

GONDWANA UNIVERSITY, GADCHIROLI

B.Sc.-I Semester I (Chemistry)

(Effective from 2017-18)

- 1) There will be two theory papers in every semester which carry 50 marks each and duration of paper is 3 hrs.
- 2) There will be internal assessment of 10 marks per paper per semester.
- 3) There will be practical examination of 4-5 hours duration and carries 30 marks.

So, the total marks allotted to the chemistry subject per semester is 150 marks.

Theory (100 marks) + Internal assessment (10+10 marks) + Practical (30 Marks) = 150 marks (total)

- 4) The internal assessment will be based on Attendance, Home assignment, Unit test, Terminal test and participation in departmental activities.

The following syllabi are prescribed on the basis of six lectures per week and six practical periods per batch per week. Each theory paper consists of four units of twelve lectures per unit.

THEORY PAPER PATTERN FOR VARIOUS SEMESTER

Semester No.	Paper –I	Paper-II	Practical
Semester I	Inorganic Chemistry (USCChT01)	Organic Chemistry (USCChT02)	PRACTICAL(USCChP01)
Semester II	Organic Chemistry (USCChT03)	Physical Chemistry (USCChT04)	PRACTICAL(USCChP02)
Semester III	Inorganic Chemistry (USCChT05)	Physical Chemistry (USCChT06)	PRACTICAL(USCChP03)
Semester IV	Inorganic Chemistry (USCChT07)	Organic Chemistry (USCChT08)	PRACTICAL(USCChP04)
Semester V	DSE I	DSE II	PRACTICAL
Semester V	DSE I	DSE II	PRACTICAL

Question Paper Pattern

Que.-1 (From Unit I) – (A-5 Marks + B-5 Marks) = 10 Marks or (a-2.5 + b-2.5 + c-2.5 + d-2.5) = 10 Marks

Que.-2 (From Unit II) – (A-5 Marks + B-5 Marks) = 10 Marks or (a-2.5 + b-2.5 + c-2.5 + d-2.5) = 10 Marks

Que.-3 (From Unit III) – (A-5 Marks + B-5 Marks) = 10 Marks or (a-2.5 + b-2.5 + c-2.5 + d-2.5) = 10 Marks

Que.-4 (From Unit IV) – (A-5 Marks + B-5 Marks) = 10 Marks or (a-2.5 + b-2.5 + c-2.5 + d-2.5) = 10 Marks

Que.-5 Solve any 10 out of 12 short answer question each carry one mark (3 short question from each unit)

B.Sc. Part I (Semester - I)

USCHT01

Paper - I (Inorganic Chemistry)

Total marks: 50 Total Lectures: 48

Note: Figures to the right hand side indicate number of lectures

UNIT I

- (A) **Atomic Structure** : Review of Bohr's Theory and its Limitations, Idea of de-Broglie matter waves, Heisenberg's uncertainty principle, Schrodinger wave equation, significance of Ψ and Ψ^2 , quantum numbers, radial and angular wave functions and probability distribution curves, atomic orbital, shapes of s, p and d-orbital, Aufbau and Pauli's exclusion principle, Hund's multiplicity rule, electronic configuration of the elements and ions. [6 L]
- (B) **Periodic Properties**: Atomic and ionic radii, ionization energy, electron affinity and electronegativity - definition, trends in periodic table and applications in predicting and explaining the chemical behavior, factors affecting ionization potential. Pauling's and Mulliken's scales of electronegativity, effective nuclear charge and Slater's rules with some exercise. [6 L]

UNIT II

- (A) **Covalent Bond**: Valence bond theory and its limitations, directional of covalent bond, overlap criteria of bond strength, Bond energy, bond strength, bond order and bond angle. 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 . [6 L]
- (B) **Molecular Orbital Theory**: LCAO approximation, wave equation for molecular orbitals, difference between bonding and antibonding MOs in terms of energy and electron density distribution curves, order of energy levels in MOs. MO diagrams for homonuclear diatomic molecules of hydrogen, helium and second row of periodic table. Concept of non-bonding MOs in HF molecule, Coulson's MO diagram of CO and NO. [6 L]

UNIT III

(A) s – Block Elements Comparative study of s – block elements with respect to: i) Atomic & ionic radii, ii) Ionisation Energy iii) Electron Affinity iv) Electronegativity v) Reducing property. Diagonal relationship between Li & Mg, Salient features of hydrides, Salvation and Complexation tendencies including their functions in biosystems. **[6 L]**

(B) p-Block Elements: Comparative study of p – block elements with respect to: i) Atomic & ionic radii, ii) Ionisation Energy iii) Electron Affinity iv) Electronegativity v) Oxidation State. Diagonal relationship between Be & Al, Preparation, properties and structure of hydrides of 5 th group elements. Nature and bonding in phosphorous trioxides (P_2O_3), phosphorous pentaoxide (P_2O_5) and oxyacids of phosphorous. **(6L)**

UNIT IV

(A)Hydrogen Bonding: Classification and effect of hydrogen bonding on viscosity, solubility, Melting point and boiling point **(2L)**

(B) Chemistry of Nobel gas: Chemical properties of Nobel gases, Chemistry of xenon, Structure and bonding in xenon fluorides and oxyfluorides. **(4L)**

(C) Theory Of Volumetric Analysis i) Acid-Base Titration: Types of acid-base titration, theory of acid-base titration a) Ostwald's theory b) Quinonied Theory, choice of suitable indicators for different acid-base titrations. ii) Redox Titration: General principles involved in redox titrations. Theory of redox indicators external and internal iii) Complexometric Titration: Theory of complexometric titration, metallochrome indicator. **(6L)**

B.Sc. Part I (Semester - I)

USCHT02

Paper – II (Organic Chemistry)

Total marks: 50 Total Lectures: 48

Note: Figures to the right hand side indicate number of lectures

UNIT-I

Fundamentals of Organic Chemistry

Physical Effects, Electronic Displacements: Definition, examples and applications of Inductive Effect, Electromeric Effect, Resonance and Hyper conjugation. Cleavage of Bonds: Homolysis and Heterolysis. **(3L)**

Structure, shape and reactivity of organic molecules: Hybridization in organic molecules (sp , sp^2 , sp^3), bond length, bond angles, bond energies. Nucleophiles and electrophiles. Reactive Intermediates: Carbocations, Carbanions and free radicals. **(5L)**

Types of Reactions : (In brief with suitable example of each), a) Addition, b) Elimination c) Substitution d) Rearrangement reactions. **(2L)**

Strength of organic acids and bases: Comparative study with emphasis on factors affecting pK values. **(2L)**

UNIT-II

Stereochemistry

(A) Basic concept of Isomerism their Type (Structural chain, position, functional group and stereoisomerism) Interconversion of Wedge Formula, Newman, Sawhorse and Fischer representations. **(4L)**

(B) Concept of chirality (upto two carbon atoms). Configuration: Geometrical and Optical isomerism; Enantiomerism, Diastereomerism and Meso compounds). Threo and erythro; D and L; cis - trans nomenclature; CIP Rules: R / S (for upto 2 chiral carbon atoms) and E / Z Nomenclature (for upto two C=C systems), Conformations with respect to ethane, butane and cyclohexane. Racemisation, resolution and its methods, inversion and retention of configuration, Asymmetric synthesis. **(8L)**

UNIT-III

Aliphatic Hydrocarbons:

Alkane: Nomenclature laboratory methods of preparation by Wurtz reaction, Kolbes reaction and decarboxylation of carboxylic acid, Industrial methods of preparations. Physical properties, reactions of alkanes. Combustion, cracking, LPG, CNG, Cetan number, Octane Numbers, Free radical mechanism of halogenations of methane. **(3L)**

Cycloalkanes: Nomenclature, Method of formation (3-6 membered rings), a) Freund's method, b) Dickmann's method. Chemical reactions of cycloalkanes: Oxidation, Aromatization and Chlorination. Baeyer's strain theory, theory of strainless rings. **(2L)**

Alkenes: Preparation: Elimination reactions: Dehydration of alkenes and dehydrohalogenation of alkyl halides (Saytzeff's rule); cis alkenes (Partial catalytic hydrogenation) and trans alkenes (Birch reduction). Reactions: cis-addition (alk. KMnO_4) and trans-addition (bromine), Addition of HX (Markownikoff's and anti-Markownikoff's addition), Hydration, Ozonolysis, oxymercuration-demercuration, Hydroboration-oxidation. **(3L)**

Diene: Nomenclature and classification, Method of formation and Chemical reactions 1-2 and 1-4 additions and Diels-Alder reaction of Conjugated dienes **(2L)**

Alkynes: Preparation: Acetylene from CaC_2 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 KMnO_4 , ozonolysis and oxidation with hot alk. KMnO_4 . **(2L)**

UNIT-IV

Aromatic hydrocarbons

Preparation (Case benzene): from phenol, by decarboxylation, from acetylene, from benzene sulphonic acid.

Reactions: (Case benzene): Mechanism of Electrophilic Aromatic Substitution Electrophilic substitution: nitration, halogenation and sulphonation. Friedel-Craft's reaction (alkylation and acylation) (upto 4 carbons on benzene). Side chain oxidation of alkyl benzenes (upto 4 carbons on benzene).

Structure and Orbital diagram of benzene, Aromaticity and Huckel's rule **(8L)**

Orientation: Effect of substituent groups. Activating and deactivating groups. Directing influence of following groups in the light of modern electronic theory (-OH, -Cl, -NO₂, -COOH and -CH₃ groups. **(4L)**

B.Sc.Semester - I

Chemistry Practical USCHP01

Total Marks: 30

Inorganic Chemistry

Volumetric Analysis

- 1) Preparation of standard solution by weighing and Preparation of 0.001 M solution from 0.1M solution by dilution.
- 2) Estimation of sodium carbonate and sodium hydrogen carbonate present in a mixture.
- 3) Estimation of Fe (II) by dichromate using internal indicator (n-phenyl Anthranilic acid)
- 4) Determination of commercial vinegar acetic acid in using NaOH
- 5) Estimation of oxalic acid by titrating it with KMnO_4
- 6) Determination of zinc by complexometric titration with EDTA
- 7) Determination of total hardness of water (permanent and temporary) by EDTA
- 8) Estimation of Cu (II) ions iodometrically using $\text{Na}_2\text{S}_2\text{O}_3$.
- 9.) Estimation of water of crystallization in Mohr's salt by titrating with KMnO_4 .

ORGANIC CHEMISTRY

QUALITATIVE ANALYSIS

1. Detection of extra elements (N, S, Cl, Br, I) in organic compounds (containing up to two Extra elements).
2. Systematic Qualitative Organic Analysis of Organic Compounds possessing mono functional groups (-COOH, phenolic, aldehydic, ketonic, amide, nitro, amines) and preparation of one derivative.
3. Separation of mixtures by Chromatography: Measure the R_f value in each case (Combination of two compounds to be given)
4. 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.
5. Identify and separate the sugars present in the given mixture by paper chromatography.
6. Differentiation between a reducing and a non reducing sugar.

Distribution of Marks for Practical Examination

Time 4-5 hours (One Day Examination)	Marks 30
Inorganic Chemistry (Exercise)	12
Organic Chemistry (Exercise)	
(Element : 4 M, Functional group: 4 M. & M. Pt./ B. Pt. 4 M).....	12
Viva-Voce	03
Record	03

Total:	30

B.Sc. Part I (Semester - II)
USCHT03
Paper – I (Organic Chemistry)
Total marks: 50 Total Lectures: 48

Note: Figures to the right hand side indicate number of lectures

UNIT I

Alkyl and Aryl Halides

Alkyl Halides (Up to 5 Carbons) Types of Nucleophilic Substitution (SN1, SN2 and SNi) reactions. Preparation: From alkenes and alcohols. Reactions: hydrolysis, nitrite & nitro formation, nitrile & isonitrile formation. Williamson's ether synthesis: Elimination vs substitution. Elimination reaction of alkyl halide with mechanism (E1, E2), Comparison of substitution and elimination reaction. **(6L)**

Aryl Halides Preparation: (Chloro & bromo benzene case): from phenol, Sandmeyer & Gattermann reactions. Reactions (Chlorobenzene): Aromatic nucleophilic substitution (replacement by -OH group) and effect of nitro substituent. Benzyne Mechanism: KNH_2/NH_3 (or $\text{NaNH}_2/\text{NH}_3$). Reactivity and Relative strength of C-Halogen bond in alkyl, allyl, benzyl, vinyl and aryl halides. **(6L)**

UNIT-II

Alcohols, Phenols and Ethers

Alcohols: Preparation: Preparation of 1°, 2° and 3° alcohols: using Grignard reagent, Ester hydrolysis, Reduction of aldehydes, ketones, carboxylic acid and esters. Reactions: With sodium, HX (Lucas test), Esterification, oxidation (with PCC, Alk. KMnO_4 , Acidic dichromate, Conc. HNO_3). Oppeneauer oxidation. **(4L)**

Diols: (Upto 6 Carbons) oxidation of diols. Pinacol-Pinacolone rearrangement. **(1L)**

Phenols: (Phenol case) Preparation: Cumene hydroperoxide method, from diazonium salts.

Reactions: Electrophilic substitution: Nitration, halogenations, Acetylation and sulphonation. Reimer-Tiemann Reaction, Gattermann-Koch Reaction, Houben-Hoesch Condensation, Schotten - Baumann Reaction. Fries rearrangement, Claisen Rearrangement. Comparative acidic strength of alcohols and phenols. **(5L)**

Ethers (aliphatic and aromatic): Introduction, synthesis and reactions of diethyl ether, Cleavage of ethers with HI, Relative reactivity of alcohols and ethers. **(2L)**

UNIT-III

Aldehydes and Ketones (Formaldehyde, acetaldehyde, acetone and benzaldehyde)

(A) Nomenclature, Structure and reactivity of the carbonyl group. **(1L)**

(B) Synthesis of aliphatic aldehyde and ketone by oxidation and dehydrogenation of alcohols, from carboxylic acid, acid chloride. Nitriles, Grignard reagent and from alkene. **(2L)**

(C) Synthesis of aromatic aldehyde (Benzaldehyde) by Rosenmund reduction Gatterman Koch reaction Reimer – Tiemann reaction and from nitriles and ketone (Benzophenone) by Friedel Craft's acylation or benzoylation **(3L)**

(D) Reactions – Reaction with HCN, ROH, NaHSO₃, NH₂-G derivatives. Iodoform test. Aldol Condensation, Cannizzaro's reaction, Benzoin, Perkin, Knoevenagel condensations, Wittig reaction, Clemmensen reduction and Wolff Kishner reduction. Meerwein-Ponndorf Verley reduction. **(6L)**

UNIT-IV

CARBOXYLIC ACIDS AND THEIR DERIVATIVES

Carboxylic acid: Nomenclature, structure and bonding, physical properties: acidity of carboxylic acids, effect of substituent's on acidic strength, preparation and reactions of carboxylic acids. Hell-Volhard-Zelinsky reaction, reduction of carboxylic acids decarboxylation mechanism of decarboxylation. Reformatsky Reaction, Perkin condensation. **(4L)**

Dicarboxylic acids: Succinic acid, Phthalic acid. Methods of formation and effect of heat and dehydrating agents. **(2L)**

Carboxylic acid Derivatives: Structure and nomenclature of acid chloride, esters, amides (urea) and acid anhydride. Relative stability of acyl derivatives. Physical properties, Interconversion of acid derivatives by nucleophilic acyl substitution, formation of carboxylic acid derivatives, chemical reaction. Mechanism of esterification and hydrolysis (acidic & basic) **(6L)**

B.Sc. Part I (Semester - II)

USCHT04

Paper – II (Physical Chemistry)

Total marks: 50 Total Lectures: 48

Note: Figures to the right hand side indicate number of lectures

UNIT I

(A) Mathematical Concepts : Logarithmic relations, Linear graphs, calculation of slopes, differentiation of functions like kx , e^x , x^n , $\sin x$, $\log x$ etc. maxima and minima, Integration of useful / relevant functions. Permutations and combinations (introductory), Factorials, Concept of units with references to C.G.S. and S.I. units Inter conversion of units. **[5L]**

(B) Ionic Equilibrium

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 of different salts. Buffer solutions, solubility and solubility product of sparingly soluble salts, applications of solubility product. **(7L)**

UNIT II

Review of Thermodynamics

(A) Recapitulation of thermodynamic terms: system, surrounding types of system (closed open & isolated), Thermodynamic, variables, intensive & extensive properties, thermodynamic processes (isothermal, adiabatic, isobaric, cyclic, reversible & irreversible) State function & path functions, properties of state functions (exact differential, cyclic rule), integrating factor, concept of heat & work. **(3L)**

(B) Statements of first law of thermodynamics, definition of internal energy & enthalpy, heat capacity at constant volume & at constant pressure, Joule-Thomson experiment, Joule Thomson coefficient & Inversion temperature, calculations of $W, Q, \Delta E$ & ΔH for expansion of gases for isothermal & adiabatic conditions for reversible process, Carnot's cycle & its efficiency, thermodynamic scale of temperature. **(5L)**

(C) Thermochemistry: Heat of reaction, standard states, relation between heat of reaction at constant volume & at constant pressure, Hess's law of constant heat of summation & its applications, bond dissociation energy & its calculations from thermochemical data, variation of heat of reaction with temperature (Kirchoff's equation). **(4L)**

UNIT III

Gaseous State

(A) Postulates of kinetic theory of gases, derivation of kinetic gas equation, deduction of various gas laws from kinetic gas equation, Qualitative discussion of the Maxwell – Boltzmann distribution of molecular velocities. Effect of temperature on molecular velocities. Different types of molecular velocities (Most probable RMS and average) and expressions for them. Their inter relationships. Mean free path collision diameter and collision number. **(6L)**

(B) Ideal gas and real gases, behavior of real gases, deviations from ideal behaviors, explanation of the terms – Compressibility factors and Boyle temperature. Causes of deviation from ideal behaviors. Van der Waal's equation of state, explanation of state, explanation of behavior of real gases. Critical phenomenon (P-V isotherms of real gases). Continuity of states. The isotherms of Vander Waal's equation, Relationship between critical constants and Van der Waal's constants Reduce equation of state law of corresponding state. **(6L)**

UNIT IV

(A) Properties of Liquid

i) Surface tension : Explanation, methods of determination using stalgmometer. Parachor value and its application

ii) Viscosity, Explanations, coefficient of viscosity, Effect of temperature on Viscosity, relative viscosity, specific and intrinsic viscosity. Method of determination by Ostwald viscometer. **(4L)**

(B) Solid State

Laws of crystallography-

i) Law of constancy of interfacial angles

ii) Law of rationality of indices

iii) Law of symmetry, symmetry of elements in crystals.

Unit cell, space lattice, orientation of lattice plane (Miller indices).

Bravais lattices, crystal systems, X-ray diffraction by crystal, derivation of Bragg's equation. Determination of crystal structure of NaCl, KCl and CsCl Laue's method and powder method. **(8L)**

**B.Sc.Semester - II
Chemistry Practical USCHP02
Total Marks: 30**

ORGANIC CHEMISTRY

Purification of an impure organic compound by crystallization / Sublimation method and determination of melting point of purified sample. (Five compounds (1) Phthalic acid, 2) Acetanilide, 3) Benzoic acid, 4) Phenylthiourea 5) Naphthalene.

Note: i) Students should report the melting point of sample before and after crystallization / Sublimation.

ii) Solvents like water, water + alcohol, Alcohol can be selected for crystallization.

1. ORGANIC PREPARATION

Mechanism of various reactions involved to be discussed. Recrystallisation, and determination of melting point and calculation of quantitative yields.

- a. Preparation of acetanilide (Acetylation of Aniline)
- b. Preparation of Benzanilide (Benzoylation of Aniline)
- c. Preparation of Iodoform from ethanol or Acetone.
- d. Preparation of m-di-Nitrobenzene (Nitration)
- e. Preparation of tri-Bromoaniline from Aniline (Bromination)
- f. Preparation of Benzoic acid from Benzamide (Hydrolysis)
- g. Preparation of Benzoic acid from Benzaldehyde (oxidation)
- h. Preparation of Semicarbazone from Acetone.
- i. Oxime and 2,4-dinitrophenylhydrazone of aldehyde/ketone

PHYSICAL CHEMISTRY PRACTICAL

Thermochemistry

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 (KNO_3 , NH_4Cl).
5. Determination of enthalpy of hydration of copper sulphate.
6. Study of the solubility of benzoic acid in water and determination of ΔH .

Ionic equilibria

pH measurements

a) 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.

b) 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.

Liquid State

1. To determine relative coefficient of viscosity of the given liquid by Ostwald viscometer.
2. To determine percentage composition (v/v) of the given mixture of ethyl alcohol and water by viscosity measurement.
3. To determine surface tension of liquid by stalagmometer.
4. To determine parachor value of $-\text{CH}_2$ group by stalagmometer.
5. To compare cleaning power of detergents by stalagmometer.

Distribution of Marks for Practical Examination

Time 4-5 hours (One Day Examination)	Marks 30
Organic Chemistry (Exercise)	12
Physical Chemistry (Exercise).....	12
Viva-Voce	03
Record	03

Total :	30

Reference Books Recommended (Common for Semester – I and Semester – II)

- Lee, J.D. *Concise Inorganic Chemistry* ELBS, 1991.
- Cotton, F.A., Wilkinson, G. & Gaus, P.L. *Basic Inorganic Chemistry*, 3rd ed., Wiley.
- Douglas, B.E., McDaniel, D.H. & Alexander, J.J. *Concepts and Models in Inorganic Chemistry*, John Wiley & Sons.
- Huheey, J.E., Keiter, E.A., Keiter, R.L. & Medhi, O.K. *Inorganic Chemistry: Principles of Structure and Reactivity*, Pearson Education India, 2006.
- Graham Solomon, T.W., Fryhle, C.B. & Snyder, S.A. *Organic Chemistry*, John Wiley & Sons (2014).
- McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition, 2013.
- Sykes, P. *A Guidebook to Mechanism in Organic Chemistry*, Orient Longman, New Delhi (1988).
- Eliel, E.L. *Stereochemistry of Carbon Compounds*, Tata McGraw Hill education, 2000.
- Finar, I.L. *Organic Chemistry* (Vol. I & II), E.L.B.S.
- Morrison, R.T. & Boyd, R.N. *Organic Chemistry*, Pearson, 2010.
- Bahl, A. & Bahl, B.S. *Advanced Organic Chemistry*, S. Chand, 2010.
- Graham Solomon, T.W., Fryhle, C.B. & Snyder, S.A. *Organic Chemistry*, John Wiley & Sons (2014).
- McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition, 2013.
- Sykes, P. *A Guidebook to Mechanism in Organic Chemistry*, Orient Longman, New Delhi (1988).
- Finar, I.L. *Organic Chemistry* (Vol. I & II), E.L.B.S.
- Morrison, R.T. & Boyd, R.N. *Organic Chemistry*, Pearson, 2010.
- Bahl, A. & Bahl, B.S. *Advanced Organic Chemistry*, S. Chand, 2010.
- Barrow, G.M. *Physical Chemistry* Tata McGraw-Hill (2007).
- Castellan, G.W. *Physical Chemistry* 4th Ed. Narosa (2004).
- Kotz, J.C., Treichel, P.M. & Townsend, J.R. *General Chemistry* Cengage Learning India Pvt. Ltd., New Delhi (2009).
- Mahan, B.H. *University Chemistry* 3rd Ed. Narosa (1998).
- Petrucci, R.H. *General Chemistry* 5th Ed. Macmillan Publishing Co.: New York (1985).
- Principles of Inorganic Chemistry by Puri. Sharma and Kalia – S. Naginchand & Co. Delhi.

- Text book of Inorganic Chemistry by A. K. De. *Wiley East Ltd.*
- Selected Topics in Inorganic Chemistry by Malik, Tuli and Madan – *S. Chand and Co.*
- Modern Inorganic Chemistry by R. C. Agrawal, *Kitab Mahal.*
- Instrumental Methods of analysis by Chatwal and Anand, *Himalaya Publishing House.*
- Concise Inorganic Chemistry by J. D. Lee, *ELBS.*
- Inorganic Chemistry by J. E. Hoheey – *Harper and Row.*
- Fundamental concepts of Inorganic Chemistry by E. S. Gilreath, *McGraw Hill book Co.*
- Modern Inorganic Chemistry by W. L. Jolly, *McGraw Hill Int.*
- Chemistry Facts, Patterns and Principles by Kneen, Rogers and Simpson, *ELBS.*
- Theoretical Principles of Inorganic Chemistry by G.S. Manku, *Tata McGraw Hill.*
- Inorganic complex compounds by Murmann, Chapman and Hall.
- Text book of Inorganic Chemistry by K. N. Upadhyaya, *Vikas Publishing House, Delhi.*
- Advanced Practical Inorganic Chemistry by Gurdeep Raj. *Goel Publishing House, Meerut.*
- Co-Ordination Chemistry by D. Banerjee, *TMH Publication.*
- Text book of Inorganic Chemistry by Marathe, Bhadange, Mopari and Kubade.
- Organic Chemistry by R. T. Morrison and R. T. Boyd, 6th edition, *PHI.*
- Organic Chemistry by Pine, 5th edition.
- Inorganic Chemistry Vol. I, II and III by Mukharjee, Singh and Kapoor – *Wiley Eastern.*
- Organic Chemistry by S. K. Ghosh.
- Reaction Mechanism in Organic Chemistry by S.M. Mukharjee and S.P. Singh.
- Spectroscopy of Organic Compounds by P. S. Kalsi.
- Stereochemistry and Mechanism through solved problems by P.S. Kalsi.
- Organic Chemistry by TWG Solomons, 4th edition, *John Wiley.*
- Hand book of Organic Analysis by H. J. Clarke, Arnold Heinmen.
- Text book of Practical Organic Chemistry by A. I. Vogel.
- Text book of Organic Chemistry by Jamode, Ganar, Makode, Waghmare, Mahaja, Toshinwal.
- Text book of Organic Chemistry by P.S. Kalsi published by *Macmillan India Ltd. 1999 Delhi.*
- Comparative Practical Organic Chemistry (Qualitative Analysis) by V. K. Ahluwalia and Sunita Dhingra, Orient Longman.
- Comprehensive Practical Organic Chemistry (Preparation and Qualitative Analysis) by V.K. Ahluwalia and Renu Agrawal. Orient Longman.
- Physical Chemistry : Walter J. Moore, 5th edn. New Delhi.
- Physical Chemistry : G. M. Barrow, *McGraw Hill, Indian Edn.*
- Principle of Physical Chemistry : Maron and Prutton.

- Principles of Physical Chemistry : Puri and Sharma
- Physical Chemistry : P. W. Atkins, 4th Edn.
- Text book of Physical Chemistry : P. L. Sony O. R. Dhrma.
- Physical Chemistry : Levine
- Practical Physical Chemistry : Palit and De.
- Practical Physical Chemistry : Yadao
- Practical Physical Chemical : Khosla.
- Laboratory Manual of Physical Chemistry : W. J. Popiel
- Chemistry for Degree Student, Dr. R.L. Madan, *S.Chand and Co. New Delhi*.
- F.Y. B.Sc. Inorganic Chemistry : Semester-I by Dr. S.B. Rewatkar, Dr. E.L.Ramteke, Y.P. Thawari & S.M.Sontakke – *Shell Publication, Nagpur*.
- F.Y. B.Sc. Organic Chemistry : Semester-I by Y.P.Thawari, Dr. S.B. Rewatkar, S.M.Sontakke, Dr. E.L.Ramteke,– *Shell Publication, Nagpur*.
- F.Y. B.Sc. Organic Chemistry : Semester-II by Y.P.Thawari, S.M.Sontakke, Dr. S.B. Rewatkar, T.D. Kose,– *Shell Publication, Nagpur*.
- F.Y. B.Sc. Physical Chemistry : Semester-II by T.D.Kose, Dr. S.B. Rewatkar, S.M.Sontakke, Y.P.Thawari, – *Shell Publication, Nagpur*.
- F.Y. B.Sc. Practical Chemistry : Semester-I by Dr.S.B. Rewatkar, Dr. E.L.Ramteke, Dr.K.R. Lanjewar, Y.P.Thawari, – *Shell Publication, Nagpur*.
- F.Y. B.Sc. Practical Chemistry : Semester-II by Dr.S.B. Rewatkar, Dr. E.L.Ramteke, Dr.K.R. Lanjewar, Y.P.Thawari, – *Shell Publication, Nagpur. (Proposed)*
- Inorganic Chemistry B. Sc. Part I, Sem-I by Dr. N.E. Kathale, S. V.Madhamshettiwar, Dr. D. B. Patil.
- Physical Chemistry B. Sc. Part I, Sem-II by Dr. N.E. Kathale, S. V. Madhamshettiwar, Dr. D. B. Patil.

Reference Books for Practicals:

- Svehla, G. *Vogel's Qualitative Inorganic Analysis*, Pearson Education, 2012.
- Mendham, J. *Vogel's Quantitative Chemical Analysis*, Pearson, 2009.
- Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., *Textbook of Practical Organic Chemistry*, Prentice-Hall, 5th edition, 1996.
- Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry* Orient-Longman, 1960.
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