B. Sc CHEMISTRY (Honours) Syllabus
CHOICE BASED CREDIT SYSTEM

w. e. f. Admission Batch (2016-2017) for Affiliated Colleges

North Orissa University
Sriram Chandra Vihar
Takatpur, Baripada
Mayurbhanj-757003
## COURSE STRUCTURE (CBCS)

**For B.Sc Honours (Chemistry)**

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<tr>
<th>Sem</th>
<th>Core Course</th>
<th>Ability Enhancement Compulsory Course (AECC)</th>
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<th>Elective Discipline Specific (DSE)</th>
<th>Generic* Elective (GE)</th>
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*A and B are different subjects other than Chemistry*
Core Papers (C): (Credit: 06 each, Theory-04, Practical-02)

1. Inorganic Chemistry I: Atomic Structure & Chemical Bonding (4 + 2)
2. Physical Chemistry I: States of Matter & Ionic Equilibrium (4 + 2)
3. Organic Chemistry I: Basics and Hydrocarbons (4 + 2)
4. Physical Chemistry II: Chemical Thermodynamics and its Applications (4 + 2)
5. Inorganic Chemistry II: s- and p-block Elements (4 + 2)
6. Organic Chemistry II: Oxygen Containing Functional Groups (4 + 2)
7. Physical Chemistry III: Phase Equilibria and Chemical Kinetics (4 + 2)
8. Inorganic Chemistry III: Coordination Chemistry (4 + 2)
9. Organic Chemistry III: Heterocyclic Chemistry (4 + 2)
10. Physical Chemistry IV: Electrochemistry (4 + 4)
11. Organic Chemistry IV: Biomolecules (4 + 4)
12. Physical Chemistry V: Quantum Chemistry & Spectroscopy (4 + 4)
13. Inorganic Chemistry IV: Organometallic Chemistry (4 + 4)

Discipline Specific Elective Papers: (Credit: 06 each) (4 papers) - DSE 1 – 4
Subject (Chemistry) oriented elective paper

Generic Elective/Interdisciplinary (04 papers –02 papers from two disciplines GE 1 to GE 4)

1. Mathematics (5) + Tut (1)
2. Physics (4) + Lab (2)
3. Computer Science (4) + Lab (2)
4. Geology (4) + Lab (2)

Skill Enhancement Courses (02 papers) (Credit: 04 each) - SEC1 to SEC 2
1. Communicative English and English writing skill (Compulsory)
2. Skill oriented Chemistry paper
SEMESTER-I

CHEMISTRY (HONOURS)

Paper: CCH-Chem-1

Subject: Inorganic Chemistry-I

Duration: 3 Hours

Lecturer: 60

Marks: 75 (Midterm-15, Endterm-60)

Group-A: 18 marks: Twelve questions (four questions from each unit) to be asked and nine questions have to be answered carrying 2 marks each.

Group-B: 42 marks: One long type questions from each unit (each can also be subdivided) with one alternative each, has to be answered]

UNIT-I

Atomic structure

Periodicity of elements
Periodicity of Elements: s, p, d, f block elements, the long form of periodic table. Detailed discussion of the following properties of the elements, with reference to s & p-block.

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

(b) Atomic radii (Van der Waals)

(c) Ionic and crystal radii.

(d) Covalent radii

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

Applications of ionization enthalpy

(f) Electronegativity, Variation of electronegativity with bond order, partial charge, hybridization, group electronegativity.

UNIT-II

Chemical bonding-I
Ionic bond: General characteristics, types of ions, size effects, radius ratio rule and its limitations.

Packing of ions in crystals. Born-Haber cycle and its application, Salvation energy. (ii) Covalent bond: Lewis structure, Valence Bond theory (Heitler-London approach). Energetic of hybridization, equivalent and non-equivalent hybrid orbitals, Resonance and resonance energy, Molecular orbital theory. Molecular orbital diagrams of diatomic and simple polyatomic molecules $\text{N}_2; \text{O}_2; \text{C}_2; \text{B}_2; \text{F}_2; \text{CO}; \text{NO}$; and their ions (idea of s-p mixing and orbital interaction to be given). Formal charge.

Chemical bonding-II
Valence shell electron pair repulsion theory (VSEPR), shapes of simple molecules and ions containing lone pairs and bond pairs of electrons, multiple bonding ( $\sigma$ and $\pi$ bond approach) and bond lengths.

Covalent character in ionic compounds, polarizing power and polarizability. Ionic character in covalent compounds: Bond moment and dipole moment. Percentage ionic character from dipole moment and electronegativity difference.
UNIT-III

Chemical Bonding-III
(i) Metallic Bond: Qualitative idea of valence bond and band theories. Semiconductors and insulators.
(ii) Weak Chemical Forces: Van der Waals forces, ion-dipole forces, dipole-dipole interactions, Instantaneous dipole-induced dipole interactions. Repulsive forces, Hydrogen bonding (theories of hydrogen bonding, valence bond treatment) Effects of chemical force, melting and boiling points, solubility energetic of dissolution process.

Reference Books:

PRACTICAL: CCH-Chem-1- LAB.


A. Titrimetric Analysis:
   (i) Calibration and use of apparatus.
   (ii) Preparation of solutions of different Molarity/Normality of titrants.

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 KMnO₄ solution.
   (ii) Estimation of oxalic acid and sodium oxalate in a given mixture.
   (iii) Estimation of Fe(II) with K₂Cr₂O₇ using internal (diphenylamine, anthranilic acid) and external indicator.

Reference text:
Vogel, A.I. A Textbook of Quantitative Inorganic Analysis, ELBS.
SEMESTER-I
CHEMISTRY (HONOURS)
Paper: CCH-Chem-2
Subject: Physical Chemistry-I

Duration: 3 Hours
Lecturer: 60
Marks: 75 (Midterm-15, Endterm-60)

[Group-A: 18 marks: Twelve questions (four questions from each unit) to be asked and nine questions have to be answered carrying 2 marks each.

Group-B: 42 marks: One long type questions from each unit (each can also be subdivided) with one alternative each, has to be answered]

UNIT-I
Gaseous state
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, 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. Behaviour of real gases: Deviations from ideal gas behaviour, compressibility factor, Z, and its variation with pressure for different gases. Causes of deviation from ideal behaviour. van der Waals equation of state, its derivation and application in explaining real gas behaviour.

UNIT-II
Liquid state
Qualitative treatment of the structure of the liquid state; Radial distribution function; physical properties of liquids; vapour pressure, surface tension and coefficient of viscosity, and their determination. Effect of addition of various solutes on surface tension and viscosity. Explanation of cleansing action of detergents. Temperature variation of viscosity of liquids and comparison with that of gases.

Solid state
Nature of the solid state, law of constancy of interfacial angles, law of rational indices, Miller indices, elementary ideas of symmetry, qualitative idea of point and space groups, seven crystal systems and fourteen Bravais lattices, a simple account of rotating crystal method and powder pattern method. Analysis of powder diffraction patterns of NaCl, CsCl and KCl. Defects in crystals.

UNIT-III
Ionic equilibria- I
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- and diprotic acids (exact treatment), Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts.

Ionic equilibria- II
Buffer solutions; derivation of Henderson equation and its applications; buffer capacity, buffer range, buffer action and applications of buffers in analytical chemistry and biochemical processes in the human body. Solubility and solubility product of sparingly soluble, salts applications of solubility product principle.
Reference Books:

PRACTICAL: CCH-Chem-2 LAB.


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.

Viscosity measurement using Ostwalds viscometer.
(a) Determination of viscosity of aqueous solutions of (i) polymer, (ii) ethanol, and (iii) sugar at room temperature.
(b) Study the variation of viscosity of sucrose solution with the concentration of solute.

pH metry.
(a) Study the 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.

Reference Books:
SEMESTER-II

CHEMISTRY (HONOURS)

Paper: CCH-Chem-3

Subject: Organic Chemistry-I

Time: 3 Hours

Lecturer: 60

Marks: 75 (Midterm-15, Endterm-60)

[Group-A: 18 marks: Twelve questions (four questions from each unit) to be asked and nine questions have to be answered carrying 2 marks each.

Group-B: 42 marks: One long type questions from each unit (each can also be subdivided) with one alternative each, has to be answered]

UNIT-I

Basics of organic chemistry

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; Electrophiles and Nucleophiles; Nucleophilicity and basicity; Types, shape and their relative stability of carbocations, carbanions, free radicals and carbenes. Introduction to types of organic reactions and their mechanism: Addition, Elimination and Substitution reactions.

Stereochemistry

Fischer Projection, Newmann and Sawhorse Projection formulae; 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 one and two chiral-centres, Disteroisomers, meso structures, Racemic mixture and resolution. Relative and absolute configuration: D/L and R/S designations. Types of cycloalkanes and their relative stability, Baeyer strain theory, Conformation analysis of alkanes (C_{2}H_{6}, C_{4}H_{10}, Cyclohexane): Relative stability with energy profile diagrams. Energy diagrams of cyclohexane: Chair, Boat and Twist boat forms. Relative stability with energy diagram.

UNIT-II

Chemistry of aliphatic hydrocarbons-I

A. Carbon-Carbon sigma bonds:


B. Cycloalkanes and Conformational Analysis

Chemistry of aliphatic hydrocarbons-II

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, hydroborationoxidation, 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-butenes, toluene, ethyl benzene. Reactions of alkynes: Acidity, Electrophilic and Nucleophilic additions. Hydration to form carbonyl compounds, Alkylation of terminal alkynes.
UNIT-III

Aromatic hydrocarbons
Structure of Benzene: Kekule & Deewar structure, stability, hybrid structure, C-C bond lengths, MO picture, Aromaticity: Hckels rule, aromatic character of arenes, cyclic carbocations/ carbanions and heterocyclic compounds with suitable examples; Aromatic, nonaromatic & anti- aromatic compounds/ions.
Electrophilic aromatic substitution: halogenation, nitration, sulphonation and Friedel-Crafts alkylation/acylation with their mechanism.
Orientation-Concept, activating and deactivating substituents, explanation of orientation, ortho/para ratio.

Reference Books:

PRACTICAL: CH-Chem-3 LAB


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 above compounds and unknown organic compounds (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)
6. Chromatography
   • Separation of a mixture of two amino acids by ascending and horizontal paper chromatography.
   • Separation of a mixture of two sugars by ascending paper chromatography.
   • Separation of a mixture of o-and p-nitrophenol or o-and p-aminophenol by thin layer chromatography (TLC).

Reference Books:
SEMESTER-II

CHEMISTRY (HONOURS)

Paper: CH-Chem-4

Subject: Physical Chemistry-II

Time: 3Hours Lecturer: 60

Marks: 75 (Midterm-15, Endterm-60)

[Group-A: 18marks: Twelve questions (four questions from each unit) to be asked and nine questions have to be answered carrying 2 marks each.
Group-B: 42marks: Three long type questions (each can also be subdivided) with one alternative each, has to be answered]

UNIT-I

Thermodynamics-I

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) and pressure on enthalpy of reactions.


UNIT-II

Thermodynamics-II

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

Systems of variable composition

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.

Solutions and Colligative Properties

Dilute solutions; lowering of vapour pressure, Raoult’s and Henrys Laws and their applications. 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.
UNIT-III

Chemical Equilibrium
Criteria of thermodynamic equilibrium, degree of advancement of reaction, chemical equilibria in ideal gases, concept of fugacity. Thermodynamic derivation of relation between Gibbs free energy of reaction and reaction quotient Coupling of exoergic and endoergic reaction. Equilibrium constants and their quantitative dependence on temperature, pressure and concentration. Free energy of mixing and spontaneity; thermodynamic derivation of relations between the various equilibrium constants $K_p$, $K_e$ and $K_x$: Le Chatelier principle (quantitative treatment); equilibrium between ideal gases and a pure condensed phase.

Reference Books:

PRACTICAL: CH-Chem-4 LAB.


1. Determination of heat capacity of a calorimeter for different volumes using change of enthalpy data of a known system (method of back calculation of heat capacity of calorimeter from known enthalpy of solution or enthalpy of neutralization).
2. Determination of heat capacity of the calorimeter and enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
3. Calculation of the enthalpy of ionization of ethanoic acid.
4. Determination of heat capacity of the calorimeter and integral enthalpy (endothermic and exothermic) solution of salts.
5. Determination of basicity/proticity of a polyprotic acid by the thermochemical method in terms of the changes of temperatures observed in the graph of temperature versus time for different additions of a base. Also calculate the enthalpy of neutralization of the first step.
6. Determination of enthalpy of hydration of copper sulphate.
7. To Study of the solubility of benzoic acid in water and determination of $\Delta H$.
8. Determination of percentage of available free chorine in bleaching powder.
9. Determination of Partition coefficient of I$_2$ between benzene and water.

Reference Books:
SEMESTER-I/II

CHEMISTRY (Generic Elective)

Paper: GE-A/B-Chem-1

Subject: Atomic Structure, Bonding, General organic chemistry & aliphatic hydrocarbons

Time: 3Hours

Marks: 75 (Midterm-15, Endterm-60)

Lecturer: 60

[Group-A: 18marks: Twelve questions (four questions from each unit) to be asked and nine questions have to be answered carrying 2 marks each.

Group-B: 42marks: Three long type questions (each can also be subdivided) with one alternative each, has to be answered]

UNIT-I

Atomic Structure


(b) What is Quantum mechanics? Time independent Schrodinger equation and meaning of various terms in it. Significance of \( \Psi \) and \( |\Psi|^2 \), Schrödinger equation for hydrogen atom. Significance of quantum numbers, orbital angular momentum and quantum numbers ml and ms. Shapes of s, p and d atomic orbitals, nodal planes. Discovery of spin, spin quantum number (s) and magnetic spin quantum number (ms).

(c) Rules for filling electrons in various orbitals, Electronic configurations of the atoms. Stability of half-filled and completely filled orbitals, concept of exchange energy. Relative energies of atomic orbitals, Anomalous electronic configurations.

UNIT-II

Chemical Bonding and Molecular Structure


Covalent bonding: VB Approach: Shapes of some inorganic molecules and ions on the basis of VSEPR and hybridization with suitable examples of linear, trigonal planar, square planar, tetrahedral, trigonal bipyramidal and octahedral arrangements. Concept of resonance and resonating structures in various inorganic and organic compounds.

MO Approach: Rules for the LCAO method, bonding and antibonding MOs and their characteristics for s-s, s-p and p-p combinations of atomic orbitals, nonbonding combination of orbitals, MO treatment of homonuclear diatomic molecules of 1\(^{st}\) and 2\(^{nd}\) periods (including idea of s-p mixing) and and heteronuclear diatomic molecules such as CO, NO and NO\(^+\). Comparison of VB and MO approaches.
UNIT-III

Fundamentals of Organic Chemistry

Stereochemistry
Conformations with respect to ethane, butane and cyclohexane. Interconversion of Wedge Formula, Newmann, Sawhorse and Fischer representations. Concept of chirality (upto two carbon atoms). Configuration: Geometrical and Optical isomerism; Enantiomerism, Diastereomerism and Meso compounds). D and L; cis-trans nomenclature and E/Z Nomenclature (for up to two C=C systems).

Aliphatic Hydrocarbons
Functional group approach for the following reactions (preparations & reactions) to be studied in context to their structure.
Alkenes: (Upto 5 Carbons) Preparation: Elimination reactions: Dehydration of alkenes and dehydrohalogenation of alkyl halides (Saytze’s rule); cis alkenes (Partial catalytic hydrogenation) and trans alkenes (Birch reduction). Reactions: cis-addition (alk. KMnO4) and trans-addition (bromine), Addition of HX (Markownikoff’s and anti-Markownikoff’s addition), Hydration, Ozonolysis,
Alkynes:(Upto 5 Carbons) Preparation: Acetylene from CaC2 and conversion into higher alkynes; by dehalogenation of tetra halides and dehydrohalogenation of vicinal-dihalides.
Reactions: formation of metal acetylides, addition of bromine and alkaline KMnO4, ozonolysis.

Reference Books:
1. J. D. Lee: A new Concise Inorganic Chemistry, E L. B. S.
PRACTICAL: GE-A/B-Chem-1 LAB.


A: Inorganic Chemistry-Volumetric Analysis

1. Estimation of sodium carbonate and sodium hydrogen carbonate present in a mixture.
2. Estimation of oxalic acid by titrating it with KMnO₄:
3. Estimation of water of crystallization in Mohrs salt by titrating with KMnO₄:
4. Estimation of Fe (II) ions by titrating it with K₂Cr₂O₇ using internal indicator.
5. Estimation of Cu (II) ions iodometrically using Na₂S₂O₃:

B: Organic Chemistry

1. Detection of extra elements (N, S, Cl, Br, I) in organic compounds (containing upto two extra elements).
2. Separation of mixtures by Chromatography: Measure the Rf value in each case (combination of two compounds to be given).
   (a) Identify and separate the components of a given mixture of 2 amino acids (glycine, aspartic acid, glutamic acid, tyrosine or any other amino acid) by paper chromatography.
   (b) Identify and separate the sugars present in the given mixture by paper chromatography.

Reference Books:

SEMESTER-III
CHEMISTRY (HONOURS)
Paper: CCH-Chem-5
Sub: - Inorganic chemistry-II
Marks: 75(End term 60 +Mid-term 15)

Duration: 3 Hours
Lecture: 60

[Group-A: 18 marks: twelve questions (four questions from each unit) to be asked and nine questions have to be answered carrying 2 marks each.
Group-B: 42 marks: One long type question from each unit (each can also be subdivided) with one alternative each has to be answered.]

UNIT-I
A. General Principles of Metallurgy

B. Acid and Bases

UNIT-II: Chemistry of S and P Block Elements
Inert pair effect, Relative stability of different oxidation states, diagonal relationship and anomalous behaviour 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. Study of the following compounds with emphasis on 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. Peroxo acids of sulphur, interhalogen compounds, polyhalide ions, pseudo-oxohalogens and basic properties of halogens.

UNIT: III
A. Noble Gases
Occurrence and uses, rationalization of inertness of noble gases, Clathrates; preparation and properties of X eF₂, X eF₄ and X eF₆; Nature of bonding in noble gas compounds (Valence bond treatment and MO treatment for X eF₂). Molecular shapes of noble gas compounds (VSEPR theory).

B. Inorganic Polymer
Types of inorganic polymers, comparison with organic polymers, synthesis, structural aspects and applications of silicones and siloxanes. Borazines, silicates and phosphazenes, and polysulphates.
Reference Books:
• Shriver & Atkins, Inorganic Chemistry 5th Ed.

PRACTICAL: CCH-Chem-5-LAB

(A)/Iodo / Iodimetric Titration
(i) Estimation of Cu(II) and K₂Cr₂O₇ using sodium thiosulphate solution (Iodimetrically).

(B) Inorganic preparations
(i) Cuprous chloride, Cu₂Cl₂.
(ii) Preparation of manganese (III) phosphate, MnP₂O₅.H₂O.
(iii) Preparation of aluminium potassium sulphate K₂SO₄.Al₂(SO₄)₂.24H₂O (Potash alum).

Reference Books:
• Vogel, A.I. A Textbook of Quantitative Inorganic Analysis, ELBS. 1978
SEMESTER-III
CHEMISTRY (HONOURS)
Paper: CCH-Chem-6
Sub: - Organic chemistry-II
Marks: 75(End term 60 +Mid-term 15)
Duration: 3 Hours
Lecture:-60

[Group-A: 18 marks: twelve questions (four questions from each unit) to be asked and nine
questions have to be answered carrying 2 marks each.
Group-B: 42 marks: One long type question from each unit (each can also be subdivided) with
one alternative each has to be answered.]

UNIT-I: Chemistry of Halogenated Hydrocarbons
Alkyl halides: Methods of preparation, nucleophilic substitution reactions \( \text{SN}_1 \), \( \text{SN}_2 \) and \( \text{SNi} \) mech-
anism with stereochemical aspects and effect of solvent etc.; nucleophilic substitution vs. elimina-
tion. Aryl halides: Preparation, including preparation from diazonium salts, nucleophilic aromatic
substitution; \( \text{SNAr} \), Benzyn mechanism. Relative reactivity of alkyl, allyl/benzyl, vinyl and aryl
halides towards nucleophilic substitution reactions.

UNIT-II:
A. Alcohols, Phenols, Ethers and Epoxides
Alcohols: preparation, properties and relative reactivity of 1, 2, 3 alcohols, Bouvaelt-Blanc Re-
duction; Preparation and properties of glycols: Oxidation by periodic acid and lead tetraacetate,
Pinacol-Pinacolone rearrangement; Phenols: Preparation and properties; Acidity and factors effect-
ing it, Ring substitution reactions, Reimer Tiemann and Kolbes Schmidt Reactions, Fries and Claisen
rearrangements with mechanism; Ethers and Epoxides: Preparation and reactions with acids. Reac-
tions of epoxides with alcohols, ammonia derivatives and LiAlH\(_4\) (16 Lectures).

B. Sulphur containing compounds
Preparation and reactions of thiols, thioethers.

UNIT-III:
A. Carbonyl Compounds
Structure, reactivity and preparation: Nucleophilic additions, Nucleophilic addition-elimination reac-
tions with ammonia derivatives with mechanism; Mechanisms of Aldol and Benzoin condensation,
Knoevenagel condensation, Perkin, Cannizzaro and Wittig reaction, Beckmann rearrangements,
haloform reaction and Baeyer Villiger oxidation, - substitution reactions, oxidations and reductions
(Clemmensen, Wolff-Kishner, LiAlH\(_4\), NaBH\(_4\), MPV.; Addition reactions of unsaturated carbonyl
compounds: Michael addition. Active methylene compounds: Keto-enol tautomerism. Preparation
and synthetic applications of diethyl malonate and ethyl acetoacetate.

B. Carboxylic Acids and their Derivatives
Preparation, physical properties and reactions of monocarboxylic acids: Typical reactions of dicar-
boxylic acids, hydroxy acids and unsaturated acids: succinic, lactic, malic, tartaric, citric, maleic and
fumaric acids; Preparation and reactions of acid chlorides, anhydrides, esters and amides; Compar-
ative study of nucleophilic substitution at acyl group -Mechanism of acidic and alkaline hydrolysis of
esters, Claisen condensation, Dieckmann and Reformatsky reactions, Hofmann-bromamide degrada-
tion and Curtius rearrangement.
Reference Books:

- Graham Solomons, T.W. Organic Chemistry, John Wiley & Sons,
  
PRACTICAL: CCH-Chem-6-LAB

Marks: 25  [Expt-15, Viva Voce-06, & Lab record-4]  
Time: 3 hrs

1. Organic preparations:

   (i) Acetylation of one of the following compounds: amines (aniline, o-, m-, p-toluidines and o-, m-, p-anisidine) and phenols (-naphthol, vanillin, salicylic acid) by any one method:

      (a) Using conventional method.
      (b) Using green approach.

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

   (iii) Bromination of any one of the following:

      (a) Acetanilide by conventional methods.
      (b) Acetanilide using green approach (Bromate-bromide method).
      (iv) Nitrification of any one of the following:

      (a) Acetanilide/nitrobenzene by conventional method.
      (b) Salicylic acid by green approach (using ceric ammonium nitrate).

The above derivatives should be prepared using 0.5-1gm. of the organic compound. The solid samples must be collected and may be used for recrystallization, melting point and TLC.

2. Preparation of

   (i) Picric Acid
   (ii) Benzoic acid from Toluene
   (iii) Idoform

Reference Books:

SEMESTER-III
CHEMISTRY (HONOURS)
Paper: CCH-Chem-7
Sub: - Physical chemistry-III
Marks: 75(End term 60 +Mid-term 15)

Duration: 3 Hours                                                                                                           L

[Group-A: 18 marks: Twelve questions (four questions from each unit) to be asked and nine
questions have to be answered carrying 2 marks each.
Group-B: 42 marks: One long type question from each unit (each can also be subdivided) with
one alternative each has to be answered.]

UNIT-I:
A. Phase Equilibria-I
Concept of phases, components and degrees of freedom, derivation of Gibbs Phase Rule for nonre-
active and reactive systems; Clausius-Clapeyron equation and its applications to solid-liquid, liquid-
vapour and solid-vapour equilibria, phase diagram for one component systems, with applications
(H_2O and sulphur system). Phase diagrams for systems of solid-liquid equilibria involving eutectic,
congruent and incongruent melting points, solid solutions (Pb-Ag system, desilverisation of lead
B Phase Equilibria-II
Three component systems, water-chloroform-acetic acid system, triangular plots. Binary solutions:
Gibbs-Duhem-Margules equation, its derivation and applications to fractional distillation of binary
miscible liquids (ideal and non-ideal), azeotropes, partial miscibility of liquids, CST, miscible pairs,
steam distillation. Nerst distribution law: its derivation and applications.

UNIT-II: Chemical Kinetics
Order and molecularity of a reaction, rate laws in terms of the advancement of a reaction, differential
and integrated form of rate expressions up to second order reactions, experimental methods of
the determination of orders, kinetics of complex reactions (integrated rate expressions up to first
order only): (i) Opposing reactions (ii) parallel reactions and (iii) consecutive reactions and their
differential rate equations (steady-state approximation in reaction mechanisms). Temperature
dependence of reaction rates; Arrhenius equation; activation energy. Collision theory of reaction
rates, qualitative treatment of the theory of absolute reaction rates.

UNIT-III:
A. Catalysis
Types of catalyst, specificity and selectivity, mechanisms of catalyzed reactions at solid surfaces;
effect of particle size and efficiency of nanoparticles as catalysts. Enzyme catalysis, Michaelis-
Menten mechanism, acid-base catalysis.

B. Surface Chemistry
Physical adsorption, chemisorption, adsorption isotherms (Langmuir, Freundlich and Gibbs isotherms),
nature of adsorbed state.
Reference Books:
• Assael, M. J.; Goodwin, A. R. H.; Stamatoudis, M.; Wakeham, W. A. & Will, S.
• Zundhal, S.S. Chemistry concepts and applications Cengage India (2011).
• Ball, D. W. Physical Chemistry Cengage India (2012).

PRACTICAL: CCH-Chem-7-LAB

I. Distribution of acetic/ benzoic acid between water and cyclohexane.
II. Study the equilibrium of at least one of the following reactions by the distribution method:
   \( \text{I}_2(aq) + \text{I}^- \rightarrow \text{I}_3(aq) \)
   \( \text{Cu}^2+ (aq) + n \text{NH}_3 \rightarrow \text{Cu(NH}_3)_n \)
III. Study the kinetics of the following reactions.
   (1) Integrated rate method:
   a. Acid hydrolysis of methyl acetate with hydrochloric acid.
   b. Saponification of ethyl acetate.
   Adsorption
   Verify the Freundlich and Langmuir isotherms for adsorption of acetic acid on activated charcoal.

Reference Books:

SKILL ENHANCEMENT COURSES (SEC)
SEMESTER-III
CHEMISTRY (HONS)
Paper: SEC-CENG-1
Subject: COMMUNICATIVE ENGLISH

Duration: 3Hours Lecturer: 60
Full Marks: 100 (Midterm-20, Endterm-80)
SEMESTER-IV
CHEMISTRY (HONOURS)
Paper: CCH-Chem-8
Sub: - Inorganic chemistry-III
Marks: 75-(End term 60 +Mid-term: 15)

Duration: 3 Hours                                          Lecture: 60

[Group-A: 18 marks: twelve questions (four questions from each unit) to be asked and nine questions have to be answered carrying 2 marks each.
Group-B: 42 marks: One long type question from each unit (each can also be subdivided) with one alternative each has to be answered.]

UNIT-I: Coordination Chemistry
Werners theory, valence bond theory (inner and outer orbital complexes), electroneutrality principle and back bonding. Crystal field theory, measurement of CFSE weak and strong fields, pairing energies, factors affecting the magnitude of 10 Dq in octahedral vs. tetrahedral coordination, tetragonal distortions from octahedral geometry, Jahn-Teller theorem, square planar geometry. Qualitative aspect of ligand field and MO Theory. IUPAC nomenclature of coordination compounds, isomerism in coordination compounds. Stereochemistry of complexes with 4 and 6 coordination numbers. Chelate effect, Labile and inert complexes.

UNIT-II:
A. Transition Elements-I
General group trends with special reference to electronic configuration, colour, variable valency, magnetic and catalytic properties, ability to form complexes. Stability of various oxidation states and e.m.f. (Latimer & Bsworth diagrams). Difference between the first, second and third transition series.

B. Transition Elements-II
Chemistry of Ti, V, Cr Mn, Fe and Co in various oxidation states (excluding their metallurgy).

UNIT-III:
A. Lanthanoids and Actinoids
Electronic configuration, oxidation states, colour, spectral and magnetic properties, lanthanide contraction, separation of lanthanides (ion-exchange method only). General features of actinoids, separation of Np, Pm, Am from U.

B. Bioinorganic Chemistry
Metal ions present in biological systems, classification of elements according to their action in biological system. Na/K-pump, carbonic anhydrase and carboxypeptidase. Excess and deficiency of some trace metals. Toxicity of metal ions (Hg, Pb, Cd and As), reasons for toxicity, Use of chelating agents in medicine. Iron and its application in bio-systems, Haemoglobin; Storage and transfer of iron.
Reference Books:


PRACTICAL: CCH-Chem-8 LAB


Gravimetric Analysis:

i. Estimation of nickel(II) using Dimethylglyoxime (DMG).

ii. Estimation of copper as CuSCN.

iii. Estimation of iron as Fe₂O₃ by precipitating iron as Fe(OH)₃.

iv. Estimation of Al(III) by precipitating with oxine and weighing as Al(oxine)₃ (aluminium oxinate).

Chromatography of metal ions

Principles involved in chromatographic separations. Paper chromatographic separation of following metal ions:

i. Ni(II) and Co(II)

ii. Fe(III) and Al(III)

Reference Book:

SEMESTER-IV  
CHEMISTRY (HONOURS)  
Paper: CCH-Chem-9  
Sub: - Organic chemistry-III  
Marks: 75-(End term 60 +Mid-term: 15)  

Duration: 3 Hours  
Lecture: 60

[Group-A: 18 marks: twelve questions (four questions from each unit) to be asked and nine questions have to be answered carrying 2 marks each.  
Group-B: 42 marks: One long type question from each unit (each can also be subdivided) with one alternative each has to be answered.]

UNIT-I: Nitrogen Containing Functional Groups  
Preparation and important reactions of nitro and compounds, nitriles. Amines: Effect of substituent and solvent on basicity; Preparation and properties: Gabriel phthalimide synthesis, Carbylamine reaction, Mannich reaction, Hoffmanns exhaustive methylation, Hofmann-elimination reaction; Distinction between 1, 2 and 3 amines with Hinsberg reagent and nitrous acid.  
Diazonium Salts: Preparation and their synthetic applications.  
Polynuclear Hydrocarbons: Reactions of naphthalene and anthracene, Structure, Preparation and structure elucidation and important derivatives of naphthalene and anthracene.

UNIT-II: Heterocyclic Compounds  
Classification and nomenclature, Structure, aromaticity in 5-numbered and 6-membered rings containing one heteroatom; Synthesis, reactions and mechanism of substitution reactions of: Furan, Pyrrole (Paal-Knorr synthesis, Knorr pyrrole synthesis, Hantzsch synthesis), Thiophene, Pyridine (Hantzsch synthesis), Pyrimidine. Fischer indole synthesis and Madelung synthesis, structure of quinoline and isoquinoline. Derivatives of furan: Furfural and furoic acid (preparation only).

UNIT-III: Alkaloids  
Natural occurrence, General structural features, Isolation and their physiological action Hoffmanns exhaustive methylation, Emdes modification, Structure elucidation and synthesis of Hygrine and Nicotine. Medicinal importance of Nicotine, Hygrine, Quinine, Morphine, Cocaine, and Reserpine. (8 Lectures) Terpenes Occurrence, classification, isoprene rule; Elucidation of structure and synthesis of Citral and -terpineol.
Reference Books:
• Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
• Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
• Acheson, R.M. Introduction to the Chemistry of Heterocyclic compounds, John Welly & Sons (1976).

PRACTICAL: CCH-Chem-9- LAB


1. Functional group test for alcohols, phenols, carbonyls, carboxylic acids, nitro, amine and amide groups.
2. Qualitative analysis of unknown organic compounds containing simple functional groups (alcohols, carboxylic acids, phenols and carbonyl compounds).

Reference Books:
SEMESTER-IV

CHEMISTRY (HONOURS)

Paper: CCH-Chem-10

Sub: - Physical chemistry-IV

Marks: 75-(End term 60 +Mid-term: 15)

Duration: 3 Hours

Lecture:-60

[Group-A: 18 marks: twelve questions (four questions from each unit) to be asked and nine questions have to be answered carrying 2 marks each. Group-B: 42 marks: One long type question from each unit (each can also be subdivided) with one alternative each has to be answered.]

UNIT-I:

A. Conductance-I


B. Conductance-II

Ionic velocities, mobilities and their determinations, transference numbers and their relation to ionic mobilities, determination of transference numbers using Hittorf and Moving Boundary methods. Applications of conductance measurement: (i) degree of dissociation of weak electrolytes, (ii) ionic product of water (iii) solubility and solubility product of sparingly soluble salts, (iv) conductometric titrations, and (v) hydrolysis constants of salts.

UNIT-II: Electrochemistry-I

Quantitative aspects of Faradays 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.

UNIT-III: Electrochemistry-II

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). Electrical properties of atoms and molecules Basic ideas of electrostatics, Electrostatics of dielectric media. Clausius-Mosotti equation and Lorenz-Laurentz equation (no derivation), Dipole moment and molecular polarizabilities and their measurements.

Reference Books:

PRACTICAL: CCH-Chem-10- LAB


Conductometry
I. Determination of cell constant.
II. Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid.
III. Perform the following conductometric titrations:
i. Strong acid vs. strong base
ii. Weak acid vs. strong base
iii. Strong acid vs. weak base

Potentiometry
I. Perform the following potentiometric titrations:
i. Strong acid vs. strong base
ii. Weak acid vs. strong base
iii. Dibasic acid vs. strong base

Reference Books:
SEMESTER-III/IV
CHEMISTRY (Generic Elective)
Paper: GE-A/B-Chem-2

Subject: Chemical energetic, equilibriums & functional organic chemistry

Time: 3Hours
Marks: 75 (Midterm-15, Endterm-60)

Group-A: 18marks: Twelve questions (four questions from each unit) to be asked and nine questions have to be answered carrying 2 marks each.
Group-B: 42marks: Three long type questions (each can also be subdivided) with one alternative each, has to be answered]

Unit-I:
A. Chemical Energetics
B. Chemical Equilibrium:

Unit-II: Ionic Equilibria
Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect. Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions, Solubility and solubility product of sparingly soluble salts applications of solubility product principle.

Unit-III:
Functional group approach for the following reactions (preparations & reactions) to be studied in context to their structure. Aromatic hydrocarbons: Preparation (Case benzene): from phenol, by decarboxylation, from acetylene, from benzene sulphonic acid. Reactions: (Case benzene): Electrophilic substitution: nitration, halogenation and sulphonation. Friedel-Crafts reaction (alkylation and acylation) (upto 4 carbons on benzene). Side chain oxidation of alkyl benzenes (up to 4 carbons on benzene).

Alkyl and Aryl Halides
Reference Books:

• I.L. Finar: Organic Chemistry (Vol. I & II), E. L. B. S.
• Arun Bahl and B. S. Bahl: Advanced Organic Chemistry, S. Chand.


1. Determination of heat capacity of calorimeter for different volumes.
2. Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
3. Determination of enthalpy of ionization of acetic acid.
4. Determination of integral enthalpy of solution of salts (KNO3, NH4Cl).
5. Determination of enthalpy of hydration of copper sulphate.
7. Measurement of pH of different solutions like aerated drinks, fruit juices, shampoos and soaps (use dilute solutions of soaps and shampoos to prevent damage to the glass electrode) using pH-meter.
8. Preparation of buffer solutions:
   (i) Sodium acetate-acetic acid.
   (ii) Ammonium chloride-ammonium hydroxide.
   & measurement of the pH of buffer solutions and comparison of the values with theoretical values.
9. Purification of organic compounds by crystallization (from water and alcohol) and distillation.
11 Preparations: Mechanism of various reactions involved to be discussed. Recrystallisation, determination of melting point and calculation of quantitative yields to be done.
   (a) Bromination of Phenol/Aniline.
   (b) Benzoylation of amines/phenols.
   (c) Oxime and 2,4 dinitrophenylhydrazone of aldehyde/ketone.

Reference Books:

• B.D. Khosla, Senior Practical Physical Chemistry, R. Chand & Co.
SKILL ENHANCEMENT COURSES (SEC)
SEMESTER-IV
Chemistry
Paper: SEC-Chem-2
Subject: Pharmaceutical and Pesticide Chemistry

Time: 3Hours  Lecture: 60

Marks: 100 (Midterm-20, Endterm-80)

[Group-A: 20 marks: twelve questions (four questions from each unit) to be asked and ten questions have to be answered carrying 2 marks each. Group-B: 60 marks: One long type question from each unit (each can also be subdivided) with one alternative each, has to be answered]

UNIT-I: Drugs & Pharmaceuticals
Drug discovery, design and development; Basic Retrosynthetic approach. Synthesis of the representative drugs of the following classes: analgesics agents, antipyretic agents, anti-inflammatory agents (Aspirin, paracetamol, Ibuprofen); antibiotics (Chloramphenicol); antibacterial and antifungal agents (Sulphonamides; Sulphanethoxazol, Sulphacetamide, Trimethoprim); antiviral agents (Acyclovir), Central Nervous System agents (Phenobarbital, Diazepam), Cardiovascular (Glyceryl trinitrate), anti-tilaproxy (Dapsone), HIV-AIDS related drugs (AZT- Zidovudine).

UNIT-II: Fermentation
Aerobic and anaerobic fermentation. Production of (i) Ethyl alcohol and citric acid, (ii) Antibiotics; Penicillin, Cephalosporin, Chloromycetin and Streptomycin, (iii) Lysine, Glutamic acid, Vitamin B2, Vitamin B12 and Vitamin C.

UNIT-III: Pesticide Chemistry
General introduction to pesticides (natural and synthetic), benefits and adverse effects, changing concepts of pesticides, structure activity relationship, synthesis and technical manufacture and uses of representative pesticides in the following classes: Organochlorines (DDT, Gammexene,); Organophosphates (Malathion, Parathion ); Carbamates (Carbofuran and carbaryl); Quinones ( Chloranil), Anilides (Alachlor and Butachlor).

Reference Books
- L. Patrick: Introduction to Medicinal Chemistry, Oxford University PressUK.
SEMESTER-V  
CHEMISTRY (HONOURS)  
Paper: CCH-Chem-11  
Sub: - Organic chemistry -IV  
Marks: 75-(End term 60 +Mid-term: 15)  
Duration: 3 Hours  
Lecture:-60

[Group-A: 18 marks: twelve questions (four questions from each unit) to be asked and nine questions have to be answered carrying 2 marks each.  
Group-B: 42 marks: One long type question from each unit (each can also be subdivided) with one alternative each has to be answered.]

UNIT-I:  
A. Nucleic Acids  
Components of nucleic acids, Nucleosides and nucleotides; Structure, synthesis and reactions of: Adenine, Guanine, Cytosine, Uracil and Thymine; Structure of polynucleotides.

B. Amino Acids, Peptides and Proteins  

UNIT-II: Lipids  
Introduction to oils and fats; common fatty acids present in oils and fats. Hydrogenation of fats and oils, Saponification value, acid value, iodine number. Reversion and rancidity.

Concept of Energy in Biosystems:  

UNIT-III: Pharmaceutical Compounds: Structure and Importance  
Classification, structure and therapeutic uses of antipyretics: Paracetamol (with synthesis), Analgesics: Ibuprofen (with synthesis), Antimalarials: Chloroquine (with synthesis). An elementary treatment of Antibiotics and detailed study of chloramphenicol, Medicinal values of curcumin (haldi), azadirachtin (neem), vitamin C and antacid (ranitidine).

Reference Books:  
PRACTICAL: CCH-Chem-11- LAB


1. Preparations of the following compounds:
   i. Aspirine,
   ii. Phenacetin,
   iii. Milk of magnesia,
   iv. Aluminum hydroxide gel,
   v. Divol.

2. Saponification value of oil or a fat.

3. Determination of Iodine number of an oil/ fat.

Reference Books:
• Arthur, I. Vogel, Quantitative Organic Analysis, Pearson.
SEMESTER-V
CHEMISTRY (HONOURS)
Paper: CCH-Chem-12
Sub: - Physical chemistry-V
Marks: 75-(End term 60 +Mid-term: 15)

Duration: 3 Hours
Lecture: 60

[Group-A: 18 marks: twelve questions (four questions from each unit) to be asked and nine questions have to be answered carrying 2 marks each.

Group-B: 42 marks: One long type question from each unit (each can also be subdivided) with one alternative each has to be answered.]

UNIT-I:
A. Quantum Chemistry

B. Chemical Bonding

UNIT-II: Molecular Spectroscopy-I
UNIT-III: Molecular Spectroscopy-II

A. Electronic spectroscopy: Franck-Condon principle, electronic transitions, singlet and triplet states, fluorescence and phosphorescence, dissociation and predissociation..

B. Photochemistry

Reference Books:

PRACTICAL: CCH-Chem-12- LAB


Colourimetry
1. Determine the concentration of HCl against 0.1 N NaOH spectrophotometrically.
2. To find the strength of given ferric ammonium sulfate solution of (0.05 M) by using EDTA spectrophotometrically.
3. To find out the strength of CuSO4 solution by titrating with EDTA spectrophotometrically.
4. To determine the concentration of Cu(II) and Fe(III) solution photometrically by titrating With EDTA

Reference Books:
• Experimental Physical Chemistry by J. N. Gurtu, R. Kapoor.
DISCIPLINE SPECIFIC ELECTIVE (DSE)
SEMESTER-V
CHEMISTRY (HONOURS)
Paper: DSE-Chem-1
Subject: Polymer Chemistry

Duration: 3 Hours
Marks: 75 (Midterm-15, Endterm-60)
Lecturer: 60

[Group-A: 18 marks: twelve questions (four questions from each unit) to be asked and nine questions have to be answered carrying 2 marks each.
Group-B: 42 marks: One long type question from each unit (each can also be subdivided) with one alternative each, has to be answered]

UNIT-I: Introduction and history of polymeric materials:
Different schemes of classification of polymers, Polymer nomenclature, Molecular forces and chemical bonding in polymers, Texture of Polymers.
Functionality and its importance:

UNIT-II: Kinetics of Polymerization:
Mechanism and kinetics of step growth, radical chain growth, ionic chain (both cationic and anionic) and coordination polymerizations, Mechanism and kinetics of copolymerization, polymerization techniques.
Crystallization and crystallinity:
Determination of crystalline melting point and degree of crystallinity, Morphology of crystalline polymers, Factors affecting crystalline melting point.
Nature and structure of polymers-Structure property relationships

UNIT-III
A. Determination of molecular weight of polymers
(Mn, Mw, etc.) by end group analysis, viscometry, light scattering and osmotic pressure methods.
Molecular weight distribution and its significance. Polydispersity index. (8 Lectures)
Glass transition temperature (Tg) and determination of Tg
WLF equation, Factors affecting glass transition temperature (Tg)

B. Polymer Solution
Criteria for polymer solubility, Solubility parameter, Thermodynamics of polymer solutions, entropy, enthalpy, and free energy change of mixing of polymers solutions
Properties of Polymers
(Physical, thermal & mechanical properties). Brief introduction to preparation, structure, properties and application of the following polymers: polyolefins, polystyrene and styrene copolymers, poly(vinyl chloride) poly(vinyl acetate), polycrylamide, fluoro polymers (Teflon), polyamides (nylon-6 and nylon 6,6), Phenol formaldehyde resins (Bakelite, Novalac), polyurethanes, silicone polymers (polysiloxane), Polycarbonates, Conducting Polymers, (polyacetylene, polyaniline).
Reference Books:

• Seymours Polymer Chemistry, Marcel Dekker, Inc.
• G. Odian: Principles of Polymerization, John Wiley.
• F.W. Billmeyer: Text Book of Polymer Science, John Wiley.
• P. Ghosh: Polymer Science & Technology, Tata Mcgraw-Hill.
• R.W. Lenz: Organic Chemistry of Synthetic High Polymers.

PRACTICAL: DSE-Chem-1-LAB


Polymer synthesis
1. Free radical solution polymerization of styrene (St) / Methyl Methacrylate (MMA) / Methyl Acrylate (MA) / Acrylic acid (AA).
   (a) Purification of monomer.
   (b) Polymerization using benzoyl peroxide (BPO) / 2,2-azo-bis-isobutylonitrile (AIBN).
3. Interfacial polymerization, preparation of polyester from isophthaloyl chloride (IPC) and phenolphthalein.
   (a) Preparation of IPC.
   (b) Purification of IPC.
   (c) Interfacial polymerization.
4. Redox polymerization of acrylamide.
5. Precipitation polymerization of acrylonitrile.
6. Preparation of urea-formaldehyde resin.
7. Preparations of novalac resin/resold resin.
8. Microscale Emulsion Polymerization of poly(methylacrylate).

Polymer characterization
1. Determination of molecular weight by viscometry:
   (a) Polyacrylamide-aq. NaNO2 solution
   (b) (Poly vinyl propyldine (PVP) in water
2. Determination of the viscosity-average molecular weight of poly(vinyl alcohol) (PVOH) and the fraction of head-to-head monomer linkages in the polymer.
3. Determination of molecular wt. by end group analysis: Polyethylene glycol (PEG) (OH group).
4. Determination of hydroxyl number of a polymer using colorimetric method.

Polymer analysis
1. Estimation of the amount of HCHO in the given solution by sodium sulphite method
2. Instrumental Techniques
3. IR studies of polymers

*at least 5 experiments to be carried out.

Reference Books:

• Malcolm P. Stevens, Polymer Chemistry: An Introduction, 3rd Ed.
• Petr Munk and Tejraj M. Aminabhavi, Introduction to Macromolecular Science, 2nd ed. John
DISCIPLINE SPECIFIC ELECTIVE (DSE)
SEMESTER-V
CHEMISTRY (HONOURS)
Paper: DSE-Chem- 2
Subject: Green Chemistry

Duration: 3Hours

Marks: 75 (Midterm-15, Endterm-60)

[Group-A: 18marks: twelve questions (four questions from each unit) to be asked and nine
questions have to be answered carrying 2 marks each.
Group-B: 42marks: One long type question from each unit (each can also be subdivided) with one
alternative each, has to be answered])

UNIT-I: Introduction to Green Chemistry
What is Green Chemistry? Need for Green Chemistry. Goals of Green Chemistry. Limitations/
Obstacles in the pursuit of the goals of Green Chemistry. (4 Lectures)

Principles of Green Chemistry and Designing a Chemical synthesis-I
Twelve principles of Green Chemistry with their explanations and examples with special emphasis
on: Designing a Green Synthesis using these principles; Prevention of Waste/ byproducts; maximum
incorporation of the materials used in the process into the final products, Atom Economy, calculation
of atom economy of the rearrangement, addition, substitution and elimination reactions. Prevention/
iminization of hazardous/ toxic products reducing toxicity. risk = (function) hazard exposure;
waste or pollution prevention hierarchy. Green solvents supercritical fluids, water as a solvent for
organic reactions, ionic liquids, fluorous biphasic solvent, PEG, solventless processes, immobilized
solvents and how to compare greenness of solvents.

UNIT-II:
Principles of Green Chemistry and Designing a Chemical synthesis-II
Explanation of principles with special emphasis on: Energy requirements for reactions alternative
sources of energy: use of microwaves and ultrasonic energy. Selection of starting materials;
avoidance of unnecessary derivatization careful use of blocking/protecting groups. Use of catalytic
reagents (wherever possible) in preference to stoichiometric reagents; catalysis and green chemistry,
comparison of heterogeneous and homogeneous catalysis, biocatalysis, asymmetric catalysis and
photocatalysis. Prevention of chemical accidents designing greener processes, inherent safer design,
principle of ISD What you dont have cannot harm you, greener alternative to Bhopal Gas Tragedy
(safer route to carcarbaryl) and Fliborough accident (safer route to cyclohexanol) subdivision of
ISD, minimization, simplification, substitution, moderation and limitation. Strengthening/ development
of analytical techniques to prevent and minimize the generation of hazardous substances in
chemical processes.

UNIT-III:
Examples of Green Synthesis/ Reactions and some real world cases
Green Synthesis of the following compounds: adpic acid, catechol, disodium iminodiacetate (alter-
native to Strecker synthesis) Microwave assisted reactions in water: Hofmann Elimination, methyl
benzoate to benzoic acid, oxidation of toluene and alcohols; microwave assisted reactions in or-
ganic solvents: Diels-Alder reaction and Decarboxylation reaction. Ultrasound assisted reactions:
sonochemical Simmons-Smith Reaction (Ultrasound alternative to Iodine). Surfactants for carbon
dioxide replacing smog producing and ozone depleting solvents with CO2 for precision cleaning and
dry cleaning of garments. Designing of Environmentally safe marine antifoulant.
Reference Books:

PRACTICAL: DSE-Chem-2-LAB

1. Safer starting materials.
   • The Vitamin C clock reaction using Vitamin C tablets, tincture of iodine, hydrogen peroxide and liquid laundry starch.
   • Effect of concentration on clock reaction.
   • Preparation and characterization of nanoparticles (Ag, Au) using plant extract.
2. Using renewable resources
   • Preparation of biodiesel from vegetable oil.
3. Avoiding waste
   • Principle of atom economy.
   • Use of molecular model kit to stimulate the reaction to investigate how the atom economy can illustrate Green Chemistry.
   • Preparation of propene by two methods can be studied.
     (I) Triethylamine ion + OH$^-$ $\xrightarrow{\text{H}_2\text{SO}_4}$ propene + trimethylpropene + water
     (II) 1-propanol $\rightarrow$ propene + water
   • The other types of reactions, like addition, elimination, substitution and rearrangement should also be studied for the calculation of atom economy. 4. Use of enzymes as catalysts
   • Benzoin condensation using Thiamine Hydrochloride as a catalyst instead of cyanide
5. Alternative Green solvents
Diels Alder reaction in water
   • Reaction between furan and maleic acid in water and at room temperature rather than in benzene and reflux.
   • Extraction of D-limonene from orange peel using liquid CO$_2$ prepared form dry ice.
   • Mechanochemical solvent free synthesis of azomethines
4. Alternative sources of energy
   • Solvent free, microwave assisted one pot synthesis of phthalocyanine complex of Cu (II).
   • Photoreduction of benzophenone to benzoinacol in the presence of sunlight.
Reference Books:

• Ryan, M.A. Introduction to Green Chemistry, Tinnesand; (Ed), American Chemical Society, Washington DC (2002).
• Cann, M.C. & Connelly, M. E. Real world cases in Green Chemistry, American Chemical Society (2008).
• Cann, M. C. & Thomas, P. Real world cases in Green Chemistry, American Chemical Society (2008).
SEMESTER-VI
CHEMISTRY (HONOURS)
Paper: CCH-Chem-13
Sub: - Inorganic chemistry-IV
Duration: 3 Hours  Marks: 75-(End term 60 +Mid-term: 15)
Lecture:-60

[Group-A: 18 marks: twelve questions (four questions from each unit) to be asked and nine
questions have to be answered carrying 2 marks each.
Group-B: 42 marks: One long type question from each unit (each can also be subdivided) with
one alternative each has to be answered.]

UNIT-I:
A.Organometallic Compounds-I
Definition and classification of organometallic compounds on the basis of bond type. Concept of
hapticity of organic ligands. Metal carbonyls: 18 electron rule, electron count of mononuclear,
polyunuclear and substituted metal carbonyls of 3d series. General methods of preparation (direct
combination, reductive carbonylation, thermal and photochemical decomposition) of mono and
binuclear carbonyls of 3d series. Structures of mononuclear and binuclear carbonyls of Cr, Mn, Fe,
Co and Ni using VBT. -acceptor behaviour of CO (MO diagram of CO to be discussed), synergetic
effect and use of IR data to explain extent of back bonding. Zeises salt: Preparation and structure,
evidences of synergetic effect and comparison of synergetic effect with that in carbonyls.

B. Organometallic Compounds-II
Metal Alkyls: Important structural features of methyl lithium (tetramer) and trialkyl aluminium
(dimer), concept of multicentre bonding in these compounds. Role of triethylaluminium in poly-
merisation of ethene (Ziegler Natta Catalyst). Species present in ether solution of Grignard reagent
and their structures. Ferrocene: Preparation and reactions (acetylation, alkylation, metallation,
Mannich Condensation), structure and aromaticity, comparison of aromaticity and reactivity with
that of benzene.

UNIT-II:
A.Theoretical Principles in Qualitative Analysis (H2S Scheme)
Basic principles involved in analysis of cations and anions and solubility products, common ion effect.
Principles involved in separation of cations into groups and choice of group reagents. Interfering
anions (fluoride, borate, oxalate and phosphate) and need to remove them after Group II.

B.Catalysis by Organometallic Compounds
Alkene hydrogenation (Wilkinsons Catalyst), Hydroformylation (Co salts), Wacker Process,
Synthetic gasoline (Fischer Tropsch reaction).

UNIT-III: Reaction Kinetics and Mechanism
Introduction to inorganic reaction mechanisms. Substitution reactions in square planar complexes,
Trans-effect and its applications, theories of trans effect, Mechanism of nucleophilic substitution in
square planar complexes. Thermodynamic and kinetic stability, Kinetics of octahedral substitution
(classification of metal ions based on water exchange rate), General mechanism of substitution in
octahedral complexes (D, I, Id, Ia).

Reference Books:

**PRACTICAL: CCH-Chem-13- LAB**


Qualitative semimicro analysis of mixtures containing 3 anions and 3 cations. Emphasis should be given to the understanding of the chemistry of different reactions. The following radicals are suggested:

\[
\text{CO}_3^{2-}, \text{NO}_2^-, \text{S}^{2-}, \text{SO}_3^{2-}, \text{CH}_3\text{COO}^- \text{, } \text{S}_2\text{O}_3^{2-}, \text{F}^-, \text{Cl}^-, \text{Br}^-, \text{I}^-, \text{NO}_3^-, \text{BO}_3^{2-}, \text{C}_2\text{O}_4^{2-}, \text{PO}_4^{3-}, \text{NH}_4^+, \text{K}^+, \text{Pb}^{2+}, \text{Cd}^{2+}, \text{Cu}^{2+}, \text{Bi}^{3+}, \text{Sn}^{2+}, \text{Sb}^{3+}, \text{Fe}^{3+}, \text{Al}^{3+}, \text{Cr}^{3+}, \text{Zn}^{2+}, \text{Mn}^{2+}, \text{Co}^{2+}, \text{Ni}^{2+}, \text{Ba}^{2+}, \text{Sr}^{2+}, \text{Ca}^{2+}, \text{Mg}^{2+}
\]

Mixtures should preferably contain one interfering anion, or insoluble component (BaSO_4, SrSO_4, PbSO_4, CaF_2, or Al_2O_3) or combination of anions e.g. CO_3^{2-} and SO_3^{2-}, NO_2^- and NO_3^-, Cl^- and Br^-, Cl^- and I^-, Br^-.

Reference Books:
• Vogels Qualitative Inorganic Analysis, Revised by G. Svehla.
• Marr & Rockett Inorganic Preparations.
SEMESTER-VI
CHEMISTRY (HONOURS)
Paper: CCH-Chem-14
Sub: - Organic chemistry-IV
Marks: 75-(End term 60 +Mid-term: 15)
Duration: 3 Hours

Lecture: -60

[Group-A: 18 marks: twelve questions (four questions from each unit) to be asked and nine
questions have to be answered carrying 2 marks each.
Group-B: 42 marks: One long type question from each unit (each can also be subdivided) with
one alternative each has to be answered.]

UNIT-I:
A. Organic Spectroscopy-I

UV Spectroscopy: Types of electronic transitions, max, Chromophores and Auxochromes,
Bathochromic and Hypsochromic shifts, Intensity of absorption; Application of Woodward rules for
calculation of \( \lambda \) max for the following systems: , the unsaturated aldehydes: ketones, carboxylic
acids and esters; Conjugated dienes: alicyclic, homoannular and heteroannular; Extended conjugated
systems (alde- hydes, ketones and dienes); distinction between cis and trans isomers.

IR Spectroscopy: Fundamental and non-fundamental molecular vibrations; IR absorption positions
of O, N and S containing functional groups; Effect of H-bonding, conjugation, resonance and ring size
on IR absorptions; Fingerprint region and its significance; application in functional group analysis.

B. Organic Spectroscopy-II

NMR Spectroscopy: Basic principles of Proton Magnetic Resonance, chemical shift and factors
influencing it; Spin-spin coupling and coupling constant; Anisotropic effects in alkene, alkyne, alde-
hydes and aromatics; Interpretation of NMR spectra of simple compounds. Mass Spectroscopy-
Basic principle, Fragmentation pattern, Instrumentation, Determination of m/e ratio. Application
of Mass Spectroscopy on CH4, C2H6, n-butane and neo-pentane. Applications of IR, UV and NMR
for identification of simple organic molecules.

UNIT-II: Carbohydrates

Occurrence, classification and their biological importance. Monosaccharides: Constitution and abso-
lute configuration of glucose and fructose, epimers and anomers, mutarotation, determination of ring
size of glucose and fructose, Haworth projections and conformational structures; Interconversions
of aldoses and ketoses; Killiani-Fischer synthesis and Ruff degradation; Disaccharides Structure
eclucidation of maltose. Polysaccharides Elementary treatment of starch, cellulose.

UNIT-III:

A. Dyes

Classification, colour and constitution; Mordant and Vat dyes; Chemistry of dyeing. Synthesis and
applications of: Azo dyes Methyl orange and Congo red (mechanism of Diazo Coupling); Triphenyl
methane dyes - Malachite Green, and crystal violet; Phthalein dyes Phenolphthalein and Fluorescein;
Natural dyes Alizarin and Indigo; Edible dyes with examples.

B. Polymers

Introduction and classification including di-block, tri-block and amphiphilic polymers; Number av-
erage molecular weight, Weight average molecular weight, Degree of polymerization, Polydispersity
Index. Polymerisation reactions -Addition and condensation -Mechanism of cationic, anionic and
free radical addition polymerization; Metallocene-based Ziegler-Natta polymerisation of alkenes;
Preparation and applications of plastics thermosetting (phenol-formaldehyde, Polyurethanes) and
thermosoftening (PVC, polythene); Fabrics natural and synthetic (acrylic, polyamido, polyester);
Rubbers natural and synthetic: Buna-S and Neoprene; Vulcanization; Polymer additives, Biodegrad-
able and conducting polymers with examples.
Reference Books:

• Billmeyer, F. W. Textbook of Polymer Science, John Wiley & Sons, Inc.
• Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
• Kemp, W. Organic Spectroscopy, Palgrave.

PRACTICAL: CCH-Chem-14- LAB


1. Extraction of caffeine from tea leaves.
2. Preparation of sodium polyacrylate.
3. Preparation of urea formaldehyde.
5. Qualitative analysis of unknown organic compounds containing mono-functional groups (carbohydrates, aryl halides, aromatic hydrocarbons, nitro compounds, amines and amides) and simple bifunctional groups, for e.g. salicylic acid, cinnamic acid, nitrophenols etc.

Reference Books:

DISCIPLINE SPECIFIC ELECTIVE (DSE)  
SEMESTER-VI  
CHEMISTRY (HONOURS)  
Paper: DSE-Chem-3  
Subject: Industrial chemicals and environment  
Duration: 3Hours  
Lecturer: 60  

Marks: 75 (Midterm-15, Endterm-60)  

[Group-A: 18marks: twelve questions (four questions from each unit) to be asked and nine questions have to be answered carrying 2 marks each.  
Group-B: 42marks: One long type question from each unit (each can also be subdivided) with one alternative each, has to be answered]  

UNIT-I: Industrial Gases and Inorganic Chemicals  
Industrial Gases: Large scale production, uses, storage and hazards in handling of the following gases: oxygen, nitrogen, argon, neon, helium, hydrogen, acetylene, carbon monoxide, chlorine, sulphur dioxide. Inorganic Chemicals: Manufacture, application and hazards in handling the following chemicals: hydrochloric acid, nitric acid, sulphuric acid, caustic soda, common salt, bleaching powder, sodium thiosulphate, hydrogen peroxide, potash alum, potassium dichromate and potassium permanganate.  

UNIT-II: Environment and its segments  

Greenhouse effect  
and global warming, Ozone depletion by oxides of nitrogen, chlorofluorocarbons and halogens, removal of sulphur from coal.  

UNIT-III:  

B. Energy & Environment  
Sources of energy: Coal, petrol and natural gas. Nuclear fusion/fission, solar energy, hydrogen, geothermal, tidal and hydel. Nuclear Pollution: Disposal of nuclear waste, nuclear disaster and its management.  

Biocatalysis: Introduction to biocatalysis: Importance in green chemistry and chemical industry
Reference Books:
• E. Stocchi: Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK.
• De, Environmental Chemistry: New Age International Pvt., Ltd, New Delhi.
• S. M. Khopkar, Environmental Pollution Analysis: Wiley Eastern Ltd, New Delhi.

PRACTICAL: DSE-Chem-3-LAB

1. Determination of dissolved oxygen in water.
2. Determination of Chemical Oxygen Demand (COD).
3. Determination of Biological Oxygen Demand (BOD).
4. Percentage of available chlorine in bleaching powder.
5. Measurement of chloride, sulphate and salinity of water samples by simple titration method (AgNO₃ and potassium chromate).
7. Estimation of SPM in air samples.
8. Preparation of borax/ boric acid.

Reference Books:
• E. Stocchi: Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK.
• De, Environmental Chemistry: New Age International Pvt., Ltd, New Delhi.
• S. M. Khopkar, Environmental Pollution Analysis: Wiley Eastern Ltd, New Delhi.
DISCIPLINE SPECIFIC ELECTIVE (DSE)
SEMESTER-VI
CHEMISTRY (HONOURS)
Paper: DSE-Chem- 4

Full Marks-100(Report-60, presentation-20, viva-voce-20)

1. Student is required to choose the topic and prepare the dissertation/project work in consultation with the teacher of the Department.
2. The topic chosen must be up to date.
3. Project Report/Dissertation should be of minimum 15(fifteen) pages of one sided printing in Times of Roman font with font size 14 having normal margin in MS Word.
4. The candidate has to submit one hard binding copy for evaluation and have to give the power point presentation.
5. The consult teacher of the Department will undertake to supervise/guide the students in the preparation of the project.
6. Students are required to submit the project to the HOD by 15\textsuperscript{th} March positively

External will be appointed by NOU and evaluated Project Report/Dissertation should be submitted to NOU