Course Structure and Syllabus

M.Sc. Applied Chemistry

(SEMESTER: I - IV)

Session: 2017-18

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

Centre for Chemical Sciences
M.Sc. Applied Chemistry

SEMESTER 1

S. No.	Paper Code	Course Title	Course Type	L	T	P	Cr
1	ACL.501	Fundamental Biology (Non-medical group)	FC	2	-	-	2
	ACL502	Fundamental Mathematics (Medical group)					
2	ACL.503	Analytical Chemistry and Instrumental Methods	CC	3	-	-	3
3	ACL.504	Inorganic Chemistry-1	CC	3	-	-	3
4	ACL.506	Organic Chemistry-I	CC	3	-	-	3
5	ACL.508	Physical Chemistry-I	CC	3	-	-	3
6	ACL.509	Quantum Chemistry	EC	4	-	-	4
7	ACP.505	Applied Practical Inorganic Chemistry-1	CC	-	-	4	2
8	ACP.507	Applied Practical Organic Chemistry-I	CC	-	-	4	2
9	XXX	Inter-Disciplinary Course (ID) (Opt any one from other Departments)	EC	2	-	-	2
		Total		**20**	**0**	**8**	**24**

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

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

SEMESTER 2

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

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

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

SEMESTER 3

S. No.	Paper Code	Course Title	Course Type	L	T	P	Cr
1	ACL.601	Inorganic Chemistry-III	CC	3	-	-	3
2	ACL.602	Organic Chemistry-III	CC	3	-	-	3
3	ACL.603	Quality Control in Analytical laboratory	EC	2	-	-	2
4	ACL.604	Pharmaceutical Products	EC	3	-	-	3
5	ACL.605	Industrial Inorganic Chemistry	CC	3	-		3
6.	ACL.606	Material Chemistry	CC	4	-	-	4
7.	ACP.607	Applied Chemistry Practical –I	CC	-	-	4	2
8.	ACP.608	Applied Chemistry Practical –II	CC	-	-	4	2
9.	ACL.609	Applied Electrochemistry	EC	2	-	-	2
	ACL 610	Aerosol Chemistry and Air Pollution Control					
	ACL.611	Chemo and Biosensor					
	ACL.612	Food Chemistry					
	Total			**20**	**0**	**6**	**24**

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

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

Examination Pattern A: Continuous Assessment

Based on Objective Type Tests (10 Marks)

Term paper (10 Marks)

Assignment(s) (5 Marks)

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

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

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

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

Examination Pattern D: End-Term Exam (Final)

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

SEMESTER 4

S. No.	Paper Code	Course Title	Course Type	L	T	P	Cr
1	ACL.621	Polymer Chemistry	CC	4	1	-	4
Opt any one of the following courses:							
2	ACL.622	Green and Industrial Organic Chemistry	EC	4	1	-	4
	ACL.623	Fuel and Energy					
	ACL.624	Environmental Chemistry					
3	ACD.600	Project	EC	-	-	-	16
		Total		**8**			**24**

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

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

Course Title: Fundamental Biology (Non-medical group)
Paper Code: ACL.501
Total Lectures: 36

L	T	P	Credits
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 **9 Hrs**

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

Unit 2 **9 Hrs**

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

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

Unit 3 **9 Hrs**

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

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

Unit 4 **9 Hrs**

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

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

Course Outcome:

After this course completion, the students will acquire knowledge of

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

SUGGESTED READINGS

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

Course Title: Fundamental Mathematics (Medical group)
Paper Code: ACL.502
Total Lectures: 36

L	T	P	Credits
2	0	0	2

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

Unit 1 **9 Hrs**

Trigonometry and Algebra

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

Unit 2 **9 Hrs**

Differential Calculus and Matrix Algebra

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

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

Unit 3 **9 Hrs**

Integral Calculus

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

Unit 4 **9 Hrs**

Elementary Differential Equations

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

Course Outcome:

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

SUGGESTED READINGS

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

Course Title: Analytical Chemistry and Instrumental Methods
Paper Code:ACL.503
Total Lectures: 54

L	T	P	Credits
3	0	0	3

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

Unit 1 **10 Hrs**

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

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

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

Unit 2 **8 Hrs**

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

Unit 3 **18 Hrs**

Potentiometry – General principles, calomel electrodes, Ag/AgCl electrodes, membrane electrodes – ion selective electrodes, glass electrodes, liquid membrane electrodes, Clark's electrode, biosensors.
Amperometry/Coulometry: Basic principles, constant current and constant potential coulometry. coulometric titrations.
Voltammetry: Principles, voltammograms, equation of voltammogram, different waveforms–linear scan, square scan and triangular scan, cyclic voltammetry.

Unit 4 **18 Hrs**

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

Course Outcome: The students will acquire knowledge of

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

SUGGESTED READINGS

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

Course Title: Inorganic Chemistry - I
Paper Code: ACL.504
Total Contact Hrs: 54

L	T	P	Credits
3	0	0	3

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

Unit 1 **10 Hrs**

Metal-Ligand Equilibria in Solution

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

Unit 2 **15 Hrs**

Reaction Mechanisms of Transition Metal Complexes

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

Unit 3 **15 Hrs**

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

Unit 4 **14 Hrs**

Crystal Fields Splitting

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

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

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

SUGGESTED READINGS

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

Course Title: Organic Chemistry-I
Paper Code: ACL.506
Total Lectures: 54

L	T	P	Credits
3	0	0	3

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

Unit 1 **16 Hrs**

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

Unit 2 **14 Hrs**

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

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

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

Unit 3 **12 Hrs**

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

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

Unit 4 **12 Hrs**

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

Course Outcome: Students will acquire the knowledge of

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

SUGGESTED READINGS

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

Course Title: Physical Chemistry-I
Paper Code: ACL.508
Total Lectures: 54

L	T	P	Credits
3	0	0	3

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

Unit 1 **10 Hrs**

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

Unit 2 **10 Hrs**

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

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

Unit 3 **12 Hrs**

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

Unit 4 **24 Hrs**

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

Course Outcome: The students will acquire knowledge of

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

SUGGESTED READINGS

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

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

Course Title: Quantum Chemistry
Paper Code: ACL.509
Total Lectures: 72

L	T	P	Credits
4	0	0	4

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

Unit 1 **18 Hrs**

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

Unit 2 **18 Hrs**

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

Unit 3 **18 Hrs**

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

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

Unit 4 **18 Hrs**

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

Course Outcome: The students will acquire knowledge of

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

SUGGESTED READINGS

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

Course Title: Applied Practical Inorganic Chemistry-I
Paper Code: ACP.505
Contact Hrs: 72

L	T	P	Credits
0	0	4	2

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

Experiments:

Introduction to good laboratory practices in chemistry.

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

Complexometric Titrations
1. Determination of Water Hardness using complexometric titrations.
2. Determination of aluminium and Magnesium ions using EDTA titration
3. Complexometric Titration of Zn(II) with EDTA

Precipitation Titrations
1. $AgNO_3$ standardization by Mohr's method.
2. Volhard's method for Cl^- determination.

Oxidation-Reduction Titrations
1. Standardization of $KMnO_4$with sodium oxalate and determination of Ca^{2+} ion.
2. Standardization of ceric sulphate with Mohr's salt and determination of Cu^{2+}, NO_2 and $C_2O_4^{-2}$ ions.
3. Standardization of $K_2Cr_2O_7$ with Fe^{2+} and determination of Fe^{3+} (Ferric alum)
4. 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+}.
5. Determination of hydrazine with KIO_3 titration.

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

Flame photometric determination: Li, Na, Kand Ca.

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

Course outcome: The students will acquire knowledge of

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

SUGGESTED READINGS

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

Course Title: Applied Practical Organic Chemistry-I
Paper Code: ACP.507
Total Contact Hrs: 72

L	T	P	Credits
0	0	4	2

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

Experiments

Safety and Handling of hazardous chemicals:

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

A. Techniques:

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

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

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

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

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

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

Course Outcome: The students will acquire knowledge of

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

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

SUGGESTED READINGS

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

SEMESTER 2

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

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

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

Course Title: Inorganic Chemistry-II
Paper Code: ACL.521
Total Contact Hrs: 54

L	T	P	Credits
3	0	0	3

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

Unit 1 **12 Hrs**

Symmetry

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

Unit2 **12 Hrs**

Group theory

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

Unit3 **14 Hrs**

Metal Complexes

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

Unit4 **16 Hrs**

Inorganic chains, rings and cages

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

Course Outcome: The students will acquire knowledge of

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

SUGGESTED READINGS

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

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

Course Title: Organic Chemistry-II
Paper Code: ACL.523
Total Lectures: 54

L	T	P	Credits
3	0	0	3

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

Unit 1 **12 Hrs**

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

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

Unit 2 **12 Hrs**

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

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

Unit 3 **18 Hrs**

Pericyclic chemistry:

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

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

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

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

Unit 4 **14 Hrs**

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

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

Course Outcome: The students will acquire knowledge of

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

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

SUGGESTED READINGS

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

Course Title: Physical Chemistry-II
Paper Code: ACL.524
Total Lectures: 54

L	T	P	Credits
3	0	0	3

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

Unit 1 **14 Hrs**

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

Unit 2 **14 Hrs**

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

Unit 3 **14 Hrs**

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

Unit 4 **14 Hrs**

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

Course Outcome: The students will acquire knowledge of

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

SUGGESTED READINGS

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

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

Course Title: Spectral Analysis
Paper Code: ACL.526
Total Lectures: 54

L	T	P	Credits
3	0	0	3

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

Unit 1 **14 Hrs**

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

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

Unit 2 **14 Hrs**

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

Unit 3 **13 Hrs**

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

Unit 4 **13 Hrs**

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

Course Outcome: The students will be able to

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

SUGGESTED READINGS

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

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

Course Title: Molecular Spectroscopy
Paper Code: ACL.527
Total Lectures: 72

L	T	P	Credits
4	0	0	4

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

Unit 1 **18 Hrs**

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

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

Unit 2 **18 Hrs**

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

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

Unit 3 **18 Hrs**

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

Unit 4 **18Hrs**

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

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

Course Outcome: The students will acquire knowledge of

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

SUGGESTED READINGS

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

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

Course Title: Applied Practical Inorganic Chemistry -II
Paper Code: ACP.522
Total Lectures: 72

L	T	P	Credits
0	0	4	2

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

1. Preparation of Chloropentaammine cobalt (III) Chloride and its IR measurements.
2. Preparation of $[Co(en)_2Cl_2]$ Cl, Na_2 $[Fe(CN)_5$ $NH_3]$. H_2O, $[UO_2$ $(NO_3)_2$ $Py_2]$, Cu_2 $(CH3COO)_4$ $(H_2O)_2$.
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

Course Outcome: The students will acquire knowledge of

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

SUGGESTED READINGS

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

Course Title: Applied Practical Physical Chemistry-II
Paper Code: ACL.525
Total Contact Hrs:72

L	T	P	Credits
0	0	4	2

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

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

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

SUGGESTED READINGS

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

Course Title: Seminar
Paper Code: ACS.599
Total Contact Hrs: 36

L	T	P	Credits
0	2	0	2

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

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

Course Outcome: The student would be able to

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

SEMESTER 3

S. No.	Paper Code	Course Title	Course Type	L	T	P	Cr
1	ACL.601	Inorganic Chemistry-III	CC	3	-	-	3
2	ACL.602	Organic Chemistry-III	CC	3	-	-	3
3	ACL.603	Quality Control in Analytical laboratory	CC	2	-	-	2
4	ACL.604	Pharmaceutical Products	CC	3	-	-	3
5	ACL.605	Industrial Inorganic Chemistry	CC	3	-		3
6.	ACL.606	Material Chemistry	CC	4	-	-	4
7.	ACP.607	Applied Practical Chemistry-I	CC	-	-	3	2
8.	ACP.608	Applied Practical Chemistry-II	CC	-	-	3	2
9.	ACL.609	Applied Electrochemistry	EC	2	-	-	2
	ACl 610	Aerosol Chemistry and Air Pollution Control					
	ACL.611	Chemo and Biosensor					
	ACL.612	Food Chemistry					
	Total			**20**	**0**	**6**	**24**

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

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

Examination Pattern A: Continuous Assessment

Based on Objective Type Tests (10 Marks)

Term paper (10 Marks)

Assignment(s) (5 Marks)

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

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

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

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

Examination Pattern D: End-Term Exam (Final)

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

Course Title: Inorganic Chemistry-III
Paper Code: ACL.601
Total Lectures: 54

L	T	P	Credits
3	0	0	3

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

Unit 1 **20 Hrs**

Lanthanides, actinides and super-heavy elements

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

Unit 2 **10 Hrs**

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

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

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

Unit 3 **12 Hrs**

Mossbauer Spectroscopy

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

Unit 4 **12 Hrs**

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

Metal Ions in Biological Systems: Metal complexes for therapeutic uses (cisplatin, carboplatin, non platinum metal complexes). The Fenton reaction, free radical chemistry and metal poisoning.

Course Outcome: The students will acquire knowledge of

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

SUGGESTED READINGS

1. Drago, Russell S. Physical Methods for Chemists, 2nd edition, 1992, Saunders College Publishing.
2. Ebsworth, E.A.V., Rankin, D.W.H. and Cracock, S. Structural Methods in Inorganic Chemistry, 1st edition, 1987, ELBS.
3. Cotton, F.A. and Lippard, S.J. Progress in Inorganic Chemistry, Vol. 8, Vol. 15, Wiley Internationals.
4. Lever, A.B.P. Inorganic Electronic Spectroscopy, 2nd edition, 1984, Elsevier Science Publishers B.V.

5. Parish, R.V. NMR, NQR, EPR and Mossbauer Spectroscopy in Inorganic Chemistry, 1st edition, 1990, Ellis Harwood.
6. Silverstein, R.M. Bassler, G.C. and Morrill, T.C. Spectrometric Identification of Organic Compounds, 6th edition, 2002, John Wiley.
7. Abraham, R.J., Fisher, J. and Loftus, P. Introduction to NMR Spectroscopy, Wiley.
8. Dyer, J.R. Application of Spectroscopy of Organic Compounds, Prentice Hall..
9. Carlin, R.I. Transition Metal Chemistry, Vol. 3, Marcell Dekker Publication
10. Martin, M.L., Delpeuch, J.J. and Martin, G.J. Practical NMR Spectroscopy, Heyden.
11. Williams, D.H. and Fleming, I. Spectroscopic Methods in Organic Chemistry, Tata McGraw-Hill.
12. Greenwood, N. N. and Earnshaw, A. Chemistry of the Elements, 1984.

Course Title: Organic Chemistry-III
Paper Code: ACL.602
Total Lectures: 54

L	T	P	Credits
3	0	0	3

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

Unit 1 **12 Hrs**

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

Unit 2 **14 Hrs**

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

Unit 3 **14 Hrs**

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

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

Unit 4 **14 Hrs**

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

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

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

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

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

Course Outcome: The students will acquire knowledge of:

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

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

SUGGESTED READINGS

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

Course Title: Quality Control in Analytical Laboratory
Code: ACL.603
Total Lectures: 36

L	T	P	Credits
2	0	0	2

Learning objective: To acquire knowledge of the quality requirements of analytical testing laboratories

Unit I **9 Hrs**

Concept of Total Quality Management, philosophy of GMP's and GLPS, ISO 9000 and ISO 14798 (NABL Accreditation). Organization and personnel, responsibilities, training, hygiene, personnel records. Premises: location, design, plan layout, construction, maintenance of sterile areas, control of contamination. Equipment, selection purchase specifications, preventive maintenance of equipment, cleaning of equipment. Raw materials: purchase specifications stores selection of vendors, control on raw materials. Warehousing, good warehousing practices, materials management.

Unit II **9 Hrs**

Statistical. Method of Least squares and weighted least squares formalism. Use of certified reference materials and procedures for interlaboratory comparisons. Definition of limits of detection and sensitivity, and concept of standard addition to assess matrix effects. Uncertainity Calculations.

Unit III **9 Hrs**

Quality control laboratory, responsibilities, good laboratory practice, routine controls, instruments reagents, sampling plans, 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 IV **9 Hrs**

Regulatory aspects of pharmaceutical and bulk drug manufacture. DRA, FDA, CPMP, ICH guidelines. Regulatory Aspects of Environmental and Food Testing USEPA, MoEF, MoFPI, AOAC guidelines. Validation: Qualification (IQ/PQ/OQ), validation and calibration of equipment's, Evaluation of Analytical data. Drug approval process, patent application and WHO certification.

Course Outcome: The students will acquire knowledge of:

1. Good laboratory practices
2. The statistical evaluations of the analytical results and their implication in regulatory approvals
3. Quality control approaches in various analytical laboratories

SUGGESTED READINGS

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

Course Tile: Pharmaceutical Products
Paper Code: ACL.604
Credits Hrs: 54

L	T	P	Credits
3	0	0	3

Learning objective: To acquire knowledge of pharmaceutics products and their importance.

Unit 1 **18 Hrs**

Herbal Products:

General Properties, Chemistry, Phytoconstituents & bioactive constituents and medicinal importance

Alkaloids Containing Herbal Drugs: *Papaver somniferium* (morphine), *Rauvolfia serpentina* (reserprine), *Atropa belladona* (atropine), *Ephedra gerardiana* (ephedrine)

Terpenes Containing Herbal Drugs: Lemon grass oil (citral and geraneol), *Artemesia annua* (artemisinin) and Taxus baccata

Phenolics containing Herbal Drugs: *Vitis vinifera* (reservertrol), *Pterocarpus marsupium* (Pterostilbene) Various Berry fruits (strawberry, cherry, raspberry etc.) including jamun (*Eugenia jambolana*), garlic & onion (quercitin)

Unit 2 **18 Hrs**

Oil and fat products:

Edible Oils and Fats: General study of the quality assessment, hydrogenation of oils, rancidity, iodine value, acid value, saponification value, Reichert-Meissel value, Polenski value and Kirschner value, adulteration of oils and fats, modifications to produce specialty fats (structured fats, nutraceuticals). Essential fatty acids: ω-3 and ω-6 fatty acids.

Soap and Detergent: preparation, different types of soap and their composition, surfactants (LAS, ABS, LABS), detergent binders and builders.

Metathesis and co metathesis reactions of fats and oils and their application in oleo chemical industry. hydroformylation reaction, cracking of fatty acids and fatty acid esters.

Unit 3 **18 Hrs**

Chemistry of Cosmetics and Perfumes

Cosmetic necessities: Acids, bases, buffers, topical agents. protective and antimicrobials, Astringents; Chemistry of emulsions in cosmetic formulation; safety issues of cosmetics. Storage and preparation of herbal drugs for commercial market. Essential oils and their importance in cosmetic industries with reference to eugenol, geraniol, sandalwood oil, eucalyptus, rose oil, jasmone, civetone, muscone.

Antiperspirants, artificial and natural flavors, colors and preservatives, artificial sweeteners.

Course Outcome: The students will acquire knowledge of:

1. Chemistry of personal care products
2. Various colloidal organic and their industrial usage
3. Natural products and their importance

SUGGESTED READINGS:

1. Gunstone: The Chemistry of oils and fats, Blackwell Publishing Ltd, UK (2004)

2. Stocchi: Industrial Chemistry, Vol -I, Ellis Horwood Ltd. UK.
3. Atta-ur-Rahman; Studies in Natural Products Chemistry, Vol-33 (Bioactive Natural Products), Elsveir (2006)
4. P.C. Jain, M. Jain: Engineering Chemistry, Dhanpat Rai & Sons, Delhi.
5. B.K. Sharma: Industrial Chemistry, Goel Publishing House, Meerut.
6. G.L. Patrick: Introduction to Medicinal Chemistry, Oxford University Press, UK.
7. Hakishan, V.K. Kapoor: Medicinal and Pharmaceutical Chemistry, Vallabh Prakashan, Pitampura, New Delhi.
8. R. Cremlyn: Pesticides, John Wiley.
9. William O. Foye, Thomas L., Lemke, David A. William: Principles of Medicinal Chemistry, B.I. Waverly Pvt Ltd. New Delhi.
10. W.A. Poucher, Perfumes, Cosmetics and Soaps (The Raw Material of Perfumery), Chapman and Hall, London

L	T	P	Credits
3	0	0	3

Course Title: Industrial Inorganic Chemistry
Paper Code: ACL.605
Total Lectures: 54

Learning objective: To acquire knowledge of various inorganic aspects as applied to various industries including electronics, fertilizers, metal, Glass and cermaics

Unit-I. 17 Hrs

Special Materials for Electronic Industry. Recent trends in sensor technology, film sensors, Semiconductor IC technology, micro-electro mechanical systems (MEMS), nanosensors. Applications of Sensors: automobile sensors, home appliance sensor, aerospace sensors, sensors for manufacturing medical diagnostic sensors, sensors for environmental monitoring. High purity silicon, germanium, gallium arsenide (GaAs), indium phosphide (InP) etc. Preparation using zone refining, crystal growth and there use in electronic industry. High temperature materials, SiC, chromite, alumina, zirconia, magnesite etc. Ionic & superionic conductors, β alumina oxide ion conductors, halide conductors superionic, fastion conductors- $RbAg_4I_5$.

Unit-II. 13 Hrs

Fertilizer Industries. General principles of plant nutrition: essential plant nutrients, functions of the essential elements, classification of commercial nitrogenous fertilizers. Manufacturing of ammonium sulphate, urea, ammonium nitrate, commercial phosphatic fertilizers. Manufacturing process and properties of phosphatic fertilizers, single super phosphate, triple super phosphate. Commercial potassic fertilizers: chemicals of potassium compounds, classification, manufacturing process and properties of potasium fertilizer, potassium sulphate, mixed fertilizer. Micronutrients: role and deficiency symptom of micronutrients. Biofertilizers: classification, demands and production, present status of fertilizer industries in India.

Unit-1II. 12 Hrs

Metal Finish Technology. Basics of electrodeposition, electroplating principles and practice, electrochemistry applied to electroplating, electroplating of metals chromium, cadmium, nickel, copper, silver, gold, purpose of metal electroplating composition and condition of plating bath, applications waste treatment and metal recovery.

Unit-1V. 12 Hrs

Glass & Ceramics. Physical and chemical properties of glasses, raw materials, manufacturing of special glasses. Ceramics and their properties, raw materials, manufacturing of ceramics, applications of colours to pottery, use of ceramics. Industrial gases: manufacturing and industrial uses of H_2, O_2, N_2, CO_2, Cl_2 & acetylene gases. Liquefaction of gases, production of low temperature. Chemicals of utility: inorganic fine chemicals, magnesia, alumina, $AlCl_3$, calcium carbonate, sodium silicate, MnO_2, $FeSO_4$, PbO_2 and NaOH.

Course Outcome: The students will acquire knowledge of:

1. Inorganic chemistry of semiconductors and materials for electronics
2. Various fertilizers used, their compositions and their manufacturing processes
3. Electroplating and its characteristics
4. High temperature material like glasses and ceramics

SUGGESTED READINGS

1. H. V. Keer, Principles of Solid state.
2. A. R. West, Solid State Chemistry and its applications, John Wiley & Sons, 2003.
3. B. K. Sharma, Engineering chemistry, Krishna Prakashan Media.
4. Lowenheim F A (1978) Electroplating MC Graw-Hill Book Company.
5. Gable, D: Principal of metal Treatment and protection. Pergaman, Press Oxford (1978)
6. Burke, Progess in ceramic science Vol. IV
7. R.R.Iash: afromulary of paints and other coating Vol. I

8. Industrial chemistry, B. K. Sharma.
9. Engineering chemistry, B. K. Sharma.
10. S. D. Shukla & G N Pandey: A text book of chemical technology Vol. 1
11. F A. Henglein: Chemical Technology (Pergamon)
12. D. Patranabis, Sensors and Transdusers, 2nd Edn, Prentice, Hall of India (2003).
13. RajankumarBasak, Fertilizers, A text Book
14. R. Balsubramaniam, Materials Science and Engineering

Course Title: Material Chemistry
Paper Code: ACL.606
Total Lectures: 72

L	T	P	Credits
4	0	0	4

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

Unit I: **18 Hrs**

Magnetic Materials (Ferrites): Introduction, structure and classification, hard and soft ferrites, synthesis of ferrites by various methods and characterization of ferrites, 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 II: **24 Hrs**

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

Thin Films
Prepartion techniques; evaporation/sputtering, chemical process, sol gel etc. Langmuir – Blodgett (LB) films, growth technique, photolithography, properties and applications of thin films.
Materials for Solid State Devices
Rectifiers, transistors, capacitors IV-V compounds, low–dimensional quantum structure; optical properties.

Unit III: **12 Hrs**

Diffraction Methods: 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.

Ionic conductors: mechanism of ionic conduction, interstitial jumps (Frenkel); vacancy mechanism, diffusion superionic conductors; phase transitions and mechanism of conduction in superionic conductors, examples and applications of ionic conductors.
Molecular Conductor: Oligo (phenylene vinylene)s, oligo(phenylene ethynylene)s, oligo (eneyne)s, oligo(thiophene vinylene), oligo (thiphene ethynylene) etc. and their applications

Unit IV: **18 Hrs**

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

Nonlinear Optical Materials: Nonlinear 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. Solid State Physics, N.W. Ashcrofy and N.D. Mermin, Saunders College.
2. Material Science and Engineering, An Introduction, W.D. Callister, Willey.
3. Principle of the Solid State, H.V. Keer, Willey Eastern.
4. Material Science, J.C. Anderson, K.D. Leaver, J.M. Alexander and R.D. Rawlings, ELBS

Course Title: Applied Electrochemistry
Paper Code: ACL.609
Total Lectures: 36

L	T	P	Credits
2	0	0	2

Learning objective: To acquire knowledge of electrochemical phenomena like corrosion and bioelectrochemistry technique.

Unit I: 9 Hrs

Conversion and storage of electrochemical energy, maximum intrinsic efficiency of an electrochemical converter. Physical interpretation of the Carnot efficiency factor in electrochemical energy converters. Power outputs. Electrochemical generators (fuel cells): hydrogen oxygen cells, hydrogen air cell, hydrocarbon air cell, alkaline fuel cell, applications of fuel cells.

Unit II 9 Hrs

Electrochemical energy storage. Properties of electrochemical energy storage: measure of battery performance, charging and discharging of a battery, storage density, energy density. Classical batteries: (i) Lead Acid (ii) Nickel-Cadmium, (iii) Zinc manganese dioxide. Modern Batteries : (i) Zinc-Air (ii) nickel-metal hydride, (iii) lithium battery, future electricity stores : storage in (i) hydrogen, (ii) alkali metals, (iii) non aqueous solutions.

Unit III 9 Hrs

Corrosion and stability of metals. Civilization and surface mechanism of the corrosion of the metals; thermodynamics and the stability of metals, corrosion current and corrosion potential -Evans diagrams. Measurement of corrosion rate: (i0 Weight loss method, (ii) Electrochemical method. Inhibiting corrosion. Cathodic and anodic protection. (i) Inhibition by addition of substrates to the electrolyte environment, (ii) by charging the corroding method from external source, anodic protection, organic inhibitors, the fuller story green inhibitors. Passivation. Structure of passivation films, mechanism of passivation, spontaneous passivation nature's method for stabilizing surfaces.

Unit IV 9 Hrs

Bioelectrochemistry. Bioelectrodics, membrane potentials, simplistic theory, modern theory, electrical conductance in biological organism: enzymes as electrodes. kinetic of electrode process. Essentials of electrode reaction. Current density, overpotential, Tafel equation, Butler Volmer equation.

Course Outcome: The students will acquire knowledge of

1. Commercial electrochemical cells and their applications
2. Mechanism of Corrosion, it measurement and remediations
3. Analytical approaches involving bioelectrochemistry

SUGGESTED READINGS

1. Modern Electrochemistry Vol. I, IIa, Vol. IIB J'OM Bockris and A.K.N. Reddy, Plenum Publication, New York.
2. Polarographic Techniques by L. Meites, Interscience.
3. "Fuel Cells : Thjeir electrochemistry". McGraw Hill Book Company, New York.
4. Modern Polarographic Methods by A.M. Bond, Marcell Dekker.
5. Polarography and allied techniques by K. Zutshi, New age International Publicatin. New Delhi.
6. "Electroaalytical Chemistry by Basil H. Vessor & Galen W. ; Wiley Interscience.
7. Electroanalytical Chemistry by Basil H. Vessor & alen w. ; Wiley Interscience.
8. Topics in pure and Applied Chemistry, Ed. S. K. Rangrajan, SAEST Publication, Karaikudi (India)

Course Title: Aerosol Chemistry and Air Pollution Control
Paper Code: ACL.610
Total Lectures: 36

L	T	P	Credits
2	0	0	2

Learning objective: To acquire knowledge air pollution monitoring and control techniques

UNIT – I **8 Hr**

Atmospheric Aerosols: Size distribution, lognormal number, surface area, volume and mass distribution, dynamics, thermodynamics of aerosol and nucleation phenomenon.

Laws, Rules and Convention: The Air (Prevention and Control of Pollution) Act – 1981 and its Amendments, Geneva Convention on long range transport of atmospheric pollutants.

UNIT-II **10 Hrs**

Ambient air sampling using impactor, cyclone, dichotomous and impingement devices, filter media selection. adsorption and adsorption based sampling, Indoor environment monitoring.

Industrial Monitoring: Flow velocity and temperature monitoring, isokinetic sampling and compositional analysis, flue gas analyzer principles for monitoring COx, NOx, SOx, hydrocarbon.

Air dispersion and Modelling: Plume behaviour and principles of air pollutants dispersion (Gaussian dispersion model) Plume rise estimation, Effluent dispersion theories and Atmospheric and Indoor chemical modeling.

Unit III **12 Hrs**

Particulates – Designs and control of filters, gravitational, centrifugal-multiple type cyclones, scrubbers and electrostatic precipitators: equipment descriptions prediction of collection efficiency and pressure drop. adsorbents, PSA, adsorption cycle, rotary bed/fluidized bed, condensation - contact condensers, shell and tube condenser, flaring.

UNIT-IV **6 Hrs**

Gaseous Pollutants - absorption: packed and plate columns. low NO_x burner, Wellman-Lord process, fuel desulphurization and denitrogenation.

Vehicular Pollution Control: Combustion cycle, fuel/air ratio and catalytic convertor; selective catalytic and selective non-catalytic reduction.

Course Outcome: The students will acquire knowledge of:

1. Various processes involved in aerosol formation and transport
2. Air pollution monitoring techniques
3. Particulate matter and volatile matter control in industries
4. The vehicular pollution technologies and the recent trends in catalyst for vehicular pollution control.

SUGGESTED READINGS

1. Jeremy, C., Tiwary, A. and Colls, J. (2009). Air pollution: measurement, modeling andmitigation, 3rd Edition, Crc Press, USA.
2. Clarke A. G. (1997). Industrial air pollution monitoring: gaseous and particulateemissions, Springer, USA.

3. Kenneth Jr., W., Davis, W. T., Warner C. F. (1998). Air pollution and its origin and control,3rd edition, Prentice Hall, USA.
4. Cheremisinoff N. P. (2002). Handbook of air pollution prevention and control,Butterworth-heinemann Publishers, UK.
5. Rao, C.S. (2006). Environmental pollution control engineering, New Age InternationalPublishers, New Delhi.
6. Vallero, D. A. (2007). Fundamentals of air pollution 4th edition, Academic Press, USA
7. Wang, L. K. Wang, L. K. Pereira N. C. (2004). Advanced air and noise pollution control.

Course Title: Chemo and Biosensors
Paper Code: ACL.611
Total Lectures: 36

L	T	P	Credits
2	0	0	2

Learning objective: To acquire knowledge of chemo-/bio-sensors and their fabrications

UNIT – I 12 Hrs

Introduction, Fundamentals of chemical sensors, selectivity and role of flow injection in chemical sensing. cation and anion recognition events, ion pair receptors, inclusion phenomenon, self-assembly. molecular approaches for designing of molecular-guest recognition event. Host-guest chemistry, receptor theory, supramolecular forces, binding constant, chelate effect, co-operativity, preorganization, complimentarity, Themodynamic and kinetic aspects of supramolecular interactions.

UNIT-II 12 Hrs

Chemical sensors based on mode of transduction; mass sensors, optical sensors, nanoparticles and sensors, electrochemical sensors and thermal sensors. chemical sensors based on chemically sensitive layer; semi-conductor gas sensors, solid electrolyte gas sensors, ion-selective electrode sensors, humidity sensors, FET sensors and bio-sensors, sensors arrays and micro total analysis system. molecular imprinting polymer (MIP) sensors

UNIT – III 12 Hrs

Biosensors: Basics & applications, relevant biology, enzymes and kinetics, design considerations. optical spectroscopy for biosensing, optical glucose sensing, optical biosensors, spr and luminiscence, luciferase biosensors. electrochemical biosensors: potentiometric biosensors, amperometric biosensors. calorimetric biosensors. affinity biosensors: antibodies and immunosensors, DNA sensors, aptamer sensors, SPR based sensor.

Course Outcome: The students will acquire knowledge of:

1. The principles behind the design of sensors
2. The various physical methods of sensor reporting
3. Various commercial sensors and their limitations

SUGGESTED READINGS

1. Encyclopedia of Sensors, American Scientific Publisher.
2. Enzyme and Microbial Biosensors: Techniques and Protocols. Humana Press, Totowa, NJ.
3. Optical Biosensors: Present & Future by Frances S. Ligler (Editor), Chris A. Taitt.
4. Biosensors: Fundamentals and Applications by Anthony P.F. Turner, Isao karube, George S. Wilson.
5. Peter Gruindle, Chemical Sensors, In Introduction for Scientists and Engineers, Springer Verlag, 2007,
6. D A Skoog, F J Holler and T A Nieman, Principles of Instrumental Analysis. ,
7. J. Janata, Principles of Chemical Sensors, Springer; 1st edition 1989. 4. R W Cattrall, Chemical Sensors, Oxford University Press, 1999.
8. Enzyme and Microbial Biosensors: Techniques and Protocols. Humana Press, Totowa.

Course Title: Food Chemistry
Paper Code: ACL-612
Total Lectures: 36
Learning objective: To acquire knowledge of current trends in food processing technology based industries

L	T	P	Credits
2	0	0	2

Unit-I. 15 Hrs

Food Science & Technology: Definition and scope, status of food industry in India, nutritive aspects of food constituents, quality factors and their measurements, food deterioration factors and their control; Food industry heat preservation and processing, cold preservations and processing, cold storage, various water in food, food dehydration and concentration, various foods, their processing and preservation method, vegetables and fruits, beverages, cereals, grains, begums and oil seeds.

Unit-II. 10 Hrs

Food Biotechnology: Industrial uses of bacteria, yeasts and molds, lactic acid fermentation, vinegar production, alcoholic fermentation, Baker's yeast, food yeast, microbial leaching and its chemistry, microbial transformations, bioconversion reactions and their application in food industry.

Unit-1II. 6 Hrs

Food Additives: Introduction, enhancers, sugar substitutes, sweetners, food colours, antioxidants, acids and bases used in food industries, food chelating agents, emulsifiers, thickening agents, gel builders, stabilizers, humectants, and anti-caking agents, common food toxicants, industrial synthesis of food grade food additives: sorbitol, sorbic acid, alginic acid, ascorbic acid, gelatin, sodium / calcium propionate, sodium / calcium alginate, sodium / potassium metabisulphite, agar agar, butylated hydroxy toluene (BHT), butylated hydroxy anisole (BHA), caramel.

Unit-1V. 5 Hrs

Nutraceuticals: Manufacturing aspects of some selected nutraceuticals: lycopene, isoflavonoids, prebiotics probiotics, glucosamine, phytosterols, etc.; formulation of functional foods containing nutraceuticals, stability and analytical issues, labelling issues.

Dairy Products:: Introduction to milk and milk products, types, chemical composition, processing, analysis. Manufacture of cream, butter, ghee, khoa, condensed milk, casein, milk powder, infant milk food, malted milk powder, fermented milk products, cheese, ice-cream; quality aspects of dairy products; equipments used for manufacture of each product.

Course Outcome: The students will acquire knowledge of:

1. Various industrial food processing technologies and associated chemical processes
2. Association of biotechnology and its relevance to food processing
3. Different additives permitted and used in food processing industries and their physicochemical properties.

SUGGESTED READINGS

1. Encyclopedia of Food Science & Technology & Nutrition. Vol. Macrae R. et al. Academic Press.
2. Handbook of Analysis and Quality Control for Fruit and Vegetable Products. 2nd Ed. By Ranganna, S. Tata-McGraw-Hill.
3. Principles of Food Science: Part-II Physical Principles of food Preservation edited by Fennema O.R. Marcel Dekker, New York.

4. Milk and Dairy Product Technology by Edgar Spreer, CRC Press
5. Modern Technology of Milk Processing & Dairy Products (4th Edition) by NIIR Board
6. Technology of Dairy Products by Ralph Early, Springer
7. Handbook of Functional Dairy Products 1st Edition by Colette Shortt, Taylor & Francis
8. Analytical Methods for Food and Dairy Powders by by Anne Dolivet, Pierre Schuck, RomainJeantet, John Wiley & Sons

Course Title: Applied Chemistry Practical-I
Paper Code: ACP.607
Total Contact Hrs: 72

L	T	P	Credits
0	0	4	2

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

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.

1. **Synthesis**: Separation and purification of organic compounds by column chromatography, percentage yield calculation (Any six)
    1. **Preparation of dyes:** Preparation of Azo dyes, Fluoroscein, Malachite green, Crystal violet etc and their TLC and melting point)
    2. **Estimation of Oils and Fats:** Saponification and ester value of the given oil or fat samples, Iodine value and acid value of given oil or fat samples.
    3. **Extraction of essential oil:** To extract the essential oils from some common plant parts.
    4. To study the saponification reaction for preparation of soap.
    5. **Synthesis of aromatics and perfumery compounds:** (Camphor, Methl cinnamate, Methyl anthranilate. Benzyl acetate. Amyl benzoate, Coumarin)
    6. Green Synthesis of some antipyretic drug molecules (paracetamol, asprin etc).
    7. To study the conversion of carbohydrates (e.g. glucose, fructose etc.) into biofuel hydroxymethylfurfural (HMF).
    8. To study Buchwald-Hartwig reaction of aryl halide with an amine using Cu-based catalyst.
    9. To study decarboxylation of Ferulic acid under microwave irradiation.
    10. To study dehydration of benzylic alcohols using imidazolium based ionic liquid.
    11. Preparation of allylic alcohols *via* Baylis-Hillman reaction using DABCO as a catalyst under neat condition and their characterization through various spectroscopic techniques.
    12. Synthesis of stilbenes *via* Heck coupling Strategy.
    13. Synthesis of triazole *via* reaction of phenylacetylne with azide in water (Huisgen cycloaddition).

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

Expected Course Outcome: The students will acquire knowledge of

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

ESSENTIAL BOOKS:

1. Harwood, L.M., Moody, C.J. *Experimental Organic Chemistry*, 1st edition, Blackwell Scientific Publishers, 1989.
2. Vogel, A.I. *Text Book of Practical Organic Chemistry*, ELBS, IVth edition, Longman Group Ltd.,1978.

3. Mann, F.G.; Saunders, B.C. *Practical Organic Chemistry*, 4th edition, New Impression, Orient Longman Pvt. Ltd., 1975.
4. Tewari, K.S.; Vishnoi, N.K.; Mehrotra, S.N. *A Textbook of Organic Chemistry*, 2nd edition, Vikas Publishing House, 1976.
5. Leonard, J.; Lygo, B. *Advanced Practical Organic Chemistry*, Chapman and Hall, 1995.
6. E. Guenther, The Essential Oils-Vol.1, Jepson Press, 2007.
7. G. Reineccius, Flavour Chemistry and Technology, 2nd Edn., 2005

Course Title: Applied Chemistry Practical-II
Paper Code: ACP.608
Total Contact Hrs: 72

L	T	P	Credits
0	0	4	2

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

1. Analysis of mixtures containing two common and two less common cations.
   Ions of the common metals: Pb, Cu, Mn, Cr, Al, Ni, Co, Ba, Sr, Ca, Mg
   Ions of less common metals: W, Se, Te, Pd, Mo, Ce, Th, Zr, Ti, V, U, Li.
2. Colorimetric estimation of Fe, Cu, Ni, Mn, Cr, NH_4^+, nitrate and phosphate ions.
3. Preparation of any four coordination complexes, purity, magnetism and their characterization by different spectroscopic techniques
   1. Tetraamminecopper(II) Sulphate
   2. Hexaaminechromium(III) Nitrate
   3. Hexaureachromium(III) Chloride
   4. Tris(ethylendiamine)nickel(II) Chloride
   5. Tris(ethylenediamine)chromium(III) Chloride
   6. Potassium tris(oxalato)ferrate(III)
   7. Potassium tris(oxalato)chromate(III)
   8. Potassium tris(oxalato)cuprate(II)
   9. Potassium hexathiocyanatochromate(III)
   10. Potassium tetrathiocyanatodiamminechromate(III)
   11. Hexathiourealead(II) nitrate
   12. Tris (thiourea)copper(I) complex
   13. Potassium tris (oxalate) aluminate
   14. Hexammine cobalt (III) chloride.
   15. Schiff base complexes of various divalent metal ions.
4. **Spectrophotometry**: Determination of stability constant of Fe(III)-salicyclic acid complex
5. **Chemical Kinetics:**
   1. Determination of order of $S_2O_8^{2-} + I^- \rightarrow SO_4^{2-} + I_2$ reaction
   2. Determination of energy of activation of $S_2O_8^{2-} + I^- \rightarrow SO_4^{2-} + I_2$ reaction
6. Determination of partition coefficient of benzoic acid between organic solvent and water.

7. **Electronics:**
1. Voltage measurement with CRO
2. Measurement of e.m.f. with thermocouple
3. To plot the characteristic curve of a diode

References

1. Inorganic Semi-Micro Qualitative Analysis, V.V. Ramanujam, The National Publishing House, Chennai, 1990.
3. Experimental Inorganic Chemistry, W.G. Palmer, Cambridge University Press, Cambridge, 1965.
4. Pant, D. Inorganic Chemistry Practical.
5. A.I. Vogel, G. Svehla, Vogel's Qualitative Inorganic Analysis, 7th Edn., Longman,1996.
6. A.I. Vogel, A Text Book of Quantitative Inorganic Analysis, Longman,1966.
7. I.M. Koltoff, E.B. Sandell, Text Book of Quantitative Inorganic Analysis, 3rd Edn., Mc Millian, 1968.
8. Khosla, B.D., Garg, V.C., and Gulati A.R., Senior Practical Physical Chemistry, 2007, S. Chand & Sons.
9. Yadav, J.B. Advanced Practical Physical Chemistry, 2008, Krishna Prakasan Media.

SEMESTER 4

S. No.	Paper Code	Course Title	Course Type	L	T	P	Cr
1	ACL.621	Applied Polymer Chemistry	CC	4	-	-	4
Opt any one of the following courses:							
2	ACL.622	Green and Industrial Organic Chemistry	EC	4	-	-	4
	ACL.623	Fuel and Energy					
	ACL.624	Environmental Chemistry					
3	ACD.600	Project	EC	-	-	-	16
		Total		**8**			**24**

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

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

Course Title: Applied Polymer Chemistry
Paper Code: ACL.621
Total Lectures: 72

L	T	P	Credits
4	0	0	4

Learning objective: To acquire knowledge of different techniques of polymerization, characterizations, processing for varied applications of polymers.

UNIT I **20 Hrs**

Polymers synthesis and Characterisation: Repeating units, degree of polymerisation, linear, branched and network polymers. Classification of polymers. Addition, radical, ionic, coordination and condensation polymerisation; their mechanism and examples. Polymerisation conditions and polymer reactions. Polymerisation in homogeneous and heterogeneous systems.

Polymer. Significance of molecular weight of polymer. Polydispersive average molecular weight. number, weight and viscosity average weights. Measurement of molecular weights. End group, viscosity, light scattering, osmotic and ultracentrifugation methods. Chemical and spectroscopic analysis of polymers. X-ray diffraction study. Thermal analysis, tensile strength, fatique, impact. Tear resistance. Hardness and abrasion resistance.

UNIT II **18 Hrs**

Structure and Properties. Configuration of polymer chains. Crystal structure of polymers. Morphology of crystalline polymers. Polymer structure and physical properties; crystalline melting point T_m, melting points of homogeneous series, effect of chain flexibility and other steric factors, entropy and heat of fusion. The glass transition temperature, T_g relationship between T_m and T_g, effects of molecular weight, diluents, chemical structure, chain topology, branching and cross linking. Property requirements and polymer utilization.

UNIT III **16 Hrs**

Polymer Processing. Plastics, elastomers and fibres. Compounding. Processing techniques, calendering, die casting, rotational casting, film casting, injection moulding, blow moulding, extrusion moulding, thermoforming, foaming, reinforcing and fibre spinning.

Phenol-formaldehyde, urea-formaldehyde, melamine-formaldehyde, epoxy resins and curing agents, Polyamides: nylon-6, nylon-6,6, processing of thermoplastics and thermosetting resins for films, fibres, foams, sheets and tubing.

UNIT 1V **18 Hrs**

Properties of Polymers. Properties of polyethylene, polyvinyl chloride, polyamides, polyesters, phenolic resins, epoxy resins and silicone polymers. Functional polymers. Fire retarding polymers, and electrically conducting polymers. Biomedical polymers, contact lens, dental polymers, artificial heart, kidney, skin and blood cells.

Biopolymers: The structure, function, and properties of synthetic (dextran, ficoll) and natural biopolymers (DNA, nucleic acids, nucleotides, proteins), conformation of nucleic acids (DNA, t-RNA, micro-RNA),

molecular architecture for some biological structures such as collagen, tissue, silk, wool, and shell. Introduction to biomedical materials and "drug delivery" formulations.

Course Outcomes: The student will have knowledge of

1. Different mechanisms of polymerization.
2. Number, weight and viscosity average molecular weights with various techniques
3. Processing of thermoplastic and thermosetting polymers.
4. concept of conducting polymers and their applications.

SUGGESTED READINGS

a. Billmeyer, Jr., F.W. Textbook of Polymer Science, Wiley.
b. Gwariker, V.R. Viswanathan N.V. and Sreedhar, J. Polymer Science, Wiley-Eastern.
c. Takemoto, K. Inaki Y. and Ottanbrite R.M. Functional Monomers and Polymers,.
d. Alcock H.R. and Lambe, F.W. Contemporary Polymer Chemistry, Prentice Hall.
e. Cowie, J.M.G. Physics and Chemistry of Polymers, Blackie Academic and Professional.
f. Gowarikar, V. R., Polymer Science, New Age International Pvt. Ltd., New Delhi (1997).
g. Odian, G., Principles of Polymerization, John Wiley & Sons (2001).
h. Peacock, A., and Calhoun, A., Polymer Chemistry-properties and applications, Hanser Publishers,Munich, (2006).
i. Chandra, R., and Adab, A., Rubber and Plastic Waste, CBS Publishers & Distributors, New Delhi, (1994).
j. Bahadur, P., and Sastry, N. V., Principles of Polymerisation, Narosa Publishing House, New Delhi (2002).

Course Title: Green and Industrial Organic Chemistry
Paper Code: ACL.622
Total Lectures: 72

L	T	P	Credits
4	0	0	4

Learning objective: To acquire knowledge of different techniques of polymerization, characterizations, processing for varied applications of polymers.

Unit 1 **18 Hrs**

Green Chemistry: Principles of green chemistry, evaluation of chemical product or process for its effect on human health and environment. Concept of atom economy, tools of green chemistry: use of renewable starting materials, green solvents (ionic liquids, supercritical fluids), multicomponent reactions (MCRs), tandem/domino reactions, microwave assisted organic synthesis (MAOS), solid phase synthesis, aqueous media reactions,

Combinatorial Chemistry: Introduction, chemical peptide and small molecule libraries, applications, assays and screening of combinatorial libraries, introduction to high throughputs screening (HTS).

Unit 2 **20 Hrs**

Applications of Green Chemistry: Green synthesis of ibuprofen and sitagliptin, design and use of co_2-surfactants for precision cleaning in industries, use of hydrogen peroxide for green oxidation technologies, environmentally preferable marine antifoulant, use of molting accelerators to replace more toxic and harmful insecticides, oxidant activators to replace chlorine based delignification process in paper and pulp industry, green chemistry process for polyester regeneration, biodegradable polyaspartate polymers.

Biocatalysis: Enzymatic synthesis of α-amino acids and peptides. Biocatalytic promiscuity of enzymes for C-C bond formation: asymmetric aldol condensations, Michael addition, Knoevenagel condensations, Henry reaction.

Unit 3 **16 Hrs**

Industrial Organic Syntheses: The raw material and basic processes, chemical processes used in industrial organic synthesis, production of methanol, ethanol, ammonia, sulfuric acid, acetaldehyde, acetic acid, isopropyl alcohol, ethylene glycol, glycerine, acetone, phenol, formaldehyde, 1,3-butadinene and styrene.

Dyes: Introduction, azo dyes, anthraquinone dyes, chemistry of disperse dyes with special emphasis on environmental safety, fluorescent dyes, natural dyes: sources and extraction methods, natural dyes for textile applications (woad, madder, purpura, weld, brazilwood, cochineal), dyes as therapeutic agents.

Unit 4 **18 Hrs**

Petrochemicals: Composition of crude petroleum, cracking, synthetic petrol, refining and different types of petroleum products and their applications. reforming, chemical structure of fuel and knocking. octane rating of fuels, cetane rating, diesel engine fuel, kerosene, LPG as a fuel.

Biofuels: Need for the use of renewable energy resources over petroleum based feedstocks, biodiesel fuels, their origin, chemical and physical properties, biomass derived chemical products: biomass conversion (carbohydrates, lignocellulose biomass) into biofuels, hydroxymethylfurfural. bioethanol production.

Course Outcomes: The student will have knowledge of

1. Green chemistry principles and their applications.
2. Organic Chemistry of industrial chemical manufacturing.
3. Organic chemistry as applied to sustainable biorefinery concept

SUGGESTED READINGS:

1. Anastas, P.T. and Warner J. C. Green chemistry, Theory and Practical. Oxford University Press, 1st edition, US, 2000.
2. Anastas, P. and Williamson, T. C. Green Chemistry Frontiers in Benign Chemical Synthesis and Processes, Oxford University Press (1999).
3. Malhotra, S. V. Ionic Liquids in Organic Synthesis, Oxford University Press, US, 2007.
4. Howard, W.L., Introduction to Industrial Chemistry, Wiley-Interscience (1986).
5. Weissermel, K., and Arpe, H.J., Industrial Organic Chemsitry, VCH (1997) 3rd ed.
6. Sheldon, R.A., Arends, I., and Hannefed, U., Green Chemistry and Catalysis, Wiley-VCH Verlag GmbH and Co. (2007).
7. Ahluwalia, V. K. and Kidwai, M., New Trends in Green Chemistry, Anamaya Publishers (2004).
8. Scragg, A.H. Biofuels: production, application and development, CAB International, UK (2009)

Course Title: Fuel and Energy

Paper Code: ACL.623

Total Lectures: 72

L	T	P	Credits
4	0	0	4

Learning objective: To acquire knowledge of different forms of renewable and sustainable sources of energy and the principle of operation..

Unit-I. 20 Hrs

Renewable Energy Sources and Devices. Solar Energy: Principles of conversion of solar radiation into heat, solar collectors, solar energy storage system, solar photovoltaic cell, solar hydrogen energy, solar pumps, heaters, dryers, cookers and refrigerators.

Wind Energy: Basic principle and conversions, site selection, wind mills, application and safety system, environmental aspects, wind energy conversion system.

Unit-II. 20 Hrs

Hydrogen Energy: Hydrogen: Its merit as a fuel; applications hydrogen production methods. - production of hydrogen from fossil fuels, electrolysis, thermal decomposition, photochemical and photo-catalytic methods. Hydrogen storage methods - metal hydrides, metallic alloy hydrides, carbon nano-tubes, sea as source of deuterium

Unit-1II. 18 Hrs

Fuels Energy: Solid Fuels: Origin, classification and analysis of coal; gasification; oxidation; hydrogenation and liquefaction of coal; solid fuel handling and storage

Liquid Fuels: Origin and classification and properties of petroleum, liquid fuels from other sources; storage and handling of liquid fuels.

Gaseous Fuels: Natural gases, methane from coal mines, manufactured gases, producer gas, water gas, refinery gas, LPG; cleaning, purification and handling of gaseous fuels

Nuclear Fuel: Basic principles, elements of nuclear power plant, nuclear reactor and fuels, advantage and disadvantages of nuclear power plants.

Unit-1V. 14 Hrs

Biomass Energy: Type of biogas plants, construction details, applications, thermal gasification of biomass.

Geothermal Energy: Sources, advantage and disadvantages of geothermal energy over other energy forms, application of geothermal energy

Ocean Wave Energy: Principles of ocean thermal energy conversion open cycle OTES (Claude cycle), ocean thermal energy system, advantages and limitation of tidal power generation, wave energy conversion devices**.**

Course Outcomes: The student will have knowledge of

1. The basis for identifying energy and fuel
2. Renewable sources of energy and technologies for tapping the energy from renewable sources.
3. Various forms of energy which could be converted to energy for use of mankind

4. Address the issues related to various energy alternatives.

SUGGESTED READINGS

1. Fuel and Energy by Steven Seidenberg, Gareth Stevens, 1992
2. Fossil Fuels (Energy: Past, Present, and Future) ed. by Robert Curley, Rosen Education Service, 2011
3. Fossil Fuels by Julie Richards, Benchmark Books, 2009
4. Hydrogen Fuel (Energy for the Future and Global Warming) by Andrew Solway, Gareth Stevens Publishing, 2007
5. Energy Autonomy: The Economic, Social & Technological Case for Renewable Energy by Hermann Scheer, Routledge, 2006.
6. Alternative Energy: Political, Economic, and Social Feasibility by Christopher A. Simon, Lanham, Maryland: Rowman & Littlefield, 2006.
7. Fuels, Energy, and the Environment by Ghazi A. Karim, CRC Press, 2012
8. Nuclear Fuel and Energy Policy by S. Basheer Ahmed, Houghton Mifflin Harcourt, 1979
9. Advances in Biodiesel Production: Processes and Technologies, Edited by R Luque and J A Melero, Woodhead Publishing, 2012.
10. Biomass Gasification and Pyrolysis: Practical Design and Theory by By Prabir Basu, Academic Press
11. Biomass for Renewable Energy, Fuels, and Chemicals by Donald L. Klass, Academic Press, 1998.
12. Coal Science, By J.A. Pajares and J.M.D. Tascón, Elsevier, 1995
13. Fundamentals of Petroleum Refining by M Fahim, Taher Al-Sahhaf and Amal Elkilani, Elsevier, 2009.
14. Handbook of Biofuels Production: Processes and Technologies Edited by R Luque, J Campelo and J Clark, Woodhead Publishing, 2010.
15. Natural Gas Conversion Edited by A. Holmen, K.-J. Jens and S. Kolboe, Elsevier, 1991

Course Title: Environmental Chemistry
Paper Code: ACL.624
Total Lectures: 72

L	T	P	Credits
4	0	0	4

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

Unit 1 : 18 Hrs

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..

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

Unit 2: 18 Hrs

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: 18 Hrs

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.

Unit 4: 18 Hrs

Chemistry of Soil: Physio-chemical composition of soil, humus, inorganic and organic components of soil, nutrients (NPK) in soil, significance of C:N ratio, 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. Biochemical and Toxicological aspects of arsenic, cadmium, lead, mercury, carbon monoxide, O_3, PAN, MIC and other carcinogens

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, 2008, W.H. Freeman, USA
2. Manahan, S. E. (2008). Fundamentals of environmental chemistry, 3rd Edition, CRC Press, USA
3. Connell D. W. (2005). Basic concepts of environmental chemistry 2nd Edition, Crc Press, USA
4. Girard J. (2010). Principles of environmental chemistry 2nd Edition, James & 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, 1st edition, 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. Eaton, A.D., American Public Health Association, American Water Works Association and Water Environment Federation (2005). *Standard Methods for the Examination of Water and Wastewater*. Washington, D. C: American Public Health Association.
10. Eckenfelder, W.W. Jr., Ford, D.L. and Englande, A.J. Jr. (2009). *Industrial water quality*. McGraw-Hill, New York.
11. Crittenden, J. C., Trussell, R. R. and HandD. W. (2005). *Water treatment: principles and design*,2nd edition, Wiley Publishers, USA.
12. Grady, C.P. Leslie, G.T. Daigger, and H.C. Lim, (1999) Biological Wastewater Treatment, Second Edition, Marcel Dekker, Inc., New York.