rules for [l, j] 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 **11 Hours**

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, Carroll, Claisen, Cope, Gabriel–Colman, Smiles and Sommelet–Hauser rearrangements.

Selective Name Reactions: Ene/Alder-ene reaction, Dakin reaction, Reformatsky, Robinson annulation, Michael addition,Hofmann-Loffler Fretag, Chichibabin reaction.

Course Outcome: The students will acquire knowledge of

1. Conformational analysis of cyclic and acyclic compounds, chirality and reactivity.
2. Basic principles of photochemical reactions, photochemistry of carbonyl and aromatic compounds.
3. Various thermally or photochemically driven pericyclic reactions and explanation for their stereochemical aspects.
4. Various molecular rearrangements and their application in organic synthesis for the conversion of different functional group.

SUGGESTED READINGS

1. Clayden, J., Greeves, N., Warren, S. and Wothers, P. (2012). *Organic Chemistry.* Oxford University Press.
2. Bansal, R. K. (2012). *A Textbook of Organic Chemistry*. New Age International.
3. Carey, F. A., and Sundberg, R. J. (2007). *Advanced Organic Chemistry: Part A: Structure and Mechanisms*. Springer Science and Business Media.
4. Kalsi, P. S. (2010). *Stereochemistry Conformation and Mechanism*. New Age International.
5. Eliel, E. L., and Wilen, S. H. (2008). *Stereochemistry of Organic Compounds*. John Wiley and Sons.
6. Carey, F. A., and Sundberg, R. J. (2007). *Advanced Organic Chemistry: Part B*. Springer Science and Business Media.
7. Finar, I. L. (1996). *Textbook of Organic Chemistry. ELBS*, Pearson Education UK.
8. Katritzky, A. R., Ramsden, C. A., Joule, J. A., and Zhdankin, V. V. (2010). *Handbook of Heterocyclic Chemistry*. Elsevier.

IQAC

9. Norman, R.O.C. and Coxon, J.M. (1998). *Principles of Organic Synthesis*. Blackie Academic and Professional.
10. Fleming, I. (2015). *Pericyclic Reactions*. Oxford University Press.
11. Singh, J. (2005). *Photochemistry and Pericyclic Reactions*. New Age International.
12. McMurry, J. (1996). *Organic Chemistry*, Brooks. Cole, New York, 657.

Course Title: Physical Chemistry-II
Paper Code: CHM.523
Total Contact Hours: 45

L	T	P	Cr
3	0	0	3

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

Unit 1 **12 Hours**

Electrochemistry: Activity-coefficients, mean activity coefficients; Debye-Huckel treatment of dilute electrolyte solutions, derivation of Debye-Huckel limiting law, extended Debye-Huckel law and conductometric titrations.

Electrochemical Cells: Concentration cells with and without liquid junction, thermodynamics of reversible electrodes and reversible cells, potentiometric titration.

Unit 2 **11 Hours**

Reaction Kinetics: Complex reactions, steady state approximation, determination of mechanisms of complex chemical reactions, temperature dependence of rate constant, Arrhenius and Eyring equations and their applications, collision and transition state theories of rate constant, treatment of unimolecular reactions, steric factor, ionic reactions: salt effect,.

Unit 3 **11 Hours**

Photochemical Reactions and Processes: Measurement of fluorescence and phosphorescence lifetimes and photoinduced electron transfer rates, photosensitization, quenching and photodimerization.

Fast Reaction Kinetics: Introduction to time-resolved techniques for absorption and emission measurements, plug flow reactor, continuous stirred flow reactor, relaxation method, study of kinetics of fast reactions by millisecond stopped-flow, nanosecond flash photolysis techniques, detection and kinetics of reactive intermediates,

IQAC

Unit 4 **11 Hours**

Adsorption and Catalysis: Colloids and their stability, Adsorption of solids, Gibbs adsorption isotherm, BET adsorption isotherm, Langmuir and Fredulich Isotherms. Homogeneous catalysis and heterogeneous catalysis, enzyme catalysis. Michealis-Menten mechanism, Lineweaver-Burk Plot, competitive, non-competitive and uncompetitive bindings, 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

IQAC

SUGGESTED READINGS

1. Laidler, K. J. (1987). *Chemical Kinetics*. Pearson Education Ltd.
2. Atkins, P. and De Paula, J. (2009) *Atkins' Physical Chemistry*. Oxford University Press.
3. Silbey, R. J. Alberty, R. A. and Bawendi, M. G. (2004) *Physical Chemistry*. Wiley-Interscience Publication.
4. Engel, T. and Reid, P. (2012). *Thermodynamics, Statistical Thermodynamics, and Kinetics*. Pearson Education.
5. Lakowicz, J. R. (2006). *Principles of Fluorescence Spectroscopy*. Springer.
6. Barrow, G. M. (2007) *Physical Chemistry*. Tata McGraw-Hill Publishers.
7. Kapoor, K. L. (2011) *Text Book of Physical Chemistry*. 3/5, Macmillan Publishers.
8. McQuarrie, D. A. and Simon, J. D. (1998) *Physical Chemistry: A Molecular Approach*. Viva Books.
9. Moore, J. W., and Pearson, R. G. (1981). *Kinetics and Mechanism*. John Wiley and Sons.
10. Raj, G. (2002). *Surface Chemistry (Adsorption)*. Goel Publishing House.
11. Moore, J. W. and Pearson, R. G.(1981) *Kinetics and Mechanism.* John Wiley and Sons.
12. Puri, B.R., Sharma L.R. and Pathania, M.S. (2013) *Principles of Physical Chemistry.* Vishal Publishing Company.

Course Title: Spectroscopic Analysis
Paper Code: CHM.524
Total Contact Hours: 45

L	T	P	Cr
3	0	0	3

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

Unit 1 **11 Hours**

UV-Visible spectroscopy: Introduction, role of solvents, chromophores and their interaction with UV-visible radiation. Woodward-Fieser rule for conjugated dienes and carbonyl compounds

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 **12 Hours**

Nuclear magnetic resonance spectroscopy: Introduction, chemical shift, isotopic nuclei, reference standards and solvents. ^{1}H- NMR spectra: spin-spin coupling, effect of deuteration, 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.

IQAC

Unit 3 **11 Hours**

^{13}C NMR: Introduction, nuclear overhauser enhancement (NOE), DEPT techniques, 2D NMRCorrelation 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 applications.

Unit 4 **11 Hours**

Mass spectrometry: Basic principles and brief outline of instrumentation. Ion formation: EI, CI, FAB, MALDI, ESI, metastable ion, McLafferty rearrangement, nitrogen rule, fragmentation process of organic molecules in relation to molecular structure determination.Relative abundance of isotopes, High resolution mass spectrometry (HRMS).Recent advances in mass spectrometry.

Course Outcome: The students will be able to

1. Understand the importance of various methods of spectroscopy analysis (UV, IR, NMR and MS)
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. (1994). *Fundamentals of molecular spectroscopy* (Vol. 851). New York: McGraw-Hill.
2. Dyer, J. R. (1965). *Applications of absorption spectroscopy of organic compounds*. Phi Learning.
3. Kalsi, P. S. (2007). *Spectroscopy of organic compounds*. New Age International.
4. Kemp, W. (1998). Organic spectroscopy, ELBS.
5. Khopkar, S. M. (1998). *Basic concepts of analytical chemistry*. New Age International.
6. Melinda, J.D. (2010). *Introduction to solid NMR Spectroscopy*. Wiley India Pvt Ltd.
7. Mendham, J., Denney, R. C., Barnes, J. D., and Thomas, M. J. K. (2008). Vogel's Textbook of Quantitative Chemical Analysis, Dorling Kindersley.
8. Pavia, D. L., Lampman, G. M., Kriz, G. S., and Vyvyan, J. A. (2008). *Introduction to spectroscopy*. Cengage Learning.
9. Silverstein, R. M., Webster, F. X., Kiemle, D. J., and Bryce, D. L. (2014). *Spectrometric identification of organic compounds*. John wiley and sons.
10. Gross, J. H. (2006). *Mass spectrometry: A textbook*. Springer Science and Business Media.

IQAC

Course Title: Molecular Spectroscopy
Paper Code: CHM.525
Total Contact Hours: 45

L	T	P	Cr
3	0	0	3

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

Unit 1 **11 Hours**

Electronic 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 of spectral lines, non-rigid rotor, Stark effect, applications.

Unit 2 **12 Hours**

Vibrational Spectroscopy: Review of harmonic oscillator, Selection rules, vibrational energies of diatomic molecules, zero point energy, force constant and bond strength, anharmonicity, vibration-rotation spectroscopy, Morse potential energy diagram, P, Q, R branches, vibrations of polyatomic molecules, overtones, hot bands and applications.

Raman Spectroscopy - Classical and quantum theories of Raman Effect, pure rotational, vibrational and vibrational-rotational Raman spectra, selection rules, mutual exclusion principle, resonance Raman Spectroscopy, surface enhanced Raman spectroscopy, coherent anti stokes Raman spectroscopy.

Unit 3 **11 Hours**

Nuclear Magnetic Resonance (NMR) Spectroscopy: Basic principles, instrumentation, magnetization vector and relaxation, NMR transitions, Bloch equation, relaxation effects and mechanism, double resonance and spin tickling, effect of quadrapole nuclei, nuclear overhauser effect (NOE), multiple pulse methods, NMR in medical diagnostics.

Unit 4 **11 Hours**

Lasers and Laser Spectroscopy: Principles of laser action, pulsed lasers, examples of lasers: He-Ne, Nd-YAG, dye lasers.

Photoelectron spectroscopy: The photoelectric effect, UV photoelectron spectroscopy UPES, X-ray photoelectron spectroscopy XPES.

Course Outcome: The students will acquire knowledge of

1. Principles of microwave, infrared-vibration-rotation Raman and infra-red Spectroscopy and their applications for chemical analysis
2. Electronic spectroscopy of different elements and simple molecules.

IQAC

3. Physical principles of nuclear magnetic and electron spin resonance spectroscopy and their application in medical diagnostics.

SUGGESTED READINGS

1. Hollas, J. M. (2004). *Modern spectroscopy*. John Wiley and Sons.
2. Lakowicz, J. R. (2006). *Principles of Fluorescence Spectroscopy*. Springer.
3. Barrow, G. M. (2007) *Physical Chemistry*. Tata McGraw-Hill Publishers.
4. Banwell, C. N., and McCash, E. M. (1994). *Fundamentals of molecular spectroscopy* (Vol. 851). New York: McGraw-Hill.
5. Carrington, A., and McLachlan, A. D. (1967). *Introduction to Magnetic Resonance: With Applications to Chemistry and Chemical Physics.* Chapman and Hall, London.
6. Lynden-Bell, R. M., and Harris, R. K. (1969). *Nuclear Magnetic Resonance Spectroscopy*. Appleton-Century-Crofts.
7. Reilley, C. N., Everhart, D. S., and Ho, F. F. L. (1982). *Applied Electron Spectroscopy for Chemical Analysis. Chemical Analysis, 63, 105*. John Wiley.
8. Chang, R. (1971). *Basic Principles of Spectroscopy*. McGraw-Hill.
9. Ghosh, P. K. (1983). *Introduction to Photoelectron Spectroscopy*. John Wileyand Sons, New York.
10. Günther, H. (2013). *NMR Spectroscopy: Basic Principles, Concepts and Applications in Chemistry*. John Wiley and Sons.

IQAC

Course Title: Practical Inorganic Chemistry –II (P)
Paper Code: CHM.526

L	T	P	Cr
0	0	4	2

Total Contact Hours: 60

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

1. Preparation of Chloropentaammine cobalt (III) CHMoride 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 (CH3COO)$_4$ $(H_2O)_2$.
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.

8. Determination of Chlorophyll content
9. Determination of gross calorific value (GCV) for fuels.
10. Determination of pour point, flash point and cloud point of liquid fuel.

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. (1979). *Practical Inorganic Chemistry*. Chapman and Hall Ltd.
2. Nakamoto, K. (1997). *Infrared and Raman Spectra of Inorganic and Coordination Compounds: Part A and B*. John Wiley and Sons,.
3. Mendham, J., Denney, R.C., Barnes, J.D. and Thomas, M. J. K. (2000). *Vogel's Textbook of Quantitative Chemical Analysis,* Pearson Education Ltd.
4. Kolthoff, I. M., and Sandell, E. B. (1944). *Text Book of Quantitative Inorganic Analysis.* The Macmillan; New york.
5. Marr, G., and Rockett, B. W. (1960). *Practical Inorganic Chemistry*. John Wiley and Sons.
6. Jolly, W.L. (1961). *Synthetic Inorganic Chemistry*. Prentice Hall, Inc.

IQAC

Course Title: Practical Physical Chemistry-II (P)
Paper Code: CHM.527
Total Contact Hours: 60

L	T	P	Cr
0	0	4	2

Learning objective: To impart knowledge and hand-on experiences of different analytical and thermodynamic techniques for chemical and biomolecular 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 potentiometric titration 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 (RI) of given liquids and determination of the concentration from RI.

8. Determination of concentrations of proteins and DNA 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 CD and Fluorescence spectrometer.
12. Study of chemical and thermal denaturation (T_m and ΔH_m) of proteins and DNA using UV-Visible and CD spectrometer.
13. Molecular weight of a non-electrolyte by cryoscopy method.
14. Determination of stability constant of Fe(III)-salicyclic acid complex by spectrophotometer.
15. Determination of mean, median, standard errors, standard deviation, coefficient of variance using software.

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. (2014). *An Advanced Course in Practical Chemistry*. New Central Book Agency (P) Ltd.
2. Maity S., and Ghosh, N.(2012). *Physical Chemistry Practical*. New Central Book Agency (P) Ltd.
3. Elias, A. J. (2002). *A Collection of Interesting General Chemistry Experiments*. Universities Press.
4. Khosla, B.D., Garg, V.C., and Gulati A.R. (2007). *Senior Practical Physical Chemistry*. S. Chand and Sons.
5. Yadav, J. B. (2006). *Advanced Practical Physical Chemistry*. Krishna Prakashan Media.
6. Das, R. C., and Behera, B. (1983). *Experimental Physical Chemistry*. Tata McGraw-Hill.
7. Das, R.C., and Behra, B. (1983). *Experimental Physical Chemistry*. 1983, Tata McGraw-Hill.
8. James, A. M., and Prichard, F. E. (1974). *Practical Physical Chemistry*. New York: Longman.
9. Ghosh, J.C. (1990). *Experiments in Physical Chemistry*, Bharati Bhavan.

IQAC

Course Title: Seminar
Paper Code: CHM.542
Total Contact Hours: 15

L	T	P	Cr
0	1	0	1

Learning objective: The course would develop scientific aptitude, critical thinking, research writing and research presentation. Seminar would emphasize on problem solving approach and use of various techniques to prove a chemical process /techniques. The seminar would emphasize upon the writeup of introduction, review of literature and cited references. The presentation would promote the use of graphical features of MS-Office and Chemdraw,® apart from spreadsheets and imaging software

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/her 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.

IQAC

Course Title: Inorganic Chemistry-III
Paper Code: CHM.551
Total Contact Hours: 45

L	T	P	Cr
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 **11 Hours**

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 **12 Hours**

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

NMR: Basic concepts of NMR with emphasis on ^{31}P, ^{19}F, ^{29}Si, ^{11}B, ^{10}B, ^{57}Se, ^{125}Te, ^{95}Mo, ^{109}Ag, ^{195}Pt, ^{119} Sn and an explanations with appropriate examples. NMR study in Fluxional organometallic compounds**.**

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 **11 Hours**

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 **11 Hours**

Nuclear Chemistry: Classification of nuclides, nuclear stability, atomic energy, types of nuclear reactions-fission and fusion, nuclear decay laws, radio analytical 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

IQAC

SUGGESTED READINGS

1. Cotton, F.A. and Lippard, S.J., (1998). *Progress in Inorganic Chemistry*. Vol. 8, Wiley Internationals.
2. Lever, A.B.P., (1984). *Inorganic Electronic Spectroscopy*. Elsevier Science Publishers B.V.
3. Parish, R.V., (1990). *NMR, NQR, EPR and Mossbauer Spectroscopy in Inorganic Chemistry*. Ellis Harwood.
4. Silverstein, R.M., Bassler, G.C., and Morrill, T.C. (2002). *Spectrometric Identification of Organic Compounds*. John Wiley and Sons.
5. Abraham, R. J., Fisher, J., and Loftus, P. (1988). *Introduction to NMR spectroscopy*. Wiley.
6. Martin, M. L., Delpuech, J. J., and Martin, G. J. J. (1980). *Practical NMR spectroscopy*. Heyden.
7. Williams, D. H., and Fleming, I. (1980). *Spectroscopic Methods in Organic Chemistry*. McGraw-Hill.
8. Greenwood, N. N., and Earnshaw, A. (2012). *Chemistry of the Elements*. Elsevier.

Course Title: Organic Chemistry-III
Paper Code: CHM.552

L	T	P	Cr
3	0	0	3

Total Contact Hours: 45

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

Unit 1 **11 Hours**

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, two group C-C disconnections; Diels-Alder reaction, control in carbonyl condensation.

Unit 2 **12 Hours**

Metal and non-metal mediated oxidation: Mechanism, selectivity, stereochemistry and applications of oxidation reactions, Baeyer-Villiger, Oppenauer oxidation, oxidation reactions using DDQ, NBS, $Pb(OAc)_4$, Selenium dioxide, PCC, PDC, Cr and Mn reagents,phase transfer catalysis, Periodic acid, Ceric ammonium nitrate,OsO_4, Swern oxidation, hydroboration, Sharpless asymmetric epoxidation, epoxidations using peracids. Recent approaches for oxidation using green oxidants.

Unit 3 **11 Hours**

Metal and non-metal mediated reduction: Mechanism, selectivity, stereochemistry and applications of catalytic hydrogenations using Pd, Pt and Ni catalysts (Lindlar, Rosenmund, Adam's catalysts) Clemmensen reduction, Wolff-Kishner reduction, Meerwein-Pondorff-Verley reduction, dissolving metal reductions, metal hydride reductions using $NaBH_4$, $NaBH_3CN$, $NaBH(OAc)_3$, $LiAlH_4$, DIBAL. Wilkinson's catalysis, Birch reduction.

Unit 4 **11 Hours**

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: aziridines, oxiranes, thiranes, azetidines, oxetanes. **Five membered heterocycles containing two**

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heteroatoms (S,N,O): Diazoles (imidazole, pyrazole), triazoles, oxazoles and thiazoles.

Benzo-fused five-membered and six membered heterocycles:Indoles, benzofurans and benzimidazoles.

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

Course Outcome: The students will acquire knowledge of:

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

SUGGESTED READINGS

1. Ahluwalia, V. K., and Parasar R. K., (2011). *Organic Reaction Mechanism***.** Narosa Publishing House (P) Ltd., New Delhi.
2. Bansal, R. K. (2012). *A Textbook of Organic Chemistry*. New Age International.
3. Bansal, R.K. Hetrocyclic Chemistry, 5th Edition, 2010, New Age International (P) Ltd., New Delhi.
4. Carey, F. A., and Sundberg, R. J. (2007). *Advanced organic chemistry: part B*. Springer Science and Business Media.
5. Finar, I. L. (1996). *Textbook of Organic Chemistry*. *ELBS*, Pearson Education UK.
6. Gilchrist, T.L., (1997). *Heterocyclic Chemistry*. Addison Wesley Longman Publishers, US.
7. Gupta R.R., Kumar M., and Gupta V., (2010). *Heterocyclic Chemistry-II Five Membered Heterocycles*. Vol. 1-3, Springer Verlag, India.
8. Joule, J.A., and Mills, K., (2010). *Heterocyc1ic Chemistry*. Blackwell Publishers, New York.
9. Smith, M. B., (2013). *March's Advanced Organic Chemistry: Reactions, Mechanisms and Structure*. John Wiley and Sons.
10. Warren, S., (2010). *Organic synthesis: The Synthon Approach*. John Wileyand Sons.
11. Warren, S., and Wyatt, P., (2010). *Designing Organic synthesis: A Disconnection Approach*. John Wiley and Sons.
12. Corey, E.J., and Cheng X.-M., (1989). *The Logic of Chemical Synthesis*. John Wiley and Sons.

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Course Title: Bio-inorganic and Biophysical Chemistry
Paper Code: CHM.553
Total Contact Hours: 45

L	T	P	Cr
3	0	0	3

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

Unit 1 **11 Hours**

Inorganic Chemistry of Enzymes - I

Metalloporphyrins: 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, ferritin, transferrin, bacterial iron transport.

Unit 2 **12 Hours**

Inorganic Chemistry of Enzymes - II

Metallothioneins: Ferridoxins, carboxypeptidase, carbonic anhydrase, blue copper proteins, superoxide dismutase, hemocyanines.

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 **11 Hours**

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, metals in the regulation of biochemical events. Metal complexes for therapeutic uses (cisplatin, carboplatin, non platinum metal complexes).

Unit 4 **11 Hours**

Biophysical Chemistry

Principles of biophysical chemistry (pH, buffer, reaction kinetics, thermodynamics), 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

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spectroscopic methods (CD, FTIR, NMR), thermodynamics of protein folding by spectroscopic and calorimetric methods, protein conformational study by NMR and fluorescence spectroscopy,

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., Keiter, R. L., and Medhi, O. K. (2006). *Inorganic chemistry: principles of structure and reactivity*. Pearson Education India.
2. Douglas, B. E., and McDaniel, D. H. (1965). *Concepts and models of inorganic chemistry*. John Wiley and Sons.
3. Cotton, F. A., and Wilkinson, G. (1988). *Advanced inorganic chemistry* (Vol. 545). New York: Wiley.
4. Elschenbroich, C. (2016). *Organometallics*. John Wiley and Sons.
5. Atkins, P., Overtone, T., Rourke, J., Weller, J., and Armstrong, F., (2010). *Shriver and Atkins' inorganic chemistry*. Oxford University Press.
6. Cowan, J.A.(1997). *Inorganic Biochemistry: An Introduction*. Wiley – VCH.
7. Lippard,S. J. (1991). *Progress in Inorganic Chemistry*. Vol. 18, Wiley-Interscience.
8. Lippard,S. J. (1991). *Progress in Inorganic Chemistry*. Vols. 38, Wiley-Interscience.
9. Lesk, A.M., (2010). *Introduction to Protein Science: Architecture, Function, and Genomics*. Oxford University Press.
10. Cantor, C.R. and Schimmel, P.R., (980). *Biophysical Chemistry*. Freeman.
11. Van Holde, K.E., Johnson, W.C., and Ho, P.S., (2006). *Principles of Physical Biochemistry*. Pearson Education.
12. Harding, S.E. and Chowdhry, B. Z. (2001). *Protein-Ligand Interactions*. Oxford University Press.

Course Title: Research Methodology
Paper Code: CHM.556
Total Lecture: 60

L	T	P	Cr
4	-	-	4

Unit 1 **15 Hours**

General principles of research: Meaning and importance of research, Critical thinking, Formulating hypothesis and development of research plan, Review of literature, Interpretation of results and discussion.

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Bibliographic index and research quality parameters- citation index, impact factor, *h* index, i10 index, etc. Research engines such as google scholar, Scopus, web of science, etc

Unit-2 **15 Hours**

Technical and scientific writing: Technical and Scientific writing - theses, technical papers, reviews, electronic communication, research papers, etc., Poster preparation and Presentation and Dissertation. Reference Management using various softwares such as Endnote, reference manager, Refworks, etc. Communication skills–defining communication; type of communication; technicques of communication, etc.

Unit-3 **15 Hours**

Library: Classification systems, e-Library, Reference management, Web-based literature search engines.

Plagiarism: Plagiarism, definition, Search engines, regulations, policies and documents/thesis/manuscripts checking through softwares, Knowing and Avoiding Plagiarism during documents/thesis/manuscripts/ scientific writing.

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Unit-4 **15 Hours**

Intellectual Property Rights: Intellectual Property, intellectual property protection (IPP) and intellectual property rights (IPR), WTO (World Trade Organization), WIPO (World Intellectual Property Organization), GATT (General Agreement on Tariff and Trade), TRIPs (Trade Related Intellectual Property Rights), TRIMS (Trade Related Investment Measures) and GATS (General Agreement on Trades in Services), Nuts and Bolts of Patenting, Technology Development/Transfer Commercialization Related Aspects, Ethics and Values in IP.

SUGGESTED READINGS

1. Gupta, S. (2005). *Research Methodology and Statistical Techniques*. Deep and Deep Publications (p) Ltd.
2. Kothari, C. R. (2008.) *Research Methodology(s)*. New Age International (p) Limited.
3. Web resources: www.sciencedirect.com for journal references, www.aip.org and www.aps.org for reference styles.
4. Web resources: www.nature.com, www.sciencemag.org, www.springer.com, www.pnas.org, www.tandf.co.uk, www.opticsinfobase.org for research updates.

Course Title: Practical Organic Chemistry-III (P)
Paper Code: CHM.554
Total Contact Hours: 60

L	T	P	Cr
0	0	4	2

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

Experiments:

1. **Synthesis**: Separation and purification of organic compounds by column chromatography, percentage yield calculation
   1. Preparation of allylic alcohols *via* Baylis-Hillman reaction using DABCO as a catalyst 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. Synthesise of benzothiazole starting from 2-aminothiophenol.
   12. To study amination of benzothiazole with various amines.
   13. To synthesize acylidine analogue of Meldrum acid.

Course Outcome: The students will acquire knowledge of

1. Various reactions conditions including modern coupling strategies and their implications.
2. Various techniques for purification, isolation, recrystallization and charcetrization of synthesized organic molecules.

SUGGESTED READINGS

1. Harwood, L.M. and Moody, C.J. (1989) *Experimental Organic Chemistry*. Blackwell Scientific Publishers.

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2. Vogel, A.I. (1978) *Textbook of Practical Organic Chemistry*. ELBS, Longman Group Ltd.
3. Mann, F.G. and Saunders, B.C. (1975) *Practical Organic Chemistry*. Orient Longman Pvt. Ltd.
4. Leonard, J. and Lygo, B.(1995) *Advanced Practical Organic Chemistry*. Chapman and Hall,.
5. Armarego, W.L. and Chai, C. (2012) *Purification of Laboratory Chemicals*. Butterworth-Heinemann.
6. Young, J.A. (1991) *Improving Safety in the Chemical Laboratory: A Practical Guide.* Wiley Publishing.

Course Title: Practical Physical Chemistry-III (P)
Paper Code: CHM.555
Total Contact Hours: 60

L	T	P	Cr
0	0	4	2

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

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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.

13. Curve fitting using linear and non-linear (Activation thermodynamic parameter, equilibrium thermodynamic parameter) regression analysis using software.
14. Determination of Michaelis-Menten (K_m) constant in enzyme kinetics.

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. (2014). *An Advanced Course in Practical Chemistry*. New Central Book Agency (P) Ltd.
2. Maity S., and Ghosh, N.(2012). *Physical Chemistry Practical*. New Central Book Agency (P) Ltd.
3. Elias, A. J. (2002). *A Collection of Interesting General Chemistry Experiments*. Universities Press.
4. Khosla, B.D., Garg, V.C., and Gulati A.R. (2007). *Senior Practical Physical Chemistry*. S. Chand and Sons.
5. Yadav, J. B. (2006). *Advanced Practical Physical Chemistry*. Krishna Prakashan Media.
6. Das, R. C., and Behera, B. (1983). *Experimental Physical Chemistry*. Tata McGraw-Hill.
7. Yadav, J.B., (2008). *Advanced Practical Physical Chemistry*. Krishna Prakashan Media.
8. James, A. M., and Prichard, F. E. (1974). *Practical Physical Chemistry*. New York: Longman.
9. Ghosh, J.C. (1990). *Experiments in Physical Chemistry*, Bharati Bhavan.

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L	T	P	Cr
0	0	32	16

Course Title: Project
Paper Code: CHM.599
Total Contact Hours:

Learning objective: The project would develop scientific aptitude, reviewing of literature, critical thinking, hypothesis development, experiment planning, synopsis writing, problem presentation and way to solve the problem.

Project supervisor would be allocated at the start of the semester and research project would be undertaken in discussion with the project supervisor. At the end of the semester the student has to prepare a project report as per the university guidelines. Upon submission of the project report, the projects would be evaluated based on a project presentation.

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. Write synopsis independently
4. Would generate interest in current topics of research.

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L	T	P	Cr
4	0	0	4

Course Title: Polymer and Solid State Chemistry
Paper Code: CHM.571
Total Contact Hours: 60

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

Unit 1 **15 Hours**

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 **15 Hours**

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 **15 Hours**

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 **15 Hours**

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.

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SUGGESTED READINGS

1. Gowariker, V. R., Viswanathan, N. V., and Sreedhar, J. (1986). *Polymer Science*. New Age International.
2. Odian, G. (2004). *Principles of Polymerization*. John Wiley and Sons.
3. Peacock, A. J., and Calhoun, A. (2012). *Polymer Chemistry: Properties and Application*. Carl Hanser Verlag GmbH Co KG.
4. Chandra, R., and Adab, A. (1994). *Rubber and Plastic Waste: Recycling, Reuse and Future Demand*. CDB Publishers.
5. Bahadur, P., and Sastry, N. V. (2005). *Principles of Polymer Science*. Narosa Publishing House, New Delhi .
6. Ashcroft, N. W., and Mermin, N. D. (1976). *Introduction to Solid State Physics*. Saunders.
7. Callister Jr, W. D., and Rethwisch, D. G. (2012). *Fundamentals of Materials Science and Engineering: An Integrated Approach*. John Wiley and Sons.
8. Anderson, J. C., Leaver, K. D., Rawlings, R. D., and Leavers, P. S. (2004). *Materials Science for Engineers*. CRC Press.
9. Keer, H. V. (1993). *Principles of the Solid State*. New Age International.

IQAC

Course Title: Concepts in Chemistry-I
Paper Code: CHM.572

L	T	P	Cr
2	0	0	2

Total Contact Hours: 30
Learning objective: To enrich the knowledge of students by exercising various topic oforganic chemistry such as applications of spectroscopy for structure elucidation,organic transformations and reagents, asymmetric synthesis and pericyclic reactions etc, so that they cancompete for National level competitive **examinations such asUGC-CSIR-NET, GATE etc.**

Unit 1 **7 Hours**
Combined Structure problems: Exercises of structure elucidation of unknown compounds *via* combined spectral interpretation of IR,UV-vis,^{1}Hand^{13}C NMR and mass spectra, along with two-dimensional NMR spectroscopy.
IUPAC nomenclature of organic molecules including regio- and stereoisomers.

Unit 2 **7 Hours**
Organic reaction mechanisms: involving addition, elimination and substitution reactions with electrophilic, nucleophilic or radical species. Determination of reaction pathways.

Various strategies for asymmetric synthesis and its applications in natural products and drug molecules.

Unit 3 **8 Hours**

Organic transformations and reagents: Functional group interconversion including oxidations and reductions; common catalysts and reagents: organic, inorganic, organometallic and enzymatic. Chemo, regio and their applications in organic synthesis. stereoselective transformations. Green catalysts in organic synthesis. Exercises on stereochemical aspects of various pericyclic reactions.

Unit 4 **8 Hours**

Reactivity of common heterocyclic compounds containing one or two heteroatoms (O, N, S) and their utility in organic synthesis.

Chemistry of natural products: Carbohydrates, proteins and peptides, fatty acids, nucleic acids, terpenes, steroids and alkaloids.

Course Outcome: The student will able to exercise and understand various applications of

1. Spectroscopic techniques for structural elucidation of unknown compounds.
2. Various reagent and organic transformations, their mechanism and stereochemical aspects.
3. Reactivity of heterocyclic compounds and utility of natural products

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SUGGESTED READINGS

1. Pavia, D.L., Lampman, G. M., Kriz, G. S., and Vyavan, J. R., (2010). *Introduction to Spectroscopy***.** Harcourt College, NY.
2. Dewick, P.M., (2009). *Medicinal Natural Products: A Biosynthetic Approach*. Wiley andSons, UK.
3. Finar, I.L. (2006). *Organic Chemistry: Stereochemistry and the Chemistry of Natural Products*. Dorling Kindersley Pvt. Ltd., India.
4. Claydon, J., Gleeves, N., Warren, S. And Wother, P., (2001). *Organic Chemistry*. Oxford University Press, UK.
5. Fleming, I., (2015). *Pericyclic Reactions*. Oxford University Press.
6. Carey B. F. A., and Sundberg R.J., (2007). *Advanced Organic Chemistry Part B*. Springer Science and Business Media Ltd.

Course Title: Concepts in Chemistry-II
Paper Code: CHM.573
Total Contact Hours: 30

L	T	P	Cr
2	0	0	2

Learning objective: To impart knowledge of quantitative errors, thermodynamics, kinetics photochemistry and electrochemistry.

Unit 1 **7 Hours**

Structure and bonding

Electronic configuration of atoms(L-S coupling) and the periodic properties of elements; Ionic radii, Ionisation potential, electron affinity, electronegativity; concept of hybridisation. Molecular orbitals and electronic configuration of homo- and hetero-nuclear diatomic molecules. Shape of polyatomic molecules; VSEPR theory, Symmetryelements and point groups for simple molecules. Acid and bases concepts, pH and pKa, HSAB concept, Buffer solution. Properties of solid state and solution phase.

Unit 2 **8 Hours**

Aspects of *s*, *p*, *d* and *f*-block elements

General characteristics of each block. Chemistry of representative (*s* and *p*-block) elements, Coordination chemistry of transition elements.Chemistry of lanthanide and Actinides.

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Unit 3 **7 Hours**

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

Unit 4 **8 Hours**

Electrochemistry: Ionic equilibria, ion conduction mechanism, solutions of nonelectrolytes and electrolytes, electrolytic conductance –Kohlrausch's Law, transport number and its determination, Nernst equation, redox systems, electrochemical cells.

Basics of Photochemistry: Absorption, excitation, laws of photochemistry, quantum yield, lifetime of excited states, photochemical stages-primary and secondary process.

Kinetics: Introduction, rates of chemical reactions, Kinetics of photochemical reactions.

Course Outcomes: The student will acquired understanding of physical concept involving in quantities errors, Kinetics, thermodynamics, photochemistry and electrochemistry.

SUGGESTED READINGS

1. Cotton, F. A., and Wilkinson, G. (1988). *Advanced Inorganic Chemistry* (Vol. 545). New York: Wiley.
2. Huheey, J. E., Keiter, E. A., Keiter, R. L., and Medhi, O. K. (2006). *Inorganic Chemistry: Principles of Structure and Reactivity*. Pearson Education India.
3. Greenwood, N. N., and Earnshaw, A. (2012). *Chemistry of the Elements*. Elsevier.
4. Miessler, G. L. and Tarr, D. A. (2011) *Inorganic Chemistry*, Pearson Education.
5. Atkins, P. (2010). *Shriver and Atkins' Inorganic Chemistry*. Oxford University Press, USA.
6. Barrow, G. M. (2007) *Physical Chemistry*. Tata McGraw-Hill Publishers.
7. Kapoor, K. L. (2011) *Text Book of Physical Chemistry*. 3/5, Macmillan Publishers.
8. Atkins, P. and De Paula, J. (2009) *Atkins' Physical Chemistry*. Oxford University Press.
9. Moore, J. W. and Pearson, R. G.(1981) *Kinetics and Mechanism.* John Wiley and Sons.
10. Puri, B.R., Sharma L.R. and Pathania, M.S. (2013) *Principles of Physical Chemistry.* Vishal Publishing Company.
11. Laidler, K. J. (1987). *Chemical Kinetics*. Pearson Education Ltd.
12. Rohatgi-Mukherjee, K. K., (1986). Fundamentals of Photochemistry. New Age International.

Course Title: Advanced Organic Synthesis
Paper Code: CHM.574
Total Contact Hours: 60

L	T	P	Cr
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 **15 Hours**

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

Unit 2 **15 Hours**

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. Stevens rearrangement.

Unit 3 **15 Hours**

Organometallic compounds: Organoboranes: Preparation of organobornaes viz hydroboration with BH_3-THF, dicylohexyl borane, disiamylborane, thexylborane, 9-BBN, diisopinocampheyl borane, functional group transformations of organo boranes: oxidation, protonolysis and rearrangements. formation of carbon-carbon-bonds *viz*organoboranes carbonylation.

Organolithium, organozinc, organosilicon, organopalladium and organostannous compounds: applications in C-C coupling reactions.

Unit 4 **15 Hours**

Reagents in organic synthesis: Gilman'sreagent, Lithium diisopropylamide (LDA), 1,3-Dithiane (Umpolung reagent), Trimethylsilyl iodide, Bakersyeast,Prevost Hydroxylation, Crown ether, Merrifield resin, Fenton's reagents, Ziegler-Natta catalyst, Lawsson reagents, K-selecteride and L-selecteride, IBX,Fetizon reagent, Dioxiranes, Tebbe reagent, Corey-Nicolaou reagent and macrolactonisation, Mosher's reagent.

Course Outcomes: The students will acquire knowledge of

1. Asymmetric synthesis and chiral resolution.
2. Various reagents including organometallic compounds, experimental conditions and their applications in organic synthesis.
3. Some important reactions utilizing phosphorus and sulphur ylides.

SUGGESTED READINGS

1. Claydon, J., Gleeves, N., Warren, S., and Wother, P., (2001). *Organic Chemistry*. Oxford University Press, UK.
2. Finar, I.L., (2012). *Organic Chemistry*. Pearson Education, UK.
3. Li, J. J., (2014). *Name Reactions: A Collection of Detailed Reaction Mechanism*. Springer-Verlag.
4. Smith, M. B., (2013). *March's Advanced Organic Chemistry: Reactions, Mechanisms, And Structure*. John Wiley and Sons.

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5. Corey, E.J. and Cheng, X.-M.(1989). *The Logic of Chemical Synthesis*. John Wiley and Sons.
6. Fuhrhop, J. H., Penzlin, G., and Li, G., (2003). *Organic Synthesis: Concepts And Methods*. John Wiley and Sons.
7. Davies, S. G., (2013). *Organotransition Metal Chemistry: Applications to Organic Synthesis: Applications to Organic Synthesis* (Vol. 2). Elsevier.
8. Aitken, A., and Kilényi, S. N., (Eds.). (1992). *Asymmetric Synthesis*. CRC Press.
9. Proctor G. (1996). *Asymmetric Synthesis*. Academic Press.
10. Mundy, B. P., Ellerd, M. G., and Favaloro Jr, F. G., (2005). *Name Reactions And Reagents In Organic Synthesis*. John Wiley and Sons.

Course Title: Chemistry of Natural Products
Paper Code: CHM.575

L	T	P	Cr
4	0	0	4

Total Contact Hours: 60
Learning objective: To impart knowledge about classification, occurrence and biosynthesis of various natural products.

Unit 1 **15 Hours**
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 **15 Hours**
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 **15 Hours**
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 **15 Hours**
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., and Meenakshi, S. (2009). *Natural Product Chemistry and Applications*. Narosa Publishing House, New Delhi.
2. Bhat, S.V., Nagasampagi, B.A., and Sivakumar, M. (2005). *Chemistry of Natural Products*. Narosa Publishing House, New Delhi.
3. Cseke, L.J., (2009). *Natural Products from Plants*. CRC Press.
4. Dewick, P.M. (2009). *Medicinal Natural Products: A Biosynthetic Approach*. Wiley andSons, UK.
5. Finar, I.L., (2006). *Organic Chemistry: Stereochemistry and the Chemistry of Natural Products*. Dorling Kindersley Pvt. Ltd., India.
6. Peterson, F. and Amstutz, R., (2008). *Natural Compounds as Drugs*. Birkhauser-Verlay.

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Course Title: Organotransition Metal Chemistry
Paper Code: CHM.576
Total Contact Hours: 60

L	T	P	Cr
4	0	0	4

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

Unit 1 **15 Hours**

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 **15 Hours**

Transition Metal Complexes

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

Unit 3 **15 Hours**

Aryls of Transition Metals

Types, routes of synthesis, stability and decomposition pathways, applicationsin organic synthesis.

Unit 4 **15 Hours**

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) oxo-palladation 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.

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SUGGESTED READINGS

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

Course Title: Environmental Chemistry

Paper Code: CHM.577

L	T	P	Cr
4	0	0	4

Total Lectures: 60

Learning objective: To acquire the knowledge of different chemical phenomena as applied to environmental interfaces, policies as guidelines emanating from these phenomena and water/wastewater treatment techniques.

Unit 1 **15 Hours**

Aquatic chemistry: Surface, ground water, marine and brackish water resources - assessment and utilization; Rivers and Lakes in India; hydrological cycle; Structure and properties of water, Water quality parameters, Physicochemical concepts of color, odour, turbidity, pH, conductivity, DO, COD, BOD and its kinetics, Carbonates and alkalinity, redox potential, Pourbiax diagram, pH-pE diagrams for Iron, oxoanions and anions, Environmental Issues: Ground water depletion; Water logging and salinity; Water Conservation and management techniques; Rain water harvesting; Watershed management; Eutrophication; Restoration of Lakes, transboundary river water sharing and interlinking of rivers.

Interfacial Interactions: Environmental chemistry of arsenic, chromium, Chemical potential, fugacity and its application to fugacity model.

Unit 2 **15 Hours**

Water treatment Technologies: Chemical and Physical Methods of wastewater treatment with emphasis on sedimentation, coagulation, adsorption, water softening, defluoridation and ion exchange process.

Membrane Processes: Reverse Osmosis, Types of membrane, characterization of membranes, nano-membranes and their formation, efficiency of different membranes in removal of different elements.

Biological wastewater treatment including Activated sludge process, trickling filter and Membrane bioreactor, biological treatment processes - process description, design and application.

Unit 3 **15 Hours**

Atmospheric chemistry: Composition of air, Chemical speciation, particles, ion and radicals, Formation of particulate matter, Photochemical reactions in the atmosphere, Chemistry of air pollutants, Photochemical smog, Acid rain, Ozone Chemistry and Montreal Protocol, Greenhouse gases and Global warming, Clean Development Mechanism and Kyoto Protocol, Persistant Organic Pollutants (POP) and Stockholm Convention.

Sources of Natural and Artificial Radiations: Dosimetry, types of dosimeters, radioactive substances, applications and handling of isotopes and other radionuclides in environment.

Biochemical and Toxicological aspects of arsenic, cadmium, lead, mercury, carbon monoxide, O_3, PAN, MIC and other carcinogens.

Unit 4 **15 Hours**

Chemistry of Soil: Physio-chemical composition of soil, humus, inorganic and organic components of soil, nutrients (NPK) in soil, significance of C:N ratio,

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cation exchange capacity (CEC), reactions in soil solution, ion exchange (physiosorption), ligand exchange (chemisorption), complexations, chelation; precipitation / dissolution.

Environmental Geochemistry: Concept of major, trace and REE. classification of trace elements, mobility of trace elements, geochemical cycles.

Waste Management: Biomass waste management, biomedical waste management and chemical waste management, design and construction of waste management site. Regulations for waste management.

Course Outcome: The student will acquire knowledge of

1. Various chemical processes in the air water and soil environment
2. Various policy implication for applied chemists
3. Treatment technologies adopted for various wastewaters

SUGGESTED READINGS

1. Baird, C., and Cann, M., (2008). *Environmental Chemistry*. W.H. Freeman, USA
2. Manahan, S. E., (2008). *Fundamentals of Environmental Chemistry*. CRC Press, USA
3. Connell D. W. (2005). *Basic concepts of Environmental Chemistry*, CRC Press, USA
4. Girard, J., (2010). *Principles of Environmental Chemistry*. Barlett Publishers, USA.
5. Harrison, R. M., (2007). *Principles of Environmental Chemistry*. RSC Publishing, UK
6. Hillel, D., (2007). *Soil in the Environment: Crucible of Terrestrial Life*. Academic Press, USA.
7. Manahan, S. E., (2010). *Water Chemistry: Green Science and Technology of Natures Most Renewable Resource*. CRC Press, USA.
8. Tchobanoglous, G., Burton, F. L., and Stensel, H. D., (2003). *Wastewater Engineering: Treatment and Reuse*. McGraw-Hill Science, USA.
9. American Public Health Association, American Water Works Association and Water Environment Federation, (2005). *Standard Methods for the Examination of Water and Wastewater*. American Public Health Association.
10. Eckenfelder, Jr., W.W., Ford, D.L., and Englande, A.J., Jr. (2009). *Industrial water quality*. McGraw-Hill.
11. Crittenden, J. C., Trussell, R. R., and Hand, D. W., (2005). *Water treatment: principles and design*. Wiley Publishers, USA.

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12. Grady Jr, C. L., Daigger, G. T., Love, N. G., and Filipe, C. D. (2011). *Biological Wastewater Treatment*. CRC Press.

Course Title: Inorganic Photochemistry
Paper Code: CHM.578
Total Contact Hours: 60

L	T	P	Cr
4	0	0	4

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

Unit 1 **15 Hours**

Basics of Photochemistry: 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.

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Unit 2 **15 Hours**

Photochemical Mechanism: Properties of excited states- structure, dipole moment, 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 **15 Hours**

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 and SET), exciplex formation,

Unit 4 **15 Hours**

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_2photocatalysis, 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., (2006). *Principles of Fluorescence Spectroscopy*, Springer.
2. Rohatgi-Mukherjee, K. K., (1986). *Fundamentals of Photochemistry*. New Age International.
3. Kryukov, A. I., and Yakuchmii, S., (1990). *Fundamentals of Photochemistry of Coordination Compounds*.
4. Kavarnos, G. J. (1993). *Fundamentals of Photoinduced Electron Transfer*. Vch Pub.
5. Valeur, B., and Berberan-Santos, M. N. (2012). *Molecular Fluorescence: Principles and Applications*. John Wiley and Sons.
6. Turro, N. J., Ramamurthy, V., and Scaiano, J. C. (2012). *Modern Molecular Photochemistry of Organic Molecules*. Wiley Publishers.
7. Ninomiya, I., and Naito, T. (2012). *Photochemical Synthesis*. Academic Press.

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Course Title: Current Trends in Organic Synthesis
Paper Code: CHM.579

L	T	P	Cr
4	0	0	4

Total Contact Hours: 60
Learning objective: To impart knowledge of current trends in free radical reactions, enolate chemistry and protection and deprotection relevant to industrial process thinking.

Unit 1 **15 Hours**
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. Recent trends in oxidative functionalization of C-H bond *via* free radical chemistry.

Unit 2 **15 Hours**
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 stereoselectiveenolate

formation; enamines and metallo-enamines; regioselectivity in generation, application in controlling the selectivity of alkylation.

Unit 3 **15 Hours**

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:

Recent advances in protection-deprotection free organic synthesis.

Unit 4 **15 Hours**

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, Vilsmeier–Haack reaction.

Course Outcome: The student would acquire the knowledge of

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

SUGGESTED READINGS

1. Finar, I.L., (2012). *Organic Chemistry Vol. 1*. Pearson Education, UK.
2. Finar, I.L., (2012). *Organic Chemsitry Vol. 2: Stereochemistry and the Chemistry of Natural Products*. Pearson Education, UK.
3. Fleming I., (2011). *Molecular Orbitals and Organic Chemical Reactions*. John Wiley and Sons.
4. Li, J. J., (2014). *Name Reactions: A Collection of Detailed Reaction Mechanisim*. Springer-Verlag.
5. Kalsi, P.S. (2010). *Organic Reactions and Their Mechanisms*. New Age International Pub.
6. McMurry, J. (1996). *Organic Chemistry*, Brooks Cole,.
7. Mukherjee, S.M., and Singh, S.P., (2009). *Reaction Mechanism in Organic Chemistry*. Macmillan India Ltd.
8. Smith, M. B., (2013). *March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure*. John Wiley and Sons.
9. Solomon, T.W.G., Fryhle, C.B. and Snyder, S. A., (2013). *Organic Chemistry*. John Wiley and Sons, Inc.

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10. Sykes, P. A.(1997). *Guide Book to Mechanism in Organic Chemistry*. Prentice Hall.
11. Carruthers, W. (2004). *Some Modern Methods of Organic Synthesis*. Cambridge Uni. Press, UK.

Course Title: Supramolecular Chemistry
Paper Code: CHM.580
Total Contact Hours: 60

L	T	P	Cr
4	0	0	4

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 **15 Hours**

Introduction: Definition and development of supramolecular chemistry, nature of binding interactions in supramolecular structures: ion-ion, ion-dipole, dipole-dipole, h-bonding, cation-□, anion-□□, □ -□□ and van der waals 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.

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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 synthesis and template effects,

Unit 2 **15 Hours**

Cation Binding: Binding Constant and its determination, concept of coordination chemistry, cation complexation using various preorganized host, soft ligands including N, S and P based macrocycles, Schiff's base, proton and ammonium ion complexation, carbon donor and π- acid ligands, siderophores.

Anion Receptor: Anion recognition and its biological relevance, concepts on anion host design, from cation to anion hosts- a simple change in pH, guanidinium- based receptors, neutral receptors, organometallic receptors, coordination interactions. Chromogenic and cluorogenic receptors, dosimeters, ion pair recognition and zwitterion recognition.

Inclusion Complexes: Molecular guests and their inclusion complexation with Cyclodextrin, molelcular clefts, tweezers, cryptophanes, cyclophanes, carcerands and hemicarcerands, solid state inclusion including clathrate formation, solid-liquid, solid-gas inclusions.

Unit 3 15 Hours

Molecular Self-assembly: Supramolecular polymers: definition, kineic and thermodynamic consideration of self-assembly. self-assembly molecules: design, synthesis and properties of the molecules, self-assembly by H-bonding, proteins and foldamers, DNA, catenanes, rotaxanes, molecular knot: topology and examples including trefoil and borromean rings, surfactants self assembly, liquid crystals.

Dendrimers structure and nomenclature, synthesis and characterization, supramolcular chemistry of dendrimers and its assembly, dendritic nanodevices

Supramolecular polymers including amphiphilic block polymers and molecular imprinter polymers, biological self assembly in amyloids, actins and fibrin, COF and supramolecular gels.

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Unit 4 15 Hours

Supramolecular and Molecular Devices: Supramolecular photochemistry and catalysis, molecular electronic devices: molecular electronic devices, molecular wires, molecular rectifiers, molecular switches and molecular logic gates, non linear optical devices, organics for photonics and electronics.

Molecular Machines: Molecular machine terminology and bio-inspiration, ratchet mechanism including pulsating and tilt mechanism, covalent and supramolecular motors and their controlling mechanisms, machines based on catenanes and rotaxanes. Applications as molecular walkers, switchable catalysts, surface analysis at molecular dimensions.

Course Outcome: The students will acquire knowledge of

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

SUGGESTED READINGS

1. Steed, J. W., and Atwood, J. L. (2013). *Supramolecular chemistry*. John Wiley and Sons.

2. Lehn, J. M., (1995). *Supramolecular Chemistry-Concepts and Perspectives*. Wiley –VCH.
3. Beer, P.D., Gale, P. A., and Smith, D. K., (1999). *Supramolecular Chemistry*. Oxford University Press.
4. Martin, N. and Nierengarten J.-F. (2012). *Supramolecular Chemistry of Fullerenes and Carbon Nanotubes*. Wiley-VCH.
5. Vicens, J. and Harrowfield J. (2007). *Calixarenes in the Nanoworld*. Springer.
6. Schalley, C. A. (2012). *Analytical Methods in Supramolecular Chemistry*. Vol. 1 and 2, Wiley-VCH.
7. Erbas-Cakmak, S., Leigh, D. A., McTernan, C. T., and Nussbaumer, A. L. (2015). Artificial molecular machines. *Chemical Rev*iew, *115*(18), 10081-10206.

Course Title: Material Chemistry
Paper Code: CHM.581
Total Contact Hours: 60

L	T	P	Cr
4	0	0	4

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

Unit 1 **15 Hours**

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 **15 Hours**
Mesmorphic behaviour, thermotropic liquid crystals, positional order, bond orientational order, nematic and smectic mesophases; smectic - nematic transition and clearing temperature -homeotropic, planar and sCHMieren 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.

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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 **15 Hours**

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.

Preparation and characterization of silica and zirconia based stationary phases by (a) dynamic chemical modification, in which chiral selector is adsorbed on the surface of the zirconia by physical forces, (b) permanent chemical modification, in which a CS is chemically bonded onto the zirconia surface, and (c) physical screening, in which zirconia surface is coated with a polymer or carbon layer, and their application in chiral separations by LC

Unit 4 **15 Hours**

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. (1976). *Introduction to Solid State Physics*. Saunders.

2. Callister Jr, W. D., and Rethwisch, D. G. (2012). *Fundamentals of Materials Science and Engineering: An Integrated Approach*. John Wiley and Sons.
3. Anderson, J. C., Leaver, K. D., Rawlings, R. D., and Leevers, P. S. (2004). *Materials Science for Engineers*. CRC Press.
4. Keer, H. V. (1993). *Principles of the Solid State*. New Age International.

Course Title: Project
Paper Code: CHM.599
Total Contact Hours: 432

L	T	P	Cr
0	0	12	6

Learning objective: The project would develop scientific aptitude, critical thinking, experiment planning, reporting and auditing the experimental data, interpretation to result discussion, research writing and research presentation.

Project supervisor would be allocated at the start of the semester and research project would be undertaken in discussion with the project supervisor. At the end of the semester the student has to prepare a project report as per the university guidelines. Upon submission of the project report, the projects would be evaluated based on a project presentation.

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. Write research proposal independently
4. Would generate interest in current topics of research.

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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	CHM.515	Basics perspective in Inorganic Chemistry	2	-	-	2	10	15	15	10	50
2	CHM.516	Introduction to Green Chemistry and Sustainability	2	-	-	2	10	15	15	10	50
3	CHM.517	Chemistry of Nanomaterials and Fabrication	2	-	-	2	10	15	15	10	50
4.	CHM.528	General Laboratory Practices	2	-	-	2	10	15	15	10	50

Course Title: Basic Perspectives in Inorganic Chemistry
Paper Code: CHM.515

Total Contact Hours: 30

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 **7 Hours**

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

Unit 2 **8 Hours**

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

Unit 3 **8 Hours**

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 **7 Hours**

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. Lippard, S.J. and Berg, J.M., (1994) *Principles of Bioinorganic Chemistry*. University Science Books.
2. Cotton, F. A., and Wilkinson, G. (1988). *Advanced Inorganic Chemistry* (Vol. 545). New York: Wiley.
3. Huheey, J. E., Keiter, E. A., Keiter, R. L., and Medhi, O. K. (2006). *Inorganic Chemistry: Principles of Structure and Reactivity*. Pearson Education India.
4. Greenwood, N. N., and Earnshaw, A. (2012). *Chemistry of the Elements*. Elsevier.

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5. Van-Loon G.W. and Duffy S.J. (2011) *Environmental Chemistry: A Global Perspective*. Oxford University Press.
6. Rao C.S. (2006) *Environmental Pollution Control Engineering*. New Age International Publishers, New Delhi,
7. Peruzzini, M. and Poli, R. (2005) *Recent Advances in Hydride Chemistry*, Elsevier Science B.V., Amsterdam.

Course Title: Introduction to Green Chemistry and Sustainability

L	T	P	Cr
2	0	0	2

Paper Code: CHM.516

Total Contact Hours: 30

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

Unit 1 **7 Hours**

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 persuitof the goals of green chemistry, types of solvent.

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Unit 2 **7 Hours**

Emerging non-conventional techniques:

Microwave heating as energy efficient source, mechanism of microwave heating, Examples of microwave assisted organic synthesis, sono-chemistry and green chemistry,

Unit 3 **8 Hours**

Green solvents:

Ionic liquids**:** properties and advantages**,** use of ionic liquids as solvent as well as catalyst, recyclability of ionic liquids. Solvent-free synthesis.

Unit 4 **8 Hours**

Value addition of abundantly available precursors:

Need for the use of renewable precursors over petroleumbased 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. (2000) *Green chemistry: Theory and* Practical. Oxford University Press, US.
2. Ahluwalia, V.K and Kidwai, M. (2004) New Trends in Green Chemistry. Springer.
3. Malhotra, S. V. (2007) Ionic Liquids in Organic Synthesis. Oxford University Press, US.
4. Ahluwalia, V.K. (2011) Green Chemistry: Greener Alternatives to Synthetic Organic Transformations. Alpha Science International Limited.
5. Klass, D. (1998) Biomass for Renewable Energy, Fuels, and Chemicals. Elsvier.

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Course Title: Chemistry of Nanomaterials and Fabrication

Paper Code: CHM.517

Total Contact Hours: 30

L	T	P	Cr
2	0	0	2

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

Unit 1 **7 Hours**

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 **7 Hours**

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 **8 Hours**

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 (TiO_2, CeO_2, 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 **8 Hours**

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

Course Title: General Laboratory Practice
Paper Code: CHM.528
Total Contact Hours: 30

L	T	P	Cr
2	0	0	2

Learning objective: To impart the basic and recent developments in good laboratory practices.

Unit 1 **7 Hours**

Good Laboratory Practices: Introduction and WHO guidelines on GLP and GMP. History of GLP. Quality assurance in GLP. Quality control laboratory, responsibilities, routine controls, instruments reagents, sampling plans.

Unit 2 **8 Hours**

Quality Standards and Quality Assurances: Advantages and disadvantages of quality standards, concepts of quality control, quality assurance its functions and advantages.

Standard test procedures, protocols, non-clinical testing, controls on animal house, data generation and storage, quality control documentation, retention samples, records. Complaints and recalls, evaluation of complaints, recall procedures, related records and documents.

Unit 3 **8 Hours**

Safety and Hazard Analysis: Chemical classification of hazards, Radiation hazard, AERB regulation for Fire and its prevention, biosafety and biohazard. Weapons of Mass destruction

Unit 4 **7 Hours**

Basic Analytical practices: Titrimetry, Gravimetric analysis, Potentiometry and Spectrophotometric analysis. Pesticides and pesticide residue extraction, Solid phase extraction etc. Trace metal sample preparations and analysis. Proteomic and metabolomic sample preparations

Course Outcome: The students will acquire knowledge of

1. Good laboratory practices
2. Quality control and Quality assurance
3. Chemical, biological and radiational hazards in laboratory and safety.
4. General know how of analytical sample preparation.

SUGGESTED READINGS

IQAC

1. Miller, J. C. Miller, J. N. (1998) *Statistics for Analytical Chemistry*. Wiley.
2. http://www.who.int/water_sanitation_health/resourcesquality/wqmchap9.pdf
3. https://www.unece.org/fileadmin/DAM/env/water/publications/documents/guidancela boratories.pdf.

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