

CURRICULUM

In

CHEMISTRY

For

**UNDER GRADUATE COURSES (B.Sc.)
(Annual System)**

**PASSED BY THE BOARD OF STUDIES
IN CHEMISTRY**

(Applicable w.e.f. the session 2019-2020)



**Department of Chemistry
Rishikesh Campus
Sridev Suman Uttarakhand University Badshahithaul
Tehri-Garhwal - 249001
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Proposed Syllabus: Chemistry Course for B.Sc (Annual System)

B. Sc. Chemistry Syllabus

Objective of the course

To teach the fundamental concepts of chemistry and their applications, the syllabus pertaining to B.Sc(3 year degree course) in the subject of chemistry has been prepared as per provision of UGC module and demand of the academic environment. The syllabus concepts are duly arranged unit wise and contents are included in such a manner so that due importance is given to requisite intellectual and laboratory skills. This B. Sc course of chemistry consists of three year course (annual system). Total marks: 600(200 per year).

B.Sc. First Year

Paper	Paper code	Course	Max. Marks	Work Hrs
I	CH-101	Inorganic Chemistry	50	60
II	CH-102	Organic Chemistry	50	60
III	CH-103	Physical Chemistry	50	60
	CH-104	Laboratory Practical	50	60
Grand Total			200	180

B.Sc. Second Year

Paper	Paper code	Course	Max. Marks	Work Hrs
I	CH-201	Inorganic Chemistry	50	60
II	CH-202	Organic Chemistry	50	60
III	CH-203	Physical Chemistry	50	60
	CH-204	Laboratory Practical	50	60
Grand Total			200	180

B.Sc. Third Year

Paper	Paper code	Course	Max. Marks	Work Hrs
I	CH-301	Inorganic Chemistry	50	60
II	CH-302	Organic Chemistry	50	60
III	CH-303	Physical Chemistry	50	60
	CH-304	Laboratory Practical	50	60
Grand Total			200	180

Note: Examiner should follow the below given pattern covering all the units for each section compulsorily:

- Twelve compulsory objective type questions of one mark each, $12 \times 1 = 12$ Marks
- Examinees to solve six short answer questions out of ten question (3 mark each) $3 \times 6 = 18$ Marks.
- Examinees to solve four long answer questions out of seven (5 mark each) $4 \times 5 = 20$ Marks

Distribution of marks for Practical exam will be as follows:

B.Sc. (FIRST YEAR)

(i)	Inorganic Mixture analysis (six radicals)	15
(ii)	Organic Experiment	12
(iii)	Physical Chemistry Experiment	10
(iv)	Viva-voce**	05
(v)	Annual record	08
	Total	50

B.Sc. (SECOND YEAR)

(i)	Inorganic Experiment	15
(ii)	Organic Experiment	12
(iii)	Physical Chemistry Experiment	10
(iv)	Viva-voce**	05
(v)	Annual record	08
	Total	50

B.Sc. (THIRD YEAR)

(i)	Inorganic Experiment	10
(ii)	Organic Experiment	12
(iii)	Physical Chemistry Experiment	15
(iv)	Viva-voce**	05
(v)	Annual record	08
	Total	50

*Full credit of marks shall be given upto 0.5% error after which for each 0.1% error, two marks shall be deducted in Quantitative analysis experiments.

**Viva-voce for ex-students shall carry 13 marks.

Three Years Degree Course Syllabus for
CHEMISTRY
B.Sc. (FIRST YEAR)

There shall be three written papers and a practical examination as follows:

Paper	Paper code	Course	Max. Marks	Work Hrs
I	CH-101	Inorganic Chemistry	50	60
II	CH-102	Organic Chemistry	50	60
III	CH-103	Physical Chemistry	50	60
	CH-104	Laboratory Practical	50	60
Grand Total			200	180

Candidate will be required to pass in Theory and Practical Separately.

B.Sc. – I Year
Chemistry Paper-I
Inorganic Chemistry (Paper Code: CH-101)

Unit – I

I. Atomic Structure:

Idea of de-Broglie matter waves (dual nature), Heisenberg uncertainty principle, atomic orbitals, Schrödinger wave equation, significance of Ψ and Ψ^2 , quantum numbers, radial and angular wave functions and probability distribution curves, shapes of s, p, d, orbitals, Aufbau and Pauli exclusion principles, Hund's multiplicity rule, Electronic configurations of the elements, effective nuclear charge.

Unit – II

II. Periodic Properties:

Atomic and ionic radii, ionization energy, electron affinity and electronegativity definitions, methods of determination or evaluation, trends in periodic table and applications in predicting and explaining the chemical behaviour.

Unit – III

III. Chemical Bonding:

(A) Covalent Bond – Valence bond theory and its limitations, directional characteristics of covalent bond, various types of hybridization and shapes of simple inorganic molecules and ions, valence shell electron pair repulsion(VSEPR) theory to NH_3 , H_3O^+ , SF_4 , ClF_3 , ICl_2^- and H_2O , MO theory, homonuclear and heteronuclear (CO , NO , CN^+ , CO , CN^+ , CO^+ , CN^-) diatomic molecules, multicenter bonding in electron deficient molecules, bond strength and bond energy, percentage ionic character from dipole moment and electro-negativity difference.

(B) Ionic Solids – Ionic structures, radius ratio effect and coordination number, limitation of radius ratio rule, lattice defects, semiconductors, lattice energy and Born-Haber cycle, solvation energy and solubility of ionic solids, polarizing power and polarisability of ions, Fajan's rule, Metallic bond-free electron, valence bond and band theories.

(C) Weak Interactions – Hydrogen bonding, Vander Waals forces.

Unit – IV

- IV. *s*-Block Elements:
Comparative study, diagonal relationship, salient features of hydrides, solvation and complexation tendencies including their function in biosystems, an introduction to alkyls and aryls.
- V. Chemistry of Noble Gases:
Chemical properties of the noble gases, chemistry of xenon, structure and bonding in xenon compounds.

Unit – V

- VI. *p*-Block Elements:
Comparative study (including diagonal relationship) of groups 13-17 elements, compounds like hydrides, oxides, oxyacids and halides of group 13-16, hydrides of boron-diborane and higher boranes, borazine, borohydrides, fullerenes, carbides, fluorocarbons, silicates (structural principle), tetrasulphur tetra nitride, basic properties of halogens, interhalogens and polyhalides.

B. Sc. Ist year
Paper-II
Organic Chemistry

Unit – I

- I. **Structure and Bonding:**
Hybridization, bond lengths and bond angles, bond energy, localized and delocalized chemical bonding, Van der Waals interactions, inclusion compounds, clathrates, charge transfer complexes, resonances, hyperconjugation, aromaticity, inductive and field effects, hydrogen bonding.
- II. **Mechanism of Organic Reactions:**
Homolytic and heterolytic bond fission, Types of reagents –electrophiles and nucleophiles, Types of organic reactions, Energy considerations.
Reactive intermediates – Carbocations, carbanions, free radicals, carbenes, arynes and nitrenes (with examples). Assigning formal charges on intermediates and other ionic species. Methods of determination of reaction mechanism (product analysis, intermediates, isotope effects, kinetic and stereochemical studies).
- III. **Alkanes and Cycloalkanes:**
IUPAC nomenclature of branched and unbranched alkanes, the alkyl group, classification of carbon atom in alkanes, Isomerism in alkanes, sources methods of formation (with special reference to Wurtz reaction, Kolbe's reaction, Corey-House reaction and decarboxylation of carboxylic acids), physical properties and chemical reactions of alkanes, Mechanism of free radical halogenation of alkanes: orientation, reactivity and selectivity.

Cycloalkanes – Nomenclature, methods of formation, chemical reactions, Baeyer's strain theory and its limitations. Ring strain in small rings (cyclopropane and cyclobutane), theory of strain less rings. The case of cyclopropane ring, banana bonds.

Unit – II

IV. **Stereochemistry of Organic Compounds:**

Concept of isomerism, Types of isomerism, Optical isomerism – elements of symmetry, molecular chirality, enantiomers, stereogenic center, optical activity, properties of enantiomers, chiral and achiral molecules with two stereogenic centers, diastereomers, threo and erythro diastereomers, meso compounds, resolution of enantiomers, inversion, retention and racemization. Relative and absolute configuration, sequence rules, D & L and R & S systems of nomenclature.

Geometric isomerism – determination of configuration of geometric isomers, E & Z system of nomenclature, geometric isomerism in oximes and alicyclic compounds.

Conformational isomerism – conformational analysis of ethane and *n*-butane, conformations of cyclohexane, axial and equatorial bonds, conformation of monosubstituted cyclohexane derivatives, Newman projection and Sawhorse formulae, Fischer and flying wedge formulae, Difference between configuration and conformation.

Unit – III

V. **Alkenes, Cycloalkenes, Dienes and Alkynes:**

Nomenclature of alkenes, methods of formation, mechanisms of dehydration of alcohols and dehydrohalogenation of alkyl halides, regioselectivity in alcohol dehydration, The Saytzeff rule, Hofmann elimination, physical properties and relative stabilities of alkenes.

Chemical reactions of alkenes – mechanism involved in hydrogenation, electrophilic and free radical additions, Markownikoff's rule, hydroboration-oxidation, oxymercuration-reduction. Epoxidation, ozonolysis, hydration, hydroxylation and oxidation with KMnO_4 , Polymerization of alkenes, Substitution at the allylic and vinylic positions of alkenes, Industrial applications of ethylene and propene.

Methods of formation, conformation and chemical reactions of cycloalkenes, Nomenclature and classification of dienes: isolated, conjugated and cumulated dienes, Structure of allenes and butadiene, methods of formation, polymerization, chemical reaction – 1, 2 and 1, 4 additions, Diels-Alder reaction.

Nomenclature, structure and bonding in alkynes, Methods of formation, Chemical reactions of alkynes, acidity of alkynes, Mechanism of electrophilic and nucleophilic addition reactions, hydroboration-oxidation, metal-ammonia reductions, oxidation and polymerization.

Unit – IV

VI. **Arenes and Aromaticity:**

Nomenclature of benzene derivatives, The aryl group, Aromatic nucleus and side chain, Structure of benzene, molecular formula and Kekulé structure, stability and carbon-carbon

bond lengths of benzene, resonance structure, MO picture, Aromaticity: The Huckel rule, aromatic ions.

Aromatic electrophilic substitution – general pattern of the mechanism, role of σ and π complexes, Mechanism of nitration, halogenation, sulphonation, mercuration and Friedel-Crafts reaction. Energy profile diagrams. Activating and deactivating substituents, orientation and ortho/para ratio, Side chain reactions of benzene derivatives, Birch reduction; Methods of formation and chemical reactions of alkylbenzenes, alkynylbenzenes and biphenyl, naphthalene and Anthracene.

Unit-V

VII. **Alkyl and Aryl Halides:**

Nomenclature and classes of alkyl halides, methods of formation, chemical reactions, Mechanisms of nucleophilic substitution reactions of alkyl halides, S_{N2} and S_{N1} reactions with energy profile diagrams;

Polyhalogen compounds: Chloroform, carbon tetrachloride; Methods of formation of aryl halides, nuclear and side chain reactions, The addition-elimination and the elimination-addition mechanisms of nucleophilic aromatic substitution reactions, Relative reactivities of alkyl halides vs allyl, vinyl and aryl halides, Synthesis and uses of DDT and BHC.

B.Sc. – I Chemistry

Paper-III

Physical Chemistry

Unit – I

I. **Gaseous States:**

Postulates of kinetic theory of gases, deviation from ideal behavior, Van der Waals equation of state, Critical Phenomena: PV isotherms of real gases, continuity of states, the isotherms of Van der Waals equation, relationship between critical constants and Van der Waals constants, the law of corresponding states, reduced equation of state.

Molecular velocities: Root mean square, average and most probable velocities, Qualitative discussion of the Maxwell's distribution of molecular velocities, collision number, mean free path and collision diameter, Liquification of gases (based on Joule –Thomson effect).

Unit – II

II. **Liquid State:**

Intermolecular forces, structure of liquids (a qualitative description), Structural differences between solids, liquids and gases, Liquid crystals: Difference between liquid crystal, solid

and liquid, Classification, structure of nematic and cholestric phases, Thermography and seven segment cells.

Unit – III

III. **Solid States:**

Definition of space lattice, unit cell, Laws of crystallography – (i) Law of constancy of interfacial angles, (ii) Law of rationality of indices (iii) Law of symmetry, Symmetry elements in crystals. X-ray diffraction by crystals, Derivation of Bragg equation, Determination of crystal structure of NaCl, KCl and CsCl (Laue's method and powder method).

IV. **Colloidal States:**

Definition of colloids, classification of colloids, Solids in liquids (sols): properties – kinetic, optical and electrical; stability of colloids, protective action, Hardy-Schulze law, gold number. Liquids in liquids (emulsions): types of emulsions, preparation, Emulsifier, Liquids in solids (gels): classification, preparation and properties, inhibition, general application of colloids, colloidal electrolytes.

Unit – IV

V. **Chemical Kinetics and Catalysis:**

Chemical kinetics and its scope, rate of a reaction, factors influencing the rate of a reaction – concentration, temperature, pressure, solvent, light catalyst, concentration dependence of rates, mathematical characteristics of simple chemical reactions – zero order, first order, second order, pseudo order, half life and mean life, Determination of the order of reaction – differential method, method of integration, method of half life period and isolation method. Radioactive decay as a first order phenomenon, Experimental methods of chemical kinetics: conductometric, potentiometric, optical methods, polarimetry and spectrophotometer. Theories of chemical kinetics: effect of temperature on rate of reaction, Arrhenius equation, concept of activation energy. Simple collision theory based on hard sphere model, transition state theory (equilibrium hypothesis), Expression for the rate constant based on equilibrium constant and thermodynamic aspects.

Catalysis, characteristics of catalyzed reactions, classification of catalysis homogeneous and heterogeneous catalysis, enzyme catalysis, miscellaneous examples.

B.Sc. – I (PRACTICAL) 180 hrs (6 Hrs/week)

Atleast three practicals from each specialization should be carried out.

Inorganic Chemistry:

- I. Semi micro Analysis – Mixture analysis for six radicals (3 cations & 3 anions), including interfering radicals.

Organic Chemistry:

Laboratory techniques:

- II. Calibration of Thermometer- 80-82⁰(Naphthalene), 113.5-114⁰(Acetanilide) 132.5-133⁰(Urea), 100⁰(Distilled Water)
- III. Determination of melting point:

- Naphthalene 80-82^o, Benzoic acid 121.5-122^o, Urea 132.5-133^o, Succinic acid 184.5-185^o, Cinnamic acid 132.5-133^o, Salicylic acid 157.5-158^o, Acetanilide 113.5-114^o, m-Dinitrobenzene 90^o, p-Dichlorobenzene 52^o, Aspirin 135^o
- IV. Determination of boiling point:
Ethanol 78^o, Cyclohexane 81.4^o, Toluene 110.6^o, Benzene 80^o
Mixed melting point determination:
Urea-Cinnamic acid mixture of various compositions (1:4, 1:1, 4:1)
- V. Distillation:
Simple distillation of ethanol-water mixture using water condenser, Distillation of nitrobenzene and aniline using air condenser
- VI. Crystallization:
Concept of induction of crystallization, Phthalic acid from hot water (using fluted filter paper and steamless funnel) Acetanilide from boiling water, Naphthalene from ethanol, Benzoic acid from water
Decolorisation and crystallization using charcoal:
Decolorisation of brown sugar (sucrose) with animal charcoal using gravity filtration.
Crystallization and decolorisation of impure naphthalene (100g of naphthalene mixes with 0.3 g of Congo Red using 1g decolorizing carbon) from ethanol.
- VII. Sublimation (Simple and Vacuum): Camphor, Naphthalene, Phthalic acid and succinic acid.
Qualitative Analysis:
- VIII. Detection of extra elements (N, S and halogens) and functional groups (phenolic, carboxylic, carbonyl, esters, carbohydrates, amines, amides, nitro and anilide) in simple organic compounds.
Physical Chemistry:
- IX. Chemical Kinetics:
1. To determine the specific reaction rate of the hydrolysis of methyl acetate/ethyl acetate catalyzed by hydrogen ions at rooms temperature.
2. To study the effect of acid strength on the hydrolysis of an ester.
3. To compare the strengths of HCl and H₂SO₄ by studying the kinetics of hydrolysis of ethyl acetate.
4. To study kinetically the reaction rate of decomposition of iodide by H₂SO₄.
Distribution Law:
1. To study the distribution of iodine between water and CCl₄.
2. To study the distribution of benzoic acid between benzene and water.
- X. Viscosity, Surface Tension:
1. To determine the percentage composition of a given mixture (non interacting systems) by viscosity method.
2. To determine the viscosity of amyl alcohol in water at different concentration and calculate the excess viscosity of these solutions.
3. To determine the percentage composition of a given binary mixture by surface tension method (acetone & ethyl methyl ketone).

B.Sc. (SECOND YEAR)

There shall be three written papers and a practical examination as follows:

Paper	Paper code	Course	Max. Marks	Work Hrs
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I	CH-201	Inorganic Chemistry	50	60
II	CH-202	Organic Chemistry	50	60
III	CH-203	Physical Chemistry	50	60
	CH-204	Laboratory Practical	50	60
Grand Total			200	180

Candidate will be required to pass in Theory and Practical Separately.

B.Sc. – II
Chemistry Paper-I
Inorganic Chemistry

Unit – I

- I. Chemistry of Elements of First Transition Series:
Characteristic properties of d-block elements. Binary compounds (hydrides, carbides and oxides) of the elements of the first transition series and complexes with respect to relative stability of their oxidation states, coordination number and geometry.
- II. Chemistry of Elements of Second and Third Transition Series:
General characteristics, comparative treatment of Zr/Hf, Nb/Ta, Mo/W in respect of ionic radii, oxidation states, magnetic behavior, spectral properties and stereochemistry.

Unit – II

- III. Coordination Compounds
Werner's coordination theory and its experimental verification, effective atomic number concept, chelates, nomenclature of coordination compounds, isomerism in coordination compounds, valence bond theory of transition metal complexes.

Unit – III

- IV. Chemistry of Lanthanide Elements
Electronic structure, oxidation states and ionic radii and lanthanide contraction, complex formation, occurrence and isolation, ceric ammonium sulphate and its analytical uses.
- V. Chemistry of Actinides
Electronic configuration, oxidation states and magnetic properties, chemistry of separation of Np, Pu and Am from U.

Unit – IV

- VI. Oxidation and Reduction
Electrode potential, electrochemical series and its applications, Principles involved in the extraction of the elements.

Unit - V

- VII. Acids and Bases

Arrhenius, Bronsted-Lowry, the Lux-Flood, solvent system and Lewis concept of acids and bases.

VIII. Non-aqueous Solvents

Physical properties of a solvent, types of solvents and their general characteristics, Reactions in non-aqueous solvents with reference to liquid NH_3 and Liquid SO_2 .

B.Sc. – II
Chemistry Paper-II
Organic Chemistry

Unit – I

I. Electromagnetic Spectrum Absorption Spectra

Ultraviolet (UV) absorption spectroscopy – absorption laws (Beer-Lambert law), molar absorptivity, presentation and analysis of UV spectra, types of electronic transitions, effect of conjugation. Concept of chromophore and auxochrome, Bathochromic, hypsochromic, hyperchromic and hypochromic shifts. U.V. spectra of conjugated enes and enones.

Infrared (I.R.) absorption spectroscopy – molecular vibrations, Hooke's law, selection rules, intensity and position of I.R. bands, measurement of I.R. spectrum, finger print region, characteristic absorptions of various functional groups and interpretation of I.R. spectra of simple organic compounds.

Unit – II

II. Alcohols

Classification and nomenclature, Monohydric alcohols – nomenclature, methods of formation by reduction of Aldehydes, Ketones, Carboxylic acids and Esters, Hydrogen bonding, Acidic nature, Reactions of alcohols.

Dihydric alcohols - – nomenclature, methods of formation, chemical reactions of vicinal glycols, oxidative cleavage [$\text{Pb}(\text{OAc})_4$ and HIO_4] and pinacol- pinacolone rearrangement.

Trihydric alcohols - nomenclature, methods of formation, chemical reactions of glycerol.

III. Phenols :

Nomenclature, structure and bonding, preparation of phenols, physical properties and acidic character, Comparative acidic strengths of alcohols and phenols, resonance stabilization of phenoxide ion. Reactions of phenols – electrophilic aromatic substitution, acylation and carboxylation. Mechanisms of Fries rearrangement, Claisen rearrangement, Gatterman synthesis, Hauben-Hoesch reaction, Lederer-Manasse reaction and Reimer-Tiemann reaction.

Unit – III

IV. Ethers and Epoxides

Nomenclature of ethers and methods of their formation, physical properties, Chemical reactions – cleavage and autoxidation, Ziesel's method.

Synthesis of epoxides, Acid and base-catalyzed ring opening of epoxides, orientation of epoxide ring opening, reactions of Grignard and organo lithium reagents with epoxides.

- V. Aldehydes and Ketones:
Nomenclature and structure of the carbonyl groups, synthesis of aldehydes and ketones with particular reference to the synthesis of aldehydes from acid chlorides, synthesis of aldehydes and ketones uses 1, 3-dithianes, synthesis of ketones from nitrites and from carboxylic acids, Physical properties. Mechanism of nucleophilic additions to carbonyl group with particular emphasis on benzoin, aldol, Perkin and Knoevenagel condensations, Condensation with ammonia and its derivatives. Wittig reaction, Mannich reaction.
Use of acetals as protecting group, Oxidation of aldehydes, Baeyer-Villiger oxidation of Ketones, Cannizzaro reaction, MPV, Clemmensen, Wolff-Kishner, LiAlH_4 and NaBH_4 reductions. Halogenation of enolizable ketones, An introduction to O, P unsaturated aldehydes and Ketones.

Unit – IV

- VI. Carboxylic Acids:
Nomenclature, structure and bonding, physical properties, acidity of carboxylic acids, effects of substituents on acid strength, Preparation of carboxylic acids, Reactions of carboxylic acids, Hell-Volhard-Zelinsky reaction, Synthesis of acid chlorides, esters and amides, Reduction of carboxylic acids, Mechanism of decarboxylation. Methods of formation and chemical reactions of halo acids, Hydroxy acids: malic, tartaric and citric acids. Methods of formation and chemical reactions of unsaturated monocarboxylic acids. Dicarboxylic acids: methods of formation and effect of heat and dehydrating agents.
- VII. Carboxylic Acid Derivatives
Structure and nomenclature of acid chlorides, esters, amides (urea) and acid anhydrides. Relative stability of acyl derivatives, Physical properties, interconversion of acid derivatives by nucleophilic acyl substitution. Preparation of carboxylic acid derivatives, chemical reaction. Mechanisms of esterification and hydrolysis (acidic and basic)

Unit - V

- VIII. Organic Compounds of Nitrogen:
Preparation of nitroalkanes and nitroarenes, Chemical reactions of nitroalkanes. Mechanisms of nucleophilic substitution in nitroarenes and their reductions in acidic, neutral and alkaline media, Picric acid.
Halogenoarenes: reactivity, Structure and nomenclature of amines, physical properties, Stereochemistry of amines, Separation of a mixture of primary, secondary and tertiary amines. Structural features effecting basicity of amines. Amine salts as phase-transfer catalysts, Preparation of alkyl and aryl amines (reduction of nitro compounds, nitrites), reductive amination of aldehydic and ketonic compounds, Gabriel-phthalimide reaction, Hofmann-bromamide reaction. Reactions of amines, electrophilic aromatic substitution in aryl amines, reactions of amines with nitrous acid. Synthetic transformations of aryl diazonium salts, azo coupling.

Physical Chemistry

Unit – I

I. Thermodynamics – I

Definitions of thermodynamic terms: System, surroundings etc. types of systems, intensive and extensive properties, State and path functions and their differentials, Thermodynamic processes, concept of heat and work.

First Law of Thermodynamics: Statement, definition of internal energy and enthalpy, Heat capacity, heat capacities at constant volume and pressure and their relationship, Joule's law – Joule-Thomson coefficient and inversion temperature. Calculation of w , q , δU & δH for the expansion of ideal gases under isothermal and adiabatic conditions for reversible process.

Thermochemistry: Standard state, standard enthalpy of formation – Hess's Law of heat summation and its applications, Heat of reaction at constant pressure and at constant volume, Enthalpy of neutralization, Bond dissociation energy and its calculation from thermochemical data, temperature dependence of enthalpy, Kirchhoff's equation

Unit – II

II. Thermodynamics – II

Second Law of Thermodynamics: Need for the law, different statements of the law, Carnot's cycle and its efficiency, Carnot's theorem. Thermodynamic scale of temperature.

Concept of entropy: Entropy as a state function, entropy as a function of V & T , entropy as a function of P & T , entropy change in physical change, Clausius inequality, entropy as a criteria of spontaneity and equilibrium, Equilibrium change in ideal gases and mixing of gases.

Gibbs and Helmholtz functions: Gibbs function (G) and Helmholtz function (A) as thermodynamic quantities, A & G as criteria for thermodynamic equilibrium and spontaneity, their advantage over entropy change, Variation of G and A with P , V and T .

Third Law of Thermodynamics: Nernst heat theorem, statement and concept of residual entropy. Nernst distribution law – thermodynamic derivation, applications.

Unit - III

III. Chemical Equilibrium

Equilibrium constant and free energy, Thermodynamic derivation of law of mass action, Le Chatelier's principle. Reaction isotherm and reaction isochore – Clapeyron-Clausius equation and its applications.

Unit – IV

IV. Electrochemistry – I:

Electrical transport: Conduction in metals and in electrolyte solutions, specific conductance molar and equivalent conductance, measurement of equivalent conductance, variation of molar equivalent and specific conductance with dilution.

Migration of ions and Kohlrausch's law, Arrhenius theory of electrolyte dissociation and its limitations, weak and strong electrolytes, Ostwald's dilution law its uses and limitations, Debye-Huckel-Onsager's equation for strong electrolytes (elementary treatment only),

Transport number, definition and determination by Hittorf's method and moving boundary method.

Applications of conductivity measurements: determination of degree of dissociation, determination of K_a of acids, determination of solubility product of a sparingly soluble salt, conductometric titrations.

V. Solutions:

Liquid – Liquid mixtures- Ideal liquid mixtures, Raoult's and Henry's law, Non-ideal system-azeotropes – HCl-H₂O and ethanol – water systems.

Partially miscible liquids- Phenol – water, trimethylamine – water, nicotine-water systems, Immiscible liquids, steam distillation.

Unit – V

VI. Electrochemistry – II:

Types of reversible electrodes – gas-metal ion, metal-ion, metal-insoluble salt anion and redox electrodes, Electrode reactions, Nernst equation, derivation of cell E.M.F. and single electrode potential, standard hydrogen electrode-reference electrodes and their applications, standard electrode potential, sign conventions, electrochemical series and its significance.

Electrolytic and Galvanic cells–reversible and irreversible cells, conventional representation of electrochemical cells, EMF of a cell and its measurements, Computation of cell EMF, Calculation of thermodynamic quantities of cell reactions (QG, QH and K) Concentration cell with and without transport, liquid junction potential, application of concentration cells, valency of ions, solubility product and activity coefficient, potentiometric titrations.

Definition of pH and pK_a, determination of pH using hydrogen, quinhydrone and glass electrodes, by potentiometric methods, Buffers – Mechanism of buffer action, Henderson-Hassel equation, application of buffer solution, Hydrolysis of salts

VII. Phase Equilibrium:

Statement and meaning of the terms-phase, component and degree of freedom, derivation of Gibb's phase rule, phase equilibria of one component system-water, 'CO₂' and 'S' systems

Phase equilibria of two component system – solid liquid equilibria simple eutectic – Bi-Cd, Pb-Ag systems, desilverisation of lead.

Solid solutions – compound formation with congruent melting point (Mg-Zn) and incongruent melting point, (FeCl₃-H₂O) and (CuSO₄-H₂O) system

B.Sc. – II (Laboratory Practical) 180 hrs. (6 hrs/week)

Atleast three practicals from each specialization should be carried out.

Inorganic Chemistry:

I. Calibration of fractional weights, pipettes and burettes, Preparation of standard solutions, Dilution – 0.1 M to 0.001 M solutions.

Quantitative Analysis:

II. Volumetric Analysis:

(a) Determination of acetic acid in commercial vinegar using NaOH.

(b) Determination of alkali content – antacid tablet using HCl.

- (c) Estimation of calcium content in chalk as calcium oxalate by permanganometry.
 - (d) Estimation of hardness of water by EDTA.
 - (e) Estimation of ferrous and ferric by dichromate method.
 - (f) Estimation of copper using thiosulphate.
- III. Gravimetric Analysis:
Analysis of Cu as CuSCN and Ni as Ni (dimethylglyoxime).
Organic Chemistry
Laboratory Techniques
- IV. A. Thin Layer Chromatography
Determination of R_f values and identification of organic compounds:
(a) Separation of green leaf pigments (spinach leaves may be used).
(b) Preparation of separation of 2, 4-dinitrophenylhydrazones of acetone, 2-butanone, hexan-2, and 3-one using toluene and light petroleum (40:60)
(c) Separation of a mixture of dyes using cyclohexane and ethyl acetate (8.5:1.5).
- V. B. Paper Chromatography: Ascending and Circular
Determination of R_f values and identification of organic compounds:
(a) Separation of a mixture of phenylalanine and glycine, Alanine and aspartic acid, Leucine and glutamic acid, Spray reagent – ninhydrin.
(b) Separation of a mixture of D, L – alanine, glycine, and L-Leucine using *n*-butanol: acetic acid:water (4:1:5), Spray reagent – ninhydrin.
(c) Separation of monosaccharide – a mixture of D-galactose and D-fructose using *n*-butanol:acetone:water (4:5:1), spray reagent – aniline hydrogen phthalate.
- VI. Qualitative Analysis:
Identification of an organic compound through the functional group analysis, determination of melting point and preparation of suitable derivatives.
Physical Chemistry
- VII. Transition Temperature
1. Determination of the transition temperature of the given substance by thermometric /dilatometric method (e.g. $\text{MnCl}_2 \cdot 4\text{H}_2\text{O}/\text{SrBr}_2 \cdot 2\text{H}_2\text{O}$).
- VIII. Phase Equilibrium
2. To study the effect of a solute (e.g. NaCl, succinic acid) on the critical solution temperature of two partially miscible liquids (e.g. phenol-water system) and to determine the concentration of that solute in the given phenol-water system.
3. To construct the phase diagram of two component (e.g. diphenylamine –benzophenone) system by cooling curve method.
- IX. Thermochemistry
1. To determine the solubility of benzoic acid at different temperatures and to determine Q_H of the dissolution process.
2. To determine the enthalpy of neutralization of a weak acid/weak base versus strong base/strong acid and determine the enthalpy of ionization of the weak acid/weak base.
3. To determine the enthalpy of solution of solid calcium chloride and calculate the lattice energy of calcium chloride from its enthalpy data using Born Haber Cycle.

B.Sc. (THIRD YEAR)

There shall be three written papers and a practical examination as follows:

Paper	Paper code	Course	Max. Marks	Work Hrs
I	CH-301	Inorganic Chemistry	50	60
II	CH-302	Organic Chemistry	50	60
III	CH-303	Physical Chemistry	50	60
	CH-304	Laboratory Practical	50	60
Grand Total			200	180

Candidate will be required to pass in Theory and Practical Separately.

B.Sc. – III Chemistry (Paper-I)
Inorganic Chemistry

Unit – I

- I. Metal-ligand bonding in Transition Metal Complexes
Limitations of valence bond theory, an elementary idea of crystal field theory, crystal field splitting in octahedral, tetrahedral and square planar complexes, factors affecting the crystal-field parameters.
- II. Thermodynamic and Kinetic Aspects of Metal Complexes
A brief outline of thermodynamic stability of metal complexes and factors affecting the stability, stability constants of complexes and their determination, substitution reactions of square planar complexes.

Unit – II

- III. Magnetic Properties of Transition Metal Complexes
Types of magnetic behavior, methods of determining magnetic susceptibility, spin-only formula, L-S coupling, correlation of μ_s and μ_{eff} values, orbital contribution to magnetic moments, application of magnetic moment data for 3d-metal complexes.
- IV. Electronic spectra of Transition Metal Complexes
Types of electronic transitions, selection rules for d-d transitions, spectroscopic ground states, spectrochemical series, Orgel-energy level diagram for d_1 and d_9 states, discussion of the electronic spectrum of $[Ti(H_2O)_6]^{3+}$ complex ion.

Unit – III

- V. Organometallic Chemistry
Definition, nomenclature and classification of organometallic compounds, Preparation, properties, bonding and applications of alkyls and aryls of Li, Al, Hg, Snl.
Metal carbonyls: 18 electron rule, preparation, structure and nature of bonding in the mononuclear carbonyls.
- VI. Silicones and Phosphazenes
Silicones and phosphazenes as examples of inorganic polymers, nature of bonding in triphosphazenes.

Unit – IV

- VII. Hard and Soft Acids and Bases (HSAB)

Classification of acids and bases as hard and soft, Pearson's HSAB concept, acid-base strength and hardness and softness, Symbiosis, theoretical basis of hardness and softness, electro negativity and hardness and softness, Drago wayland equation, donor acceptor number.

Unit - V

VIII. Bioinorganic Chemistry

Essential and trace elements in biological processes, metalloporphyrins with special reference to hemoglobin and myoglobin, cooperative effect, Biological role of alkali and alkaline earth metal ions with special reference to Ca^{2+} .

B.Sc. – III Chemistry (Paper-II)

Organic Chemistry

Unit – I

I. Spectroscopy

Nuclear magnetic resonance (NMR) spectroscopy, Proton magnetic resonance (^1H NMR) spectroscopy, nuclear shielding and deshielding, chemical shift and molecular structure, spin-spin splitting and coupling constants, areas of signals, interpretation of ^1H NMR spectra of simple organic molecules such as ethyl bromide, ethanol, acetaldehyde, 1, 1, 2-tribromoethane, ethyl acetate, toluene and acetophenone, Problems pertaining to the structures elucidation of simple organic compounds using UV, IR and ^1H NMR spectroscopic, techniques.

Unit – II

II. Organometallic Compounds

Organomagnesium compounds: the Grignard reagents, formation, structure and chemical reactions. Organozinc compounds: formation and chemical reactions. Organolithium compounds: formation and chemical reactions.

III. Organosulphur Compounds

Nomenclature, structural formation, methods of formation and chemical reactions of thiols, thioethers, sulphonic acids, sulphonamides and Sulphaguanidine.

IV. Hetrocyclic Compounds

Introduction: Molecular orbital picture and aromatic characteristics of pyrrole, furan, thiophene and pyridine, Methods of synthesis and chemical reactions with particular emphasis on the mechanism of electrophilic substitution, Mechanism of nucleophilic substitution reaction in pyridine derivatives, Comparison of basicity of pyridine, piperidine and pyrrole.

Introduction to condensed five and six membered heterocycles, Preparation and reactions of indole, quinoline and isoquinoline with special reference to Fisher indole synthesis, Skraup synthesis and Bischler-Nepieralski synthesis, Mechanism of electrophilic substitution reactions of indole, quinoline and isoquinoline.

Unit – III

- V. Carbohydrates
Classification and nomenclature, Monosaccharides, mechanism of osazone formation, interconversion of glucose and fructose, chain lengthening and chain shortening of aldoses. Configuration of monosaccharides, Erythro and threo diastereomers, Conversion of glucose into mannose, Formation of glycosides, ethers and esters, Determination of ring size of monosaccharides, Cyclic structure of D(+)-glucose, Mechanism of mutarotation. Structures of ribose and deoxyribose,
An introduction to disaccharides (maltose, sucrose and lactose) and polysaccharides(starch and cellulose) without involving structure determination.
- VI. Amino Acids, Peptides, Proteins and Nucleic Acids:
Classification, structure and stereochemistry of amino acids, Acid-base behavior isoelectric point and electrophoresis, Preparation and reactions of O-amino acids, Structure and nomenclature of peptides and proteins, Classification of proteins, peptide structure determination, end group analysis, selective hydrolysis of peptides, classical peptide synthesis, solid-phase peptide synthesis, Structures of peptides and proteins, Levels of protein structure, Protein denaturation/ renaturation; Nucleic acids : Introduction, constituents of nucleic acids, Ribonucleosides and ribonucleotides, The double helical structure of DNA.

Unit – IV

- VII. Fats, Oils and Detergents
Natural fats, edible and industrial oils of vegetable origin, common fatty acids, glycerides, hydrogenation of unsaturated oils, Saponification value, iodine value, acid value, Soaps, synthetic detergents, alkyl and aryl sulphonates.
- VIII. Synthetic Polymers
Addition or chain-growth polymerization, Free radical vinyl polymerization, ionic vinyl polymerization, Ziegler-Natta polymerization and vinyl polymers, Condensation or step growth-polymerization, Polyesters, polyamides, phenol formaldehyde resins, urea formaldehyde resins, epoxy resins and polyurethanes, Natural and synthetic rubbers, Elementary idea of organic conducting polymers.
- IX. Synthetic Dyes
Colour and constitution (electronic Concept), Classification of dyes, Chemistry and synthesis of Methyl orange, Congo red, Malachite green, crystal violet, phenolphthalein, fluorescein, Alizarin and Indigo.

Unit – V

- X. Organic Synthesis via Enolates
Acidity of O-hydrogens, alkylation of diethyl malonate and ethyl acetoacetate, Synthesis of ethyl acetoacetate: the Claisen condensation, Keto-enol tautomerism of ethylacetoacetate. Alkylation of 1, 3-dithianes, Alkylation and acylation of enamines.

B.Sc. – III Chemistry (Paper-III)

Physical Chemistry

Unit – I

I. Introducton:

Black-body radiation, Planck's radiation law, photoelectric effect, heat capacity of solids, Bohr's model of hydrogen atom (without derivation) their solution of overall solution and its defects, Compton effect, de-Broglie's hypothesis, the Heisenberg's uncertainty principle, Hamiltonian Operator.

II. Elementary Quantum Mechanics:

Schrödinger wave equation and its importance, physical interpretation of the wave function, postulates of quantum mechanics, particle in a one dimensional box. Schrödinger wave equation for H-atom, separation into three equations (without derivation), quantum numbers and their importance, hydrogen like wave functions, radial wave functions, angular wave functions.

Molecular orbital theory, basic ideas – criteria for forming M.O. from A.O., construction of M.O's by LCAO – H^{2+} ion, calculation of energy levels from wavefunctions, physical picture of bonding and anti-bonding wave functions, concept of σ , σ^* , π , π^* orbitals and their characteristics, Hybrid orbitals – sp , sp^2 , sp^3 , calculation of coefficients of A.O's used in sp and sp^2 hybrid orbitals and interpretation of geometry.

Introduction to valence bond model of H_2 , comparison of M.O. and V.B. models.

Unit – II

III. Physical Properties and Molecular Structure:

Optical activity, polarization – (Clausius – Mossotti equation), orientation of dipoles in an electric field, dipole moment, induced dipole moment, measurement of dipole moment-temperature method and refractivity method, dipole moment and structure of molecules, magnetic properties-paramagnetism, diamagnetism and ferromagnetic, Magnetic susceptibility, its measurements and its importance.

Unit – III

IV. Spectroscopy:

Introduction: Electromagnetic radiation, regions of the spectrum, basic features of different spectrophotometers, statement of the born-oppenheimer approximation, degrees of freedom.

Rotational Spectrum: Diatomic Molecules: Energy levels of a rigid rotor (semi-classical principles), selection rules, spectral intensity, distribution using population distribution (Maxwell-Boltzmann distribution) determination of bond length, qualitative description of non-rigid rotor, isotope effect.

Vibrational Spectrum: Infrared Spectrum: Energy levels of simple harmonic oscillator, selection rules, pure vibrational spectrum, intensity, determination of force constant and qualitative relation of force constant and bond energies, effect of anharmonic motion and isotope on the spectrum, idea of vibrational frequencies of different functional groups.

Raman Spectrum: Concept of polarizability, pure rotational and pure vibrational Raman spectra of diatomic molecules, selection rules.

Electronic Spectrum: Concept of potential energy curves for bonding and anti-bonding molecular orbitals, qualitative description of selection rules and Franck-Condon principle.

Qualitative description of σ , π and T M.O. their energy levels and the respective transition.

Unit – IV:

V. Photochemistry:

Interaction of radiation with matter, difference between thermal and photochemical processes, Laws of photochemistry: Grothus – Drapper law, Stark – Einstein law, Jablonski diagram depicting various processes occurring in the excited state, qualitative description of fluorescence, phosphorescence, non- radiative processes (internal conversion, intersystem crossing), quantum yield, photosensitized reactions – energy transfer processes (simple examples), Kinetics of Photo chemical reaction.

Unit – V

VI. Solutions, Dilute Solutions and Colligative Properties:

Ideal and non-ideal solutions, methods of expressing concentrations of solutions, activity and activity coefficient. Dilute solution, colligative properties, Raoult's law, relative lowering of vapour pressure, molecular weight determination. Osmosis, laws of osmotic pressure, its measurement and determination of molecular weight from osmotic pressure. Elevation of boiling point and depression of freezing, Thermodynamic derivation of relation between molecular weight and elevation in boiling point and depression in freezing point. Experimental methods for determining various colligative properties. Abnormal molar mass, Van't Hoff factor, Colligative properties of degree of dissociation and association of solutes.

B.Sc. – III (LABORATORY PRACTICAL) 180 hrs. (12 hrs./week)

Atleast three practicals from each specialization should be carried out.

Inorganic Chemistry:

I. Synthesis and Analysis:

- (a) Preparation of sodium trioxalato ferrate (III), $\text{Na}_3[\text{Fe}(\text{C}_2\text{O}_4)_3]$ and determination of its composition by permagnetometry.
- (b) Preparation of Ni-DMG complex, $[\text{Ni}(\text{DMG})_2]$
- (c) Preparation of copper tetra ammine complex. $[(\text{Cu}(\text{NH}_3)_4)\text{SO}_4]$.
- (d) Preparation of cis-and trans-*bis*-oxalato diaqua chromate (III) ion.

II. Instrumentation:

- Colorimetry- (a) Job's method (b) Mole-ratio method
- Adulteration – Food stuffs.
- Effluent analysis, water analysis
- Solvent Extraction- Separation and estimation of Mg(II) and Fe(II)
- Ion Exchange Method- Separation and estimation of Mg(II) and Zn(II)

Organic Chemistry:

III. Laboratory Techniques- Steam Distillation

- Naphthalene from its suspension in water
- Clove oil from cloves
- Separation of o-and p-nitro phenols

IV. Column Chromatography-

- Separation of fluorescein and methylene blue
- Separation of leaf pigments from spinach leaves
- Resolution of racemic mixture of (+) mandelic acid

V. Qualitative Analysis-

- Analysis of an organic mixture containing two solid components using water, NaHCO_3 , NaOH for separation and preparation of suitable derivatives
- VI. Synthesis of Organic Compounds-
- Acetylation of salicylic acid, aniline, glucose and hydroquinone, Benzoylation of aniline and phenol
 - Aliphatic electrophilic substitution
Preparation of iodoform from ethanol and acetone
 - Aromatic electrophilic substitution
Nitration:
Preparation of m-dinitrobenzene
Preparation of p-nitroacetanilide
Halogenation
Preparation of p-bromoacetanilide
Preparation of 2, 4, 6-tribromophenol
 - Diazotization/coupling
Preparation of methyl orange and methyl red
 - Oxidation
Preparation of benzoic acid from toluene
 - Reduction
Preparation of aniline from nitrobenzene
Preparation of m-nitroaniline from m-dinitrobenzene
- VII. Stereo chemical Study of Organic Compounds via Models
R and S configuration of optical isomers
E, Z configuration of geometrical isomers
Conformational analysis of cyclohexanes and substituted cyclohexanes
Physical Chemistry :
- VIII. Electrochemistry:
- To determine the strength of the given acid conductometrically using standard alkali solution.
 - To determine the solubility and solubility of a sparingly soluble electrolyte conductometrically.
 - To study the saponification of ethyl acetate conductometrically.
 - To determine the ionization constant of a weak acid conductometrically.
 - To titrate potentiometrically the given ferrous ammonium sulphate solution using $\text{KMnO}_4/\text{K}_2\text{Cr}_2\text{O}_7$ as titrant and calculate the redox potential of $\text{Fe}^{2+}/\text{Fe}^{3+}$ system on the hydrogen scale.
- IX. Refractometry, Polarimetry:
- To verify law of refraction of mixtures (e.g. of glycerol and water) using Abbe's refractometer.
 - To determine the specific rotation of a given optically active compound.
 - To determine stoichiometry and stability constant of complexes.
- X. Molecular Weight Determination:
- Determination of molecular weight of a non-volatile solute by Rast method/ Beckmann freezing point method.
 - Determination of the apparent degree of dissociation of an electrolyte (e.g. NaCl) in aqueous solution at different concentrations by ebullioscopy.
- Colorimetry:

1. To verify Beer – Lambert Law for $\text{KMnO}_4/\text{K}_2\text{Cr}_2\text{O}_7$ and determining the concentration of the given solution of the substance from absorption measurement.