3 Year B.Sc. Chemistry (2021 – 2024 batch)

SEMESTER-I				
Sl no	**Subject Code**	**Subject**	**Contact Hours per week (L+T+P)**	**Credits**
1	ENG 110040	Communicative English	3+1+0	4
2	CHM 111110	Inorganic Chemistry I	3+1+0	4
3	CHM 112010	Inorganic Chemistry Practical	2+0+0	2
4	CHM 111120	Organic Chemistry I	3+1+0	4
5	CHM 112020	Organic Chemistry Practical	2+0+0	2
6	PHY 111110	Physics I	3+1+0	4
7	PHY 112010	Physics I (Practical)	2+0+0	2
TOTAL CREDITS				**22**

SEMESTER-II				
Sl no	**Subject Code**	**Subject**	**Contact Hours per week (L+T+P)**	**Credits**
1	CHM 121010	Physical Chemistry II	3+1+0	4
2	CHM 121020	Organic Chemistry II	3+1+0	4
3	CHM 121030	Fundamentals of Mathematics	3+1+0	4
4	ENV 120060	Environmental Studies	3+1+0	4
5	CHM 122070	Organic Chemistry Practical II	2+0+0	2
6	CHM 122080	Physical Chemistry Practical II	2+0+0	2
7	KOR 125060	Basic Korean Language	2+0+0	2
TOTAL CREDITS				**22**

Semester I

Communicative English

Unit-1**:** Parts of speech, articles, auxiliary verbs, preposition
Unit-2: Phrases, Clauses, sentences, tense, voice, narration, functional elements in sciences

Unit-3: Paragraph writing, summary writing, paraphrasing, précis writing, letter writing, resumes, C.V., job applications, report writing, note taking, dictation.
Unit-4: Reading comprehension (from subject area)
Unit-5: Functional use of language, situational use of language, academic use of language
Unit-6: Listening and speaking, conversation, language laboratory

Recommended books:
New headway (intermediate), Joanna Cooke, Liz Soars, John Soars, Oxford University press, 2002.

Inorganic Chemistry

Learning objective:

1. Atomic theory and its evolution.
2. Learning scientific theory of atoms, concept of wave function.
3. Elements in periodic table; physical and chemical characteristics, periodicity.
4. To predict the atomic structure, chemical bonding, and molecular geometry based on accepted models.

Course outcome:

1. To understand atomic theory of matter, composition of atom.
2. Identity of given element, relative size, charges of proton, neutron and electrons, and their assembly to form different atoms.
3. Defining isotopes, isobar and isotone.
4. Physical and chemical characteristics of elements in various groups and periods according to ionic size, charge, etc. and position in periodic table.
5. Characterize bonding between atoms, molecules, interaction and energetics (ii) hybridization and shapes of atomic, molecular orbitals, bond parameters, bond-distances and energies.
6. Valence bond theory incorporating concepts of hybridization predicting geometry of molecules.
7. Importance of hydrogen bonding, metallic bonding.

Self-study:

1. Electronic configuration of various elements in periodic table
2. Predicting structure of molecules
3. How hydrogen bonding, metallic bonding is important in common materials' scientific applications to material fabrication

Atomic Structure: (10 classes of 60 minutes each)

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

Periodicity of Elements: (10 classes of 60 minutes each)

s, p, d, f block elements, the long form of periodic table. Detailed discussion of the following properties of the elements, with reference to *s* and *p*-block.

(a) Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table.

(b) Atomic radii (van'der Waals)

(c) Ionic and crystal radii.

(d) Covalent radii (octahedral and tetrahedral)

(e) Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization energy. Applications of ionization enthalpy.

(f) Electron gain enthalpy, trends of electron gain enthalpy.

(g)Electronegativity, Pauling, Mullikan, Allred Rachow scales, electronegativity and bond order, partial charge, hybridization, group electronegativity. Sanderson electron density ratio.

Chemical Bonding: (14 classes of 60 minutes each)

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

(ii) *Covalent bond:* Lewis structure, Valence Shell Electron Pair Repulsion Theory (VSEPR), Shapes of simple molecules and ions containing lone-and bond-pairs of electrons multiple bonding, sigma and pi-bond approach, Valence Bond theory, (Heitler-London approach). Hybridization containing s, p and s, p, d atomic orbitals, shapes of hybrid orbitals, Bents rule, Resonance and resonance energy, Molecular orbital theory. Molecular orbital diagrams of

simple homonuclear and heteronuclear diatomic molecules, MO diagrams of simple tri and tetra-atomic molecules, e.g., N_2, O_2, C_2, B_2, F_2, CO, NO, and their ions; HCl, BeF_2, CO_2, HCHO, (idea of s-p mixing and orbital interaction to be given). Covalent character in ionic compounds, polarizing power and polarizability. Fajan rules, polarization. Ionic character in covalent compounds: Bond moment and dipole moment. ionic character from dipole moment and electronegativities.

Metallic bonding and Weak chemical forces: (6 classes of 60 minutes each)

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

(iv) *Weak Chemical Forces:* van'der Waals, ion-dipole, dipole-dipole, induced dipole dipole-induced dipole interactions, Lenard-Jones 6-12 formula, hydrogen bond, effects of hydrogen bonding on melting and boiling points, solubility, dissolution.

Recommended Books/References:

1.Lee, J. D. *Concise Inorganic Chemistry,* Wiley, 5^{th} Ed^{n}.

2.Douglas, B.E., McDaniel, D.H., Alexander J.J., *Concepts & Models of Inorganic Chemistry, (Third Edition)* John Wiley & Sons,1999.

3.Atkins, P. W. and DePaula, J. *Physical Chemistry*, Tenth Edition, Oxford University Press, 2014.

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

<u>Core course-II: Inorganic Chemistry Practical</u>

(A) Titrimetric Analysis

(i) Calibration and use of apparatus.

(ii) Preparation of solutions of different Molarity/Normality of titrants.

(iii) Use of primary and secondary standard solutions.

(B) Acid-Base Titrations

(i) Estimation of carbonate and hydroxide present together in mixture.

(ii) Estimation of carbonate and bicarbonate present together in a mixture.

(iii) Estimation of free alkali present in different soaps/detergents

(C) Oxidation-Reduction Titrimetry

(i) Estimation of Fe(II) and oxalic acid using standardized $KMnO_4$ solution.

(ii) Estimation of oxalic acid and sodium oxalate in a given mixture.

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

Recommended Books/References:

1. Mendham, J., A. I. Vogel's *Quantitative Chemical Analysis* Sixth Edition, Pearson, 2009.
2. Svehala G. and Sivasankar I. B, Vogel's Qualitative Inorganic Analysis, Pearson, India, 2012.

Core course-III: Organic Chemistry-I

Learning objectives:

1. Basic of organic molecules, structure, bonding, reactivity and reaction mechanisms.
2. Stereochemistry of organic molecules – conformation and configuration, asymmetric molecules and nomenclature.
3. Aromatic compounds and aromaticity, mechanism of aromatic reactions.

Course outcome:

1. Understanding hybridization and geometry of atoms, 3-D structure of organic molecules, identifying chiral centers.
2. Reactivity, stability of organic molecules, structure, stereochemistry.
3. Electrophile, nucleophiles, free radicals, electronegativity, resonance, and intermediates along the reaction pathways.
4. Mechanism of organic reactions (effect of nucleophile/leaving group, solvent), substitution *vs*. elimination.

Self-study:

1. Design and syntheses of organic molecules.
2. Structure identification through IR, NMR and Mass spectroscopic data.
3. Lab/Instrumentation techniques used for analyzing reaction mechanisms.

4. Advanced soft-wares/Models used for predicting stereochemistry/study of energy minimization of organic molecules.

Basics of Organic Chemistry: (10 classes of 60 minutes each)

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

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

Stereochemistry: (6 classes of 60 minutes duration each)

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

Chemistry of Aliphatic Hydrocarbons: (18 classes of 60 minutes duration each)

A. Carbon-Carbon sigma bonds

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

B. Carbon-Carbon pi-bonds

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

C. Cycloalkanes and Conformational Analysis

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

Aromatic Hydrocarbons (6 classes of 60 minutes duration each)

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

Recommended Books/References:

1. Morrison, R. N. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Pine S. H. Organic Chemistry, Fifth Edition, McGraw Hill, (2007)
3. F. A. Carey, Organic Chemistry, Seventh Edition, Tata McGraw Hill (2008).

Core course-IV: Organic Chemistry Practical

1. Checking the calibration of the thermometer.
2. Purification of organic compounds by crystallization using the following solvents:
   a. Water b. Alcohol c. Alcohol-Water
3. Determination of the melting points of given organic compounds and unknown organic compounds (using Kjeldahl method and electrically heated melting point apparatus).
4. Effect of impurities on the melting point – mixed melting point of two unknown organic compounds.
5. Determination of boiling point of liquid compounds. (boiling point lower than and more than 100 °C by distillation and capillary method)

5.Chromatography

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

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

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

Recommended Books/Reference:

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

Generic Elective Papers: Mathematical methods in chemistry/Biology-I

Mathematical Methods in chemistry (generic elective)

Fundamentals of mathematics: (10 classes of 60 minutes duration each)

Mathematical functions, polynomial expressions, logarithms, exponential function, units of a measurement, inter-conversion of units, constants and variables, equation of a straight line, plotting graphs, data representation, pi-charts, histogram.

Uncertainty in experimental techniques: Displaying uncertainties and measurements in chemistry, decimal places, significant figures, combining quantities.

Uncertainties in measurement: types of uncertainties, combining uncertainties. Use of statistical tools, Data reduction and the propagation of errors, binomial, Poisson and Gaussian distributions, Graphical and numerical data reduction. Numerical curve fitting: the method of least squares (regression).

Algebraic operations on real scalar variables, Roots of quadratic equations analytically and iteratively, Numerical methods of finding roots (Newton-Raphson, binary –bisection).

Mathematical series: (10 classes of 60 minutes duration each)

Power series, Maclaurin, Taylor series, convergence (e.g. pressure virial equation of state, colligative properties). Pythagoras theorem in three dimensions. Trigonometric functions, identities.

Differential calculus: (10 classes of 60 minutes duration each)

The tangent line and the derivative of a function, numerical differentiation, differentials of higher order derivatives, discontinuities, stationary points, maximum-minimum problems, inflexion points, limiting values of functions: L'Hopital's rule, combining limits.

Calculus of several variables*:* Functions, change of variables, total differential, chain rule, partial differentiation, Euler's theorem, exact and inexact differentials (applications tin the domains of thermodynamics, surface chemistry), line/surface-integrals.

Integral calculus: (10 classes of 60 minutes duration each)

Integration, odd-even functions, indefinite integrals, standard integrals, methods of integration (by parts, substitution, partial fractions and others. Examples from kinetics, thermodynamics, nuclear chemistry and surface chemistry, numerical integration (Trapezoidal and Simpson rules, e.g. entropy/enthalpy change from heat capacity data), probability distributions and mean values. Tri-gonometric functions (applications in chemistry need to be emphasized throughout)

Recommended Books/References:

1 Chemical Maths Book, E. Steriner, Oxford University Press (1996).
2 Maths for Chemists, Vols 1 and 2 M. C. R. Cockett and G. Dogget, Royal Society of Chemistry, Cambridge (2003).

(The above course structure, number of classes and recommended books/references are suggestive. Faculty/academic bodies may incorporate revision as per need).

Generic Elective (Biology-I)

Cell and Cellular Processes: (14 classes of 60 minutes)

The Cell Theory; Prokaryotic and eukaryotic cells; Cell size and shape; Eukaryotic Cell components

Cell Organelles

Mitochondria: Structure, marker enzymes, composition; mitochondrial biogenesis; Semiautonomous organelle; Symbiont hypothesis; Proteins synthesized within mitochondria; mitochondrial DNA

Chloroplast: Structure, marker enzymes, composition; semiautonomous nature, chloroplast DNA

ER, Golgi body & Lysosomes: Structures and roles. Signal peptide hypothesis, N-linked glycosylation, Role of golgi in O-linked glycosylation. Cell secretion, Lysosome formation.
Peroxisomes and Glyoxisomes: Structures, composition, functions in animals and plants and biogenesis.

Nucleus (10 classes of 60 minutes duration each)

Nuclear Envelope- structure of nuclear pore complex; chromatin; molecular organization, DNA packaging in eukaryotes, euchromatin and heterochromatin, nucleolus and ribosome
The functions of membranes; Models of membrane structure; The fluidity of membranes; Membrane proteins and their functions; Carbohydrates in the membrane; Faces of the membranes; Selective permeability of the membranes; Cell wall

Cell Cycle: (6 classes of 60 minutes duration each)

Role of Cell division; Overview of Cell cycle; Molecular controls; Meiosis Interphase, Mitosis and Meiosis.

Instrumentation techniques: (10 classes 60 minutes duration each)

Principles of microscopy; Light Microscope; Phase contrast microscopy; Fluorescence microscopy; Confocal microscopy; Sample Preparation for light microscopy; Introduction to Electron microscopy (EM)- Scanning EM and sample analysis with examples.

Recommended books/References:

1. Campbell, N.A. and Reece, J. B. Biology (Eighth edition) Pearson Benjamin Cummings, San Francisco, (2008).
2. Raven, P.H *et al* Biology, Seventh edition Tata McGraw Hill, New Delhi (2006).
3 Sheeler, P and Bianchi, D.E. Cell and Molecular Biology (Third edition) John Wiley (2006)

(The above course structure, number of classes and recommended books/references are suggestive. Faculty/academic bodies may incorporate revision as per need).

Generic elective: Tutorials/practical for Biology (preferably any six from the following list)

1. Study of prokaryotic cells (bacteria), viruses, eukaryotic cells using microscope.
2. Study of the photomicrographs of cell organelles

3. To study the structure of plant cell through temporary mounts.

4. To study the structure of animal cells by temporary mounts-squamous epithelial cell and nerve cell.

5. Preparation of temporary mounts of striated muscle fiber

6. To prepare temporary stained preparation of mitochondria from striated muscle cells/ cheek epithelial cells using vital stain Janus green.

7. To prepare temporary stained squash from root tips of *Allium cepa* and to study the various stages of mitosis.

8. Study the effect of temperature, organic solvent on semi permeable membrane.

9. Demonstration of dialysis of starch and simple sugar.

10. Study of plasmolysis and deplasmolysis on *Rhoeo* leaf.

11. Measure the cell size (either length or breadth/diameter) by micrometry.

12. Study the structure of nuclear pore complex by photograph (from Gerald Karp)

(The above course structure, number of classes and recommended books/references are suggestive. Faculty/academic bodies may incorporate revision as per need).

Semester II

Physical Chemistry-I

Learning objective:

1. Familiarization with various states of matter.
2. Physical properties of each state of matter and laws related to describe the states.
3. Calculation of lattice parameters.
4. Electrolytes and electrolytic dissociation, salt hydrolysis and acid-base equilibria.

Course outcome:

1. Understanding Kinetic model of gas and its properties.
2. Maxwell distribution, mean-free path, kinetic energies.
3. Behavior of real gases, its deviation from ideal behavior, equation of state, isotherm, and law of corresponding states.
4. Liquid state and its physical properties related to temperature and pressure variation.

5. Properties of liquid as solvent for various household and commercial use.
6. Solids, lattice parameters – its calculation, application of symmetry, solid characteristics of simple salts.
7. Ionic equilibria – electrolyte, ionization, dissociation.
8. Salt hydrolysis (acid-base hydrolysis) and its application in chemistry.

Self-study:

1. Determination of lattice parameters of given salt.
2. Study of X-Ray diffraction pattern and finding out reference from JCPDI file.
3. Numerical related to salt hydrolysis, ionic equilibria.

Gaseous state: (**12 classes of 60 minutes duration each**)

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

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

Liquid state: (5 classes of 60 minutes duration each)

Structure and physical properties of liquids; vapour pressure, surface tension, viscosity, and their dependence on temperature, Effect of addition of various solutes on surface tension, cleansing action of detergents. Structure of water.

Ionic equilibria: (13 classes of 60 minutes duration each)

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect; dissociation constants of mono-, di- and tri-protic acids.

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

Brönsted-Lowry concept of acid-base reactions, solvated proton, relative strength of acids, types of acid-base reactions, levelling solvents, Lewis acid-base concept, Classification of Lewis acids, Hard and Soft Acids and Bases (HSAB) Application of HSAB principle.

Qualitative treatment of acid – base titration curves (calculation of pH at various stages). Theory of indicators; selection of indicators and their limitations. Multistage equilibria in polyelectrolytes.

Solid state: (10 classes of 60 minutes duration each)

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

Recommended Text books/references:

1. Atkins, P. W. & Paula, J. de *Atkin's Physical Chemistry* 8th Ed., Oxford University Press (2006).

2. Ball, D. W. *Physical Chemistry* Thomson Press, India (2007).

3. Castellan, G. W. *Physical Chemistry* 4th Ed. Narosa (2004).

4. Mortimer, R. G. *Physical Chemistry* 3rd Ed. Elsevier: NOIDA, UP (2009).

5 G. M. Barrow, Tata McGraw Hill (Fifth Edition) (2007)

Physical chemistry Practical

1. Surface tension measurements.

a. Determine the surface tension by (i) drop number (ii) drop weight method.

b. Study the variation of surface tension of detergent solutions with concentration.

2. **Viscosity measurements using Ostwald's viscometer**.

a. Determination of viscosity of aqueous solutions of (i) polymer (ii) ethanol and (iii) sugar at room temperature.

b. Viscosity of sucrose solution with the concentration of solute.

3. pH metry

a. Effect on pH of addition of HCl/NaOH to solutions of acetic acid,
sodium acetate and their mixtures.

b. Preparation of buffer solutions of different pH

i. Sodium acetate-acetic acid

ii. Ammonium chloride-ammonium hydroxide

c. pH metric titration of (i) strong acid vs. strong base, (ii) weak acid vs. strong base.

d. Determination of dissociation constant of a weak acid.

Recommended text books/references:

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

2.Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry 8th Ed*.; McGraw-Hill: New York (2003).

3 Halpern, A. M. & McBane, G. C. *Experimental Physical Chemistry 3rd Ed.;* W.H. Freeman & Co.: New York (2003).

4 Athawale V. D. amd Mathur P. Experimental Physical Chemistry,, New Age Intenational (2001)

Organic Chemistry-II

Learning objective:

1. Familiarization about classes of organic compounds and their methods of preparation.
2. Basic uses of reaction mechanisms.
3. Name reactions, uses of various reagents and the mechanism of their action.

Course outcome:

1. Preparation and uses of various classes of organic compounds.
2. Organometallic compounds and their uses.

3. Organic chemistry reactions and reaction mechanisms.
4. Use of reagents in various organic transformation reactions.

Self-study:

1. Elucidating reaction mechanisms for organic reactions.
2. Organometallic compounds and their uses.
3. Use of active methylene groups in organic mechanism and preparation of new organic compounds.

Chemistry of Halogenated Hydrocarbons: (8 classes of 60 minutes duration each)

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

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

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

Organometallic compounds of Mg and Li and their use in synthesis.

Alcohols, Phenols, Ethers and Epoxides: (6 classes of 60 minutes duration each)

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

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

Ethers and Epoxides: Preparation and reactions with acids. Reactions of epoxides with alcohols, ammonia derivatives and $LiAlH_4$

Carbonyl Compounds: (10 classes of 60 minutes duration each)

Structure, reactivity and preparation; Nucleophilic additions, Nucleophilic addition-elimination reactions with ammonia derivatives with mechanism; Mechanisms of Aldol and Benzoin condensation, Knoevenagel condensation, Claisen-Schmidt, Perkin, Cannizzaro and Wittig reaction, Beckmann and Benzil-Benzilic acid rearrangements, haloform reaction and

Baeyer Villiger oxidation, α-substitution reactions, oxidations and reductions (Clemmensen, Wolff-Kishner, $LiAlH_4$, $NaBH_4$, MPV, PDC and PGC);

Addition reactions of unsaturated carbonyl compounds: Michael addition.

Active methylene compounds: Keto-enol tautomerism. Preparation and synthetic applications of diethyl malonate and ethyl acetoacetate.

Carboxylic Acids and their Derivatives: (10 classes of 60 minutes duration each)

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

Sulphur containing compounds: (6 classes of 60 minutes duration each)

Preparation and reactions of thiols, thioethers and sulphonic acids.

Recommended Books/references:

1 Solomons, T.W. *Organic Chemistry,* John Wiley & Sons, Inc.

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

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

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

Organic Chemistry-Practical

1.Functional group tests for alcohols, phenols, carbonyl and carboxylic acid group.

2. Organic preparations:

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

ii. Benzolyation of one of the amines (aniline, *o*-, *m*-, *p*- toluidines and *o*-, *m*-, *p*-anisidine) and one of the phenols (*β*-naphthol, resorcinol, *p*-cresol) by Schotten-Baumann reaction.

iii. Oxidation of ethanol/ isopropanol (Iodoform reaction).

iv. Bromination (any one)

a. Acetanilide by conventional methods

b. Acetanilide using green approach (Bromate-bromide method)

v. Nitration: (any one)

a. Acetanilide/nitrobenzene by conventional method

b. Salicylic acid by green approach (using ceric ammonium nitrate).

vi. Selective reduction of *meta* dinitrobenzene to *m*-nitroaniline.

vii. Reduction of *p*-nitrobenzaldehyde by sodium borohydride.

viii. Hydrolysis of amides and esters.

ix. Semicarbazone of any one of the following compounds: acetone, ethyl methyl ketone, cyclohexanone, benzaldehyde.

x. *S*-Benzylisothiouronium salt of one each of water soluble/ insoluble acids (benzoic acid, oxalic acid, phenyl acetic acid and phthalic acid).

xi. Aldol condensation with either conventional or green method.

xii. Benzil-Benzilic acid rearrangement.

Collected solid samples may be used for recrystallization, melting point and TLC.

Recommended Books/References:

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

2 Furniss, B.S., Hannaford, A.J., Smith, P.W.G. & Tatchell, A.R. *Practical Organic Chemistry, 5th Ed.* Pearson (2012)

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

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

Physics-I (Generic Elective)

Mathematical Physics: (8 classes of 60 minutes duration each)

Scalar and vector products, polar and axial vectors, triple and quadruple products.

Vector calculus:

Scalar and vector fields, differentiation of a vector, gradient, divergence, curl and O operations and their meaning, idea of line, surface and volume integrals, Gauss and Stokes' theorem.

Classical Mechanics: (18 classes of 60 minutes duration each)

Particle dynamics: Newton's laws of motion, conservation of linear momentum, center of mass, conservative forces, work energy theorem, particle collision.

Rotational kinematics and dynamics: Rotational motion, forces and pseudo forces, torque and angular momentum, kinetic energy of rotation, rigid body rotation dynamics, moment of inertia, conservation of angular momentum, comparison of linear and angular momentum, motion of a top.

Oscillations: Linearity and superposition principle, free oscillation with one and two degrees of freedom, simple pendulum, combination of two simple harmonic motions. Lissajous figures, free and damped vibrations, forced vibrations and resonance, Q factor; wave equation, travelling and standing waves, superposition of waves, phase and group velocity.

Wave optics: (14 classes of 60 minutes duration each)

Interference, division of amplitudes, Young's double split, Fresnel's biprism, interference in thin films and wedged shaped films. Fresnel diffraction: Diffraction at a single slit and a circular aperture, diffraction at a double split, plane transmission grating, resolving power of a telescope and a microscope, resolving and dispersive power of a plane diffraction grating. Polarization: Polarization by reflection and refraction, Brewster's law, double refraction, nicol prism, quarter and half-wave plates, Production and analysis of circularly and elliptically polarized light.

Recommended Text books/references:

1. Spiegel, M. R. *Vector Analysis* Schaum Outline Series. McGraw-Hill (1974)
2. Beiser, A. *Concepts of Modern Physics* McGraw-Hill (2002).
3. Resnick, R., Halliday, D. and Krane, K. S. Physics I and II Fifth Ed. John Wiley (2004)
4. Serway, R. A. & Jewett, J. W. *Physics for Scientists and Engineers* Sixth Ed.

(The above course structure, number of classes and recommended books/references are suggestive. Faculty/academic bodies may incorporate revision as per need).

Physics-I (Generic Elective) – Practicals

(Recommended that physics practical to be carried out from mechanics and optics as per availability of facilities with minimum 3 experiments from each group)

Group-A: Mechanics

1. Determination of spring constant of a spring by (i) static, and (ii) dynamic methods.
2. Study of damped harmonic oscillator- Q factor.
3. Determination of temperature coefficient of resistance using platinum resistance thermometer.
4. Study of thermal couple calibration and inversion temperature.
5. LCR study of resonance Q-factor.
6. Kator's pendulum- Bar pendulum.

Group-B:Optics

7. Determination of wavelength of light by Fresnel's biprism.
8. Determination of wavelength of sodium light by Newton's arrangement.
9. Determination of refractive index of tint glass using a spectrometer.
10. Determination of dispersive power of a glass prism using Cauchy's constant. Also determine the resolving power of a prism.
11. Determination of wavelength of sodium light using a plane transmission grating and resolving power of a diffraction grating.
12. Determination of specific rotation of cane sugar solution using a polarimeter.

Environmental Studies (Ability Enhancement course)

Ecosystems: (6 classes of 60 minutes duration each)

Biogeochemical cycles of carbon, nitrogen and sulphur.

Air Pollution: (10 classes of 60 minutes duration each)

Major regions of atmosphere. Chemical and photochemical reactions in atmosphere. Air pollutants: types, sources, particle size and chemical nature; Photochemical smog: its constituents and photochemistry. Environmental effects of ozone, Major sources of ambient air pollution by SO_x, CO, NO_x, H_2S, hydrocarbons and other foul smelling gases. Methods of estimation of particulates, CO, NO_x, SO_x and control measures. Indoor pollution. Effects of air pollution on living organisms and vegetation. Greenhouse effect and Global warming, Ozone depletion by oxides of nitrogen, chlorofluorocarbons and Halogens, removal of sulphur from coal. Control of particulates from coal combustion.

Water Pollution: (10 classes of 60 minutes duration each)

Hydrological cycle, water resources, aquatic ecosystems, Sources and nature of water pollutants, Techniques for measuring water pollution, Impacts of water pollution on

hydrological and ecosystems. Drinking water purification methods. Effluent treatment plants (primary, secondary and tertiary treatment). Industrial effluents from the following industries and their treatment: steel, electroplating, textile, tannery, dairy, petroleum and petrochemicals, agro, fertilizer, etc. and sludge disposal.

Industrial waste management: **(5 classes of 60 minutes duration each)**

Incineration of waste. Water treatment and purification (reverse osmosis, electro dialysis, ion exchange). Water quality parameters for waste water, industrial water and domestic water.

Energy & Environment: (5 classes of 60 minutes duration each)

Sources of energy: Coal, petrol and natural gas. Nuclear Fusion / Fission, Solar energy, Hydrogen, geothermal, Tidal and Hydel, etc.

Nuclear Pollution: **(4 classes of 60 minutes duration each)**

Disposal of nuclear waste, nuclear disaster and its management.

Recommended Text books/References:

1. Stocchi E. *Industrial Chemistry*, Vol-I, Ellis Horwood Ltd. UK.
2. Felder R. M. Rousseau R. W. *Elementary Principles of Chemical Processes*, Wiley Publishers, New Delhi.
3. Kent: J. A. Riegel's *Handbook of Industrial Chemistry*, CBS Publishers, New Delhi.
4. Dara S. S. *A Textbook of Engineering Chemistry*, S. Chand & Company Ltd. New Delhi.
5. De A. K., *Environmental Chemistry*: New Age International Pvt., Ltd, New Delhi.
6. Khopkar S. M., *Environmental Pollution Analysis*: Wiley Eastern Ltd, New Delhi.
7. Manahan S. E, *Environmental Chemistry*, CRC Press (2005).
8. Miller G. T., *Environmental Science* 11th edition. Brooks/ Cole (2006).
9. Mishra A., *Environmental Studies*. Selective and Scientific Books, New Delhi (2005).
10. Sodhi G. S. Fundamental Concepts of Environmental Chemistry (Thirs Edition), Narosa (2009)

SEMESTER-III				
Sl no	**Subject Code**	**Subject**	**Contact Hours per week (L+T+P)**	**Credits**
1	CHM 211010	Inorganic Chemistry II	3+0+0	3
2	CHM 211020	Physical Chemistry III	3+0+0	3
3	PHY 211030	Physics II	3+0+0	3
4	DGI 210100	Disaster Management	2+0+0	2
5	PIR 215010	Social Science Course: Introduction to Indian Constitution	2+0+0	2
6	CHM 215010	Skill Enhancement Course: Dyes, Paints and Pigments	3+0+0	3
7	CHM 212010	Inorganic Chemistry Practical II	2+0+0	2
8	CHM 212020	Physical Chemistry III Practical	2+0+0	2

SEMESTER-IV				
Sl no	**Subject Code**	**Subject**	**Contact Hours per week (L+T+P)**	**Credits**
1	CHM 221010	Physical Chemistry IV	3+0+0	3
2	CHM 221020	Analytical Chemistry	3+0+0	3
3	CHM 221030	Transition Metals and Coordination Chemistry	3+0+0	3
4	CHM 221040	Stereochemistry and Molecular Rearrangement	3+0+0	3
5	CHM 221050	Intellectual Property Rights	3+0+0	3
6	CHM 221060	Advance Mathematics	3+0+0	3
7	CHM 221070	Organic Chemistry Practical III	2+0+0	2
8	CHM 221080	Analytical Chemistry Practical	2+0+0	2

9	PHY 212020	Physics II Practical	2+0+0	2					
TOTAL CREDITS				**22**	**TOTAL CREDITS**				**22**

Semester III

Inorganic Chemistry-II

Learning objective:

1. Oxidation-Reductions and their use in metallurgy.
2. Chemistry of s and p-block elements.
3. Chemistry of noble gases.
4. Inorganic polymers and their use.

Course outcome:

1. Understanding redox reactions in hydrometallurgy processes.
2. Structure, bonding of s and p block materials and their oxides/compounds.
3. Understanding chemistry of boron compounds and their structures.
4. Chemistry of noble gases and their compounds; application of VSEPR theory in explaining structure and bonding.
5. Understanding chemistry of inorganic polymers, their structures and uses.

Self-study:

1. Extraction of metals through metallurgical operations and their uses.
2. Bonding of various s and p block elements.
3. Use of boron compounds.
4. Chemistry of inorganic polymers and their uses.

Oxidation-Reduction and general principle of metallurgy: (8 classes of 60 minutes duration each)

Redox equations, Standard Electrode Potential and its application to inorganic reactions. Occurrence of metals based on standard electrode potentials. Ellingham diagrams for reduction of metal oxides using carbon or carbon monoxide as reducing agent. Electrolytic

Reduction, Hydrometallurgy. Methods of purification of metals: Electrolytic Kroll process, Parting process, van Arkel- de Boer process and Mond's process, Zone refining.

Chemistry of *s* and *p* Block Elements: (16 classes of 60 minutes duration each)

Inert pair effect, Relative stability of different oxidation states, diagonal relationship and anomalous behavior of first member of each group. Allotropy and catenation. Complex formation tendency of *s* and *p* block elements. Hydrides and their classification ionic, covalent and interstitial. Basic beryllium acetate and nitrate.

Structure, bonding, preparation, properties and uses. Boric acid and borates, boron nitrides, borohydrides (diborane) carboranes and graphitic compounds, silanes, Oxides and oxoacids of nitrogen, Phosphorus and chlorine. Per-oxo acids of Sulphur inter-halogen compounds, poly-halide ions, pseudo-halogens, properties of halogens.

Noble Gases: (8 classes of 60 minutes duration each)

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

Inorganic Polymers: (8 classes of 60 minutes duration each)

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

Recommended books/references:

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

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

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

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

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

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

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

Inorganic Chemistry-practical

(A) Iodo / Iodimetric Titrations

(i) Estimation of Cu(II) and $K_2Cr_2O_7$ using sodium thiosulphate solution (Iodimetrically).

(ii) Estimation of (i) arsenite and (ii) antimony iodimetrically

(iii) Estimation of available chlorine in bleaching powder iodometrically.

(B) Inorganic preparations

(i) Cuprous Chloride, Cu_2Cl_2

(ii) Preparation of Aluminium potassium sulphate (Potash alum) or Chrome alum.

Recommended books/references:

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

(The above list of experiments are suggestive. Faculty/academic bodies may incorporate revision/may incorporate text and reference books as per need).

Mathematics-II

Differential equations: (8 classes of 60 minutes duration each)

Solving differential equations with separable variables, series solution, numerical solutions of differential equations those appear in Newtonian mechanism, harmonic oscillator, Linear differential equations with constant coefficients.

Partial differential equations: separation of variables. **(10 classes of 60 minutes duration each)**

Multiple integrals. Change variables. Vector derivative operators. Multiple integrals involving other coordinate systems (spherical polar). Maximum and minimum of functions of several variables. Stationary points, complex numbers, complex plane, Euler's formula and polar form of complex numbers, complex conjugates, modulus of a complex number.

Operators: (6 classes of 60 minutes duration each)

Operator algebra, linear and Hermitian operators, eigenfunctions and eigenvalues, commutators of operators.

Vectors and coordinate systems: (6 classes of 60 minutes duration each)

Unit vectors (application in solid state), addition and subtraction of vectors, multiplication of vectors. Vector calculus. Vectors and coordinate systems in three dimensions (Cartesian, spherical polar and their inter-conversion), Jacobian.

Determinants and Matrices: (10 classes of 60 minutes each)

Determinant, Matrix algebra, Simultaneous equations: method of substitution and elimination, consistency and independence. Homogeneous linear equations. Simultaneous equations with more than two unknowns, Cramer's rule, matrix inversion, orthogonal and unitary matrices, diagonalization of a matrix.

Recommended Books/references:

McQuarrie D. A. Mathematics for Physical Chemistry Opening Doors, University Science Books (2008).

(The above course structure/number of classes are suggestive. Faculty/academic bodies may incorporate revision/may incorporate text and reference books as per need).

Biology-II/Biochemistry

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

Proteins: Classification, biological importance; Primary, secondary and tertiary structures of proteins: α-helix and β- pleated sheets, Denaturation of proteins.

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

Lipids: Biological importance of triglycerides and phosphoglycerides and cholesterol; Lipid membrane, Liposomes and their biological functions and underlying applications.

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

Recommended Books/References:

1. Berg, J.M., Tymoczko, J.L. and Stryer, L. (2006) Biochemistry. VI the Edition. W.H. Freeman and Co.
2. Nelson, D. L., Cox, M. M. and Lehninger, A. L. (2009) principles of Biochemistry.IV Edition. W.H. Freeman and Co.
3. Murray, R.K., Granner, D.K., Mayes, P.A. and Rodwell, V.W. (2009) Harper's Illustrated Biochemistry. XXVIII edition. Lange medical Books/ McGraw-Hill

(The above course structure/number of classes are suggestive. Faculty/academic bodies may incorporate revision/may incorporate text and reference books as per need).

Generic Elective Practical (Biology-II/Biochemistry)

1. Quantitative estimation of protein using Lowry's method. Determine the concentration of the unknown sample.
2. Action of salivary amylase at optimum conditions
3. Effect of pH on the action of salivary amylase
4. Effect of temperature on salivary amylase
5. Effect of inhibitor on salivary amylase
6. Study of the activity of Trypsin using fresh tissue extracts.
7. Effect of temperature, organic solvents, on semi-permeable membrane.
8. Isolation of Genomic DNA from E Coli

Physical Chemistry-II

Learning objective:

1. Laws of thermodynamics and concepts.
2. Partial molar quantities and its attributes.

3. Dilute solution and its properties.

Course outcome:

1. Understanding the concept of system, variables, heat, work, and laws of thermodynamics.
2. Understanding the concept of heat of reactions and use of equations in calculations of bond energy, enthalpy, etc.
3. Understanding the concept of entropy; reversible, irreversible processes. Calculation of entropy using 3nd law of thermodynamics.
4. Understanding the application of thermodynamics: Joule Thompson effects, partial molar quantities.
5. Understanding theories/thermodynamics of dilute solutions.

Self-study:

1. Use of thermochemical equations for calculation of energy and related terms.
2. Use of thermodynamics in explaining chemical behavior of solute/solvent and reactions.
3. Study of calorimeter principle and its use.

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

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

Second Law:

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

Third law of thermodynamics: (4 classes of 60 minutes duration each)

Third Law of thermodynamics, residual entropy, calculation of absolute entropy of molecules.

Free Energy Functions: (6 classes of 60 minutes duration each)

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

Recommended Books/References

1 Atkins P. and De Paula, J. *Physical Chemistry* Tenth Ed., OUP, 2014.

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

3 Engel, T. and Reid, P. *Physical Chemistry 3rd Ed.,* Prentice Hall, 2012.

4 McQuarrie, D. A. and Simon, J. D. *Molecular Thermodynamics* Viva Books, 2004.

5 Roy, B. N. Fundamentals of Classical and Statistical Thermodynamics Wiley, 2001

6 Commonly Asked Questions in Thermodynamics. CRC Press, 2011.

7 Levine, I .N. *Physical Chemistry* 6th Ed., Tata Mc Graw Hill, 2010.

8 Metz, C.R. *2000 solved problems in chemistry,* Schaum Series, 2006.

<u>Physical Chemistry-Practical</u>

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

2. Study the equilibrium of at least one of the following reactions by the distribution method:

(i) I_2 (aq) + I^- ---→ I_3^-(aq)

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

3. Study the kinetics of the following reactions.

a. Acid hydrolysis of methyl acetate with hydrochloric acid.

b. Saponification of ethyl acetate.

Adsorption

Verification of Freundlich and Langmuir isotherms for adsorption of acetic acid and selected organic dye(s) on activated charcoal.

(Use of calorimeter for calculation of heat of reactions may be demonstrated)

Recommended Books/References:

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

2.Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry,* Eighth Edition, McGraw-Hill(2003).

3 Halpern, A. M. and McBane, G. C. *Experimental Physical Chemistry,* Third Edition, W, H. Freeman (2003).

SEMESTER-V				
Sl no	**Subject Code**	**Subject**	**Contact Hours per week (L+T+P)**	**Credits**
1	CHM311040	Chemistry of Biomolecules	3+1+0	4
2	CHM311010	Quantum Chemistry	3+1+0	4
3	CHM311020	Heterocyclic Chemistry I	3+1+0	4
4	CHM311030	Chemistry in Everyday Life	3+1+0	4
5	CHM312010	Adv.Inorganic Chemistry Practical	0+0+2	2
TOTAL CREDITS				**18**

SEMESTER-VI				
Sl no	**Subject Code**	**Subject**	**Contact Hours per week (L+T+P)**	**Credits**
		Heterocyclic chemistry-II	3+1+0	4
		Advanced Physical Chemistry	3+1+0	4
		Organic Spectroscopy	3+1+0	4
		Advanced Inorganic Chemistry	3+1+0	4
		Biomolecule chemistry practical and Seminar/Minor Project	Practical (2)+ Seminar/ Project (6)	8
TOTAL CREDITS				**24**

Semester V

Chemistry of Biomolecules

Unit-I

Amino acids, Peptides and Proteins: Amino acids –Preparative methods, physical properties, dipolar nature, chemical reactions and configuration. Peptides: Peptide-linkage, peptide synthesis and structure of polypeptides. Proteins: General characteristics and secondary structure.

Alkaloids: Occurrence, importance, general structural features, Hofmann exhaustive methylation, structure, and synthesis of nicotine and piperine.

Unit-II

Carbohydrates: Sucrose, starch and cellulose (structural aspects only).

Vitamins and Hormones: Chemical constitution and physiological functions of vitamins A, B2
(Riboflavin), C (Ascorbic acid); Thyroxin and estrone.

Terpenes: Occurrence, isolation, classification, Isoprene rule, structure and synthesis of citral, geraniol and a-terpineol.

Unit-III

Drugs: Classification, preparation and uses of the following:
Antipyretics and Analgesics: Aspirin, Paracetamol, Phenylbutazone.
Sulpha drugs: Sulphanilimide, Sulphapyridine, sulphathiazole, sulphaguani-dine. Mechanism of action of sulpha drugs.
Antimalarials: Chloroquine, Primaquine.
Antibiotics: Chloramphenicol.

Books Recommended:

1. "Organic Chemistry", R. T. Morrison and R. N. Boyd, 6th Edition (1992), Prentice-Hall of India (P) Ltd., New Delhi.
2. Organic Chemistry", S. M. Mukherji, S. P. Singh, and R. P. Kapoor, 1st Edition (1985), 5th Reprint (1999), New Age International (P) Ltd. Publishers, New Delhi.
3. "Organic Chemistry", I. L. Finar, Vol. II, 5th Edition (1975), Reprinted in1996, ELBS and Longman Ltd., New Delhi.
4. "Organic Polymer Chemistry", K. J. Saunders, 2nd Edition (1988), Chapman & Hall, London.
5. Chemistry of Natural Products: G. R. Chatwal

Quantum Chemistry

Unit I

A review of the black body radiation and the old quantum theory. The wave nature of electron. The Uncertainty Principle, Schrödinger's wave mechanics. Eigenfunctions and normalizations. Quantum mechanical operators, Expectation value of a physical quantity. Orthogonality of wave functions, Postulates of quantum mechanics.

Unit II

Free Particle, the particle in a one-dimensional box and its solutions, particle in two-dimensional and three-dimensional box, degeneracy, example of quantum mechanical tunnelling, Harmonic Oscillator model, Step-up, and step-down ladder operators, Harmonic oscillators wave functions and energy,

Unit III

Spherical polar coordinates, rigid rotor model, solution to rigid rotor, Legendre polynomial, angular momentum, the hydrogen atom, Laguerre polynomials, hydrogen like wave functions.

Textbooks and References:

1. Quantum Chemistry, I. N. Levine, 7th Edition, Pearson (2016)
2. Quantum Chemistry, D. A. McQuarrie, Viva Students Edition (2016)
3. Quantum Chemistry, R. K. Prasad, 4th Edition, New Age Publishers (2020)

4. Introduction to Quantum Chemistry, A. Chandra, 4th Edition, McGraw Hill Education (2017)

Heterocyclic chemistry

Unit –I:

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

Unit-II:

Four-membered heterocycles: oxitanes, azatidanes and thietanes - synthetic approaches and reactivities.

Five-membered aromatic heterocycles:

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

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

c) With three and four heteroatoms: triazoles and tetrazoles - synthetic approaches and reactivity.

Unit-III:

Condensed five-membered Heterocycles:

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

Six-membered Heterocycles with one, two and three heteroatoms:

a) Chemistry of pyridine group.

b) Chemistry of pyridazines and pyrimidines.

c) Chemistry of pyrazines and triazines.

Recommended Books

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

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

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

4. Heterocyclic chemistry: Parikh

Chemistry in Everyday Life

Unit-I: Respiration and energy production

Respiration, Respiratory enzymes, brief outline of haemoglobin and myoglobin, oxygen transport mechanism in body, co-operativity, Respiration in lower animals, hemocyanin, hemerythrin, non-heme Fe-S proteins.

Energy production in body, ATP, enzyme responsible for food digestion, mechanism of food digestion, active site of cytochrome c-oxidase.

Unit-II:
Chemical aspects of some common health hazards
Anaemia, sickle cell anaemia, leukaemia, mechanism, blood pressure regulation, blood sugar, arthritis, carbon monoxide poisoning in mines, cyanide poisoning, fluorosis, poisoning of Hg, Cd, Pb, As etc. , toxicity arising from daily used chemicals.

Unit-III: Vitamins and minerals
Need for vitamin in body, types of vitamins, water soluble and fat soluble vitamins, Vitamin B-12 (Cyanocobalamin), vitamin C,Vitamin D, Vitamin K. Role of minerals in body, iodine deficiency, effects and remedies.

Unit-IV: Significance of Radical chemistry in living system
Radical production in environment, superoxide and peroxide, health impact, action of radicals, cell mutation, diseases caused by free radical, cancer, radical quencher, anti-oxidants, natural anti-oxidants like vegetables, beverages like tea and coffee, fruits.
Radical destroying enzymes: superoxide dismutase, catalase, peroxidase, mechanism of action.

Books recommended:

1. Elements of Bio-Inorganic Chemistry, G. N. Mukherjee, A. Das; 3rd Ed, UN Dhur & sons Pvt Ltd, Kolkata, 2008.

2. Chemistry in Daily Life, Kirpal Singh; 3rd Ed, PHI Learning Pvt Ltd, New Delhi, 2012

Semester VI

Heterocyclic chemistry-II

Heterocyclic Chemistry

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

Four-membered heterocycles: oxitanes, azatidanes and thietanes - synthetic approaches and reactivities

Six-membered Heterocycles with one, two and three heteroatoms:

a) Chemistry of pyridine group;

b) Chemistry of pyridazines and pyrimidines.

c) Chemistry of pyrazines and triazines.

Recommended Books/references:

1. Heterocyclic Chemistry, J.A. Joule, K. Mills, Wiley, 2010.
2. The Essence of heterocyclic Chemistry, A. R. Parikh, H. Parikh, R. Khunt, New Age Int. Publication,
3. Principles of Modern Heterocyclic Chemistry, L. A. Paquette, W. A. Benjamin, New York, 1968.
1. Heterocyclic Chemistry, J.A. Joule and G. F. Smith, van Nostrand, London, 1978.
2. Comprehensive Heterocyclic Chemistry. The structure, reactions, synthesis and use of Heterocyclic compounds, (Ed. A.R. Katritzky and C. W. Rees),. Vol 1-8, Pergamon Press, 1984.
3. Handbook of Heterocyclic Chemistry, A. R. Katritzky, Pergamon Press, 1985.
4. Van der plas, H. C. Ring transformations of Heterocycles, Vols 1 and 2, Academic Press, 1974.

Advanced Physical Chemistry

Learning objective:

1. Electrochemistry – electrochemical cell, EMF measurements and applications of electrochemistry
2. Catalyst – mechanism, acid base catalysis, enzyme catalysis.
3. Adsorption isotherms.

Course outcome:

1. understanding theories of reaction rates, determination of rate of opposing/parallel/chain reactions with suitable examples, application of steady state kinetics, Steady-state approximation.
2. Catalyst – mechanism of catalytic action, enzyme catalysis.
3. Langmuir, Freundlich – adsorption isotherms, significance, multilayer adsorption – theory and significance.

Self-study:

1. Electrochemical cell construction

2. Study of reaction kinetics, Fast reactions.
3. Heterogeneous catalysis used in industry and its mechanism of action.
4. Application of adsorption isotherms in metal adsorption, significance.

Electrochemistry

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

Surface chemistry and catalysis:

Physical adsorption, chemisorption, adsorption isotherms (Freundlich, Temkin, Derivation of Langumuir adsorption isotherms, surface area determination), BET theory of multilayer adsorption (no derivation), Adsorption in solution. Types of catalyst, specificity and selectivity, mechanisms of catalyzed reactions at solid surfaces; effect of particle size and efficiency of nanoparticles as catalysts. Enzyme catalysis, Michaelis-Menten mechanism, acid-base catalysis.

Thermodynamics of solutions: Partial molar quantities, dependence of thermodynamic parameters on composition; Gibbs-Duhem equation, chemical potential of ideal mixtures, change in thermodynamic functions in mixing of ideal gases. Dilute solutions; lowering of vapour pressure, Raoult's and Henry's Laws and their applications. Excess thermodynamic functions. Thermodynamic derivation using chemical potential to derive relations between the four colligative properties: [(i) relative lowering of vapour pressure, (ii) elevation of boiling point, (iii) Depression of freezing point, (iv) osmotic pressure] and amount of solute. Applications in calculating molar masses of normal, dissociated and associated solutes in solution.

Recommended books/References:

1. Atkins P. W. and De Paula J., *Physical Chemistry, (*tenth edition) Oxford University Press, 2014.

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

3 McQuarrie, D. A. & Simon, J. D., *Molecular Thermodynamics*, Viva Books, 2004.

4 Engel, T. & Reid, P. *Physical Chemistry* Third Edition, Prentice-Hall,2012.

5 Zundhal, S.S. *Chemistry concepts and applications* Cengage India, 2011

6 Ball, D. W. *Physical Chemistry* Cengage India, 2012.

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

8 Levine, I. N. *Physical Chemistry 6th Ed.,* Tata McGraw-Hill, 2011.

9.Metz, C. R. *Physical Chemistry 2nd Ed.,* Tata McGraw-Hill, 2009

Organic Spectroscopy

Organic Spectroscopy

Basic Principles of UV Spectroscopy:

Application of Woodward-Fiser rule in interpretation of Organic compounds.

Basic principles of IR Spectroscopy:

Identification of Functional groups of various classes of organic compounds,

NMR (^{1}H and ^{13}C NMR):

Application of Chemical Shifts, Splitting of signals, Spin coupling and Over Houser effect in interpretation of NMR spectra, Isotopic exchange

Basic principles Mass Spectrometry:

Application of fragmentation rule in characterization of organic compounds. Problems on structure elucidation of organic compounds based on spectral data.

Recommended Books/References:

1. Flemming I, .Williams B. H. , Mornil T. C. , McGraw Hill Fourth Edition 1987.

2. Silverstein R. M, Bassler G. C, Mornil T. C. John Wiley (Fifth Edition)

3.John R. Dyer, Applications of absorption spectroscopy of organic compounds,
Prentice Hall India (2012).

Advanced Inorganic Chemistry

Course Objective of studying Advanced Inorganic Chemistry:

This introduces the elementary concepts of main group elements. Students will be described about the chemistry of boron and silicon in synthesis of different inorganic compounds. This also covers the preparation, and analysis of organometallic compounds through fundamental approach.

Learning objective:

1. Understanding chemistry of main group elements.
2. Understsanding boranes, diborones and silicon chemistry.
3. Understanding organometallic chemistry and its applications.

Unit-I

1. **Representative Chemistry of Main Group Elements**

   a. Organometallic chemistry of lithium and magnesium: synthesis, structure and reactivity.
   b. Chemistry of boron: Boranes, bonding in boranes, topology of boranes and higher boranes, synthesis and reactivity, Carboranes and metallacarboranes. New Lewis acids based on boron; polymer-supported Lewis acids.
   c. Chemistry of Aluminum: Aluminum alkyls and their uses in polymerization of olefins.
   d. C_{60} and carbon nanotubes: discovery, preparation and selected reactions.
   e. Chemistry of Silicon: Organosilicon compounds, Silicates and aluminosilicates.

Unit-II

2. **Unusual Compounds of Main Group Elements**

   Chemistry of multiple bonding: Multiple bonding in heavier main group elements. Unusual compounds of main group elements: (i) Si=Si, Si≡Si, P=P double bond, Bi-Bi double bond. Synthesis, structure and reactivity.

   a. Chemistry of low valent compounds: Synthesis, structure and bonding model and reactivity; examples of Al(I), Si(II) low valent compounds.
   b. Inorganic rings and polymers. Cyclo- and heterocyclophosphazenes and the polymers derived from them. Polysilanes. Borazine and boron nitride.
   c. Chemistry of halides of noble gases: recent trends. CFC's and ozone layer depletion.

Unit-III

3. Organometallic Chemistry

(a) σ – bonded ligands:
Metal - carbonyls / Metal - phosphines / metal - nitrosyls / metal isocyanide: structure, reactivity and bonding.
Metal - carbenes, metal - carbynes, Fischer carbenes, Schrock carbenes, N-heterocyclic carbenes, olefin metathesis.

(b) π - bonded ligands:
Metal-olefins, metal-alkynes, metal-dienes, Metal-Cp Metal-Cp* complexes : Synthesis, structure, bonding and reactivity.

(c) Applications of organometallics in organic synthesis:
C-C bond coupling reactions (Heck, Sonogoshira, Suzuki).

(d) Reduction reactions using transition metal hydrides; asymmetric hydrogenation, hydroxylation, hydroformylation.

Recommended Books:

1. Organometallics: A Concise Introduction, C. Elschenbroich and A. Salzer, 3rd Edn. 1999.
2. Chemistry of the Elements, N. N. Greenwood and A. Earnshaw, 2nd Edn., Elsevier, 2005.
3. Modern Inorganic Chemistry, W. L. Jolly, McGraw Hill, New York, 2nd Edn., 1991.
4. Concepts and Models of Inorganic Chemistry, B. Douglas, D. McDaniel and J. Alexander, John Wiley, New York, 3rd Edn., 1993.
5. Organometallic Chemistry of the Transition Metals, R. H. Crabtree, Wiley, New York, 1988.

Biomolecule chemistry practical and Seminar/Minor Project

Biomolecular Laboratory

1.Systematic identification of organic compounds (monofunctional and simple bifunctional) and preparation of their derivatives.
2. Preparation of the following compounds: Suphanilic acid, dibenzyl acetone, methyl orange, dinitrobenzene from benzene, isolation of caffine.
3. Estimation of phenol (bromide-bromate method) and aniline (bromide-bromate and acetylation methods).
4. Equivalent weight of an acid (neutralization).

(Course teacher shall decide the modalities/addition or incorporation of revision in the practical based on available infrastructural facilities)

Project Work

The project work shall be carried out under the supervision of a faculty(s) of the Chemistry. Interdisciplinary work within the Dept/School is also encouraged. The project work can be a review and/or experimental work to be carried out as per the supervision of faculty/faculties

concerned. At the end of the semester, the candidate shall be evaluated at the centre and the report shall be sent to the examination department. Valuation shall be out of 100 marks (8 credits) as per following:

A tentative marking shall be as per following:
Presentation of work: 30 marks
Submission of report (hard copy need to be submitted): 50
Viva-voce: 20

Seminar: The students need to present a topic of choice (under the guidance of a mentor).

Couse Map for B.Sc.(Chemistry) Learning Outcome-Based Curriculum Frame Work							
Table-1							
Programme outcome	**Courses (1st Sem.)**						
	Inorg.Chem-1	Inorg.Chem. Pract.	Org.Chem.I	Org.Chem. Practical	Physics	Gen.Elec Tutorial	English for Comm.
Disciplinary knowledge and skill	X	X	X	X	X	X	X
Critical thinking and problem solving ability	X	X	X	X	X	X	
Sense of enquiry	X	X	X	X	X	X	
Team player	X	X		X		X	X
Skilled project manager		X		X		X	
Digitally Literate	X		X		X	X	X
Ethical awareness		X		X		X	X

Couse Map for B.Sc.(Chemistry) Learning Outcome-Based Curriculum Frame Work							
Table-1							
Programme outcome	**Courses (2ND Sem.)**						
	Phy. Chem-1	Phy.Chem. Pract.	Org. Chem.	Org.Chem. Practical	Physics-I Gen.Elect.	Physics Pract.	Env. Studies/Korean language course
Disciplinary knowledge and skill	X	X	X	X	X	X	X
Critical thinking and problem solving ability	X	X	X	X	X	X	X
Sense of enquiry	X	X	X	X	X	X	X
Team player	X	X		X		X	X
Skilled project manager		X		X	X	X	X
Digitally Literate	X		X		X	X	X
Ethical awareness		X	X	X		X	X

Couse Map for B.Sc.(Chemistry) Learning Outcome-Based Curriculum Frame Work							
Table-1							
Programme outcome	**Courses (3RD Sem.)**						
	Physical. Chem-III	Disaster Mgt	Inorg.Chem. II	Inorg.Chem. Practical/Physics pract.	Generic Elect. (social Sci)	Skill Enhan.	
Disciplinary knowledge and skill	X	X	X	X	X	X	
Critical thinking and problem solving ability	X	X	X	X	X	X	
Sense of enquiry	X	X	X	X	X	X	
Team player	X	X		X		X	
Skilled project manager		X		X	X	X	
Digitally Literate	X		X		X	X	
Ethical awareness		X	X	X	X	X	

Couse Map for B.Sc.(Chemistry) Learning Outcome-Based Curriculum Frame Work							
Table-1							
Programme outcome	**Courses (4TH Sem.)**						
	Physical.Chem-II	Physical Chem. Pract.	Analytical	Anal. Practi practical	Gen. Elec. Chemistry/ Math	Gen. Elect. Pract.	IPR
Disciplinary knowledge and skill	X	X	X	X	X	X	X
Critical thinking and problem solving ability	X	X	X	X	X	X	X
Sense of enquiry	X	X	X	X	X	X	X
Team player	X	X		X		X	X
Skilled project manager		X		X	X	X	X
Digitally Literate	X		X		X	X	X
Ethical awareness		X	X	X		X	X

Couse Map for B.Sc.(Chemistry) Learning Outcome-Based Curriculum Frame Work						
Table-1						
Programme outcome	**Courses (5TH Sem.)**					
	Biomolecule	Quantum	Heterocyclic	Inorg Chem. Practical	Discipline Specific Elect. (Chem in everyday life)	
Disciplinary knowledge and skill	X	X	X	X	X	
Critical thinking and problem solving ability	X	X	X	X	X	
Sense of enquiry	X	X	X	X	X	
Team player	X	X		X		
Skilled project manager		X		X	X	
Digitally Literate	X		X		X	
Ethical awareness		X		X		

Couse Map for B.Sc.(Chemistry) Learning Outcome-Based Curriculum Frame Work								
Table-1								
Programme outcome	**Courses (6TH Sem.)**							
	Heterocyclic	Adv.phy.chem	Org.spect.	Inorg.Chem.	Discipline Specific Elect./Biomolecule	DSE. II Pract.	Seminar	NC course
Disciplinary knowledge and skill	X	X	X	X	X	X	X	X
Critical thinking and problem solving ability	X	X	X	X	X	X	X	X
Sense of enquiry	X	X	X	X	X	X	X	X
Team player	X	X		X		X	X	X
Skilled project manager		X		X	X	X	X	X
Digitally Literate	X		X		X	X	X	X
Ethical awareness		X		X	X	X	X	X