SIDO KANHU MURMU UNIVERSITY, DUMKA

COURSES OF STUDY

FOUR YEAR UNDERGRADUATE PROGRAMME

CHEMISTRY (Major and IRC)

SUBJECT CODE: CHE

Implemented from

Academic Session 2022-2026

PROGRAM STRUCTURE & DISTRIBUTION OF MARKS

B.Sc. CHE (H)

FOUR YEAR UNDER GRADUATE PROGRAM

Program Structure				Distribution of marks					
Semester	Paper code	Title of the course	Category of the course	Internal		External		Full Marks	Credit
				FM	PM	FM	PM		
SEM-I	CHE- MJ-1	Atomic structure, periodicity and chemical bondind, Carbon-Carbon pi bonds, Aromaticity	Major	15	06	60	24	75	04
	CHE- MJ 1 LAB	Practical	Major Practical	-	-	25	10	25	02
	CHE-IRC-1	Atomic structure, Chemical bonding, fundamentals of organic chemistry, stereo chemistry, aliphatic hydrocarbon	Introductory	15	06	60	24	75	02
	CHE-IRC 1 LAB	Practical	Introductory Practical	-	-	25	10	25	01
SEM-II	CHE- MJ-2	Chemical thermodynamics, chemical equilibrium, solutions and colligative properties	Major	15	06	60	24	75	04
	CHE- MJ 2 LAB	Practical	Major Practical	-	-	25	10	25	02
	CHE-IRC-2	Chemical Energetics, Equilibria & Functional Organic Chemistry-I	Introductory	15	06	60	24	75	02
	CHE-IRC 1 LAB	Practical	Introductory Practical	-	-	25	10	25	01

QUESTION PATTERN & EVALUATION

Internal Evaluation: (15 Marks)	• Attendance/overall class performance will carry 5 marks. • Internal examination 10 marks. (There will be two groups of questions. Question No 1 will be very short answer type in Group A consisting of five questions of 1 marks each. Group B will contain descriptive type two questions of five marks each, out of which any one to answer
External Evaluation (60 Marks)	• There will be two group of questions. Group A is compulsory which will contain three questions. Question No. 1 will be very short answer type consisting of five questions of 1 mark each. Question N0. 2 & 3 will be short answer type of 5 marks. Group B will contain descriptive type five questions of fifteen marks each, out of which any three are to answer. There may be subdivisions in each question asked in theory Examinations

SEMESTER 1

MAJOR COURSE- CHE- MJ-1 **(Credits: Theory-04)**

Total Marks: 75 **(15 Marks Internal Examination + 60 Marks End Semester Examination)**

Atomic structure, periodicity and chemical bondind, Carbon-Carbon pi bonds, Aromaticity.

(Total Credit Hours: 60)

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

Unit II: 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 (octahedral and tetrahedral)

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

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

(g) Electronegativity, Pauling's/ Mulliken's/ Allred Rachow's/ and Mulliken-Jaffé's electronegativity scales. Variation of electronegativity with bond order, partial charge, hybridization, group electronegativity.

Unit III: Chemical Bonding:

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

(ii) *Covalent bond:* Lewis structure, Valence Bond theory (Heitler-London approach). Energetics of hybridization, equivalent and non-equivalent hybrid orbitals. Bent's rule, Resonance and resonance energy, Molecular orbital theory. Molecular orbital diagrams of diatomic and simple polyatomic molecules N_2, O_2, C_2, B_2, F_2, CO, NO, and their ions; HCl, BeF_2, CO_2, (idea of s-p mixing and orbital interaction to be given). Formal charge, Valence shell electron pair repulsion theory (VSEPR), shapes of simple molecules and ions containing lone pairs and σ bond and π bond. Covalent character in ionic compounds, polarizing power and polarizability. Fajan's rules and consequences of polarization. Ionic character in covalent compounds: Bond moment and dipole moment. Percentage ionic character from dipole moment and electronegativity difference.

(iii) *Weak Chemical Forces:* van der Waals forces, ion-dipole forces, dipole-dipole interactions, induced 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 energetics of dissolution process. Principles involved in volumetric analysis to be carried out in class.

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

(v) **Aromatic Hydrocarbons** *Aromaticity:* Hückel's rule, aromatic character of arenes, cyclic carbocations/carbanions and heterocyclic compounds with suitable examples. Electrophilic aromatic substitution: halogenation, nitration, sulphonation and Friedel-Craft's alkylation/acylation with their mechanism. Directing effects of the groups.

MAJOR PRACTICAL- CHE- MJ 1 LAB (Credits: Practical-02)
Total Marks: 25 (25 Marks End Semester Examination) (Total Credit Hours: 60)

Group-A

(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.

(iv) Group-B

1. Surface tension measurements.

a. Determine the surface tension by drop number method

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

2. Viscosity measurement using Ostwald's 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.

Reference Books:

1. Lee, J.D. Concise Inorganic Chemistry, ELBS, 1991.
2. Multistage equilibria in polyelectrolyte systems; hydrolysis and hydrolysis constants.
3. Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry Ed., Oxford University Press (2006).
4. Ball, D. W. Physical Chemistry Thomson Press, India (2007).
5. Castellan, G. W. Physical Chemistry 4th Ed. Narosa (2004).
6. Mortimer, R. G. Physical Chemistry 3rd Ed. Elsevier: NOIDA, UP (2009).
7. Vogel, A.I. A Textbook of Quantitative Inorganic Analysis, ELBS.

INDRODUCTORY REGULAR COURSE- CHE-IRC-1 **(Credits: Theory-02)**
Total Marks: 75 **(15 Marks Internal Examination + 60 Marks End Semester Examination)**

Unit I: Atomic Structure: Review of: Bohr's theory and its limitations, dual behaviour of matter and radiation, de-Broglie's relation, Heisenberg Uncertainty principle. Hydrogen atom spectra. Need of a new approach to Atomic structure. 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). 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

Ionic Bonding: General characteristics of ionic bonding. Energy considerations in ionic bonding, lattice energy and solvation energy and their importance in the context of stability and solubility of ionic compounds. Statement of Born-Landé equation for calculation of lattice energy, Born-Haber cycle and its applications, polarizing power and polarizability. Fajan's rules, ionic character in covalent compounds, bond moment, dipole moment and percentage ionic character.

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.

Unit III: Fundamentals of Organic Chemistry

Physical Effects, Electronic Displacements: Inductive Effect, Electromeric Effect, Resonance and Hyperconjugation. Cleavage of Bonds: Homolysis and Heterolysis. 45 Structure, shape and reactivity of organic molecules: Nucleophiles and electrophiles. Reactive Intermediates: Carbocations, Carbanions and free radicals.

Strength of organic acids and bases: Comparative study with emphasis on factors affecting pK values. Aromaticity: Benzenoids and Hückel's rule.

Unit IV: 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). 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).

Unit V: Aliphatic Hydrocarbons

Functional group approach for the following reactions (preparations & reactions) to be studied in context to their structure.

Alkanes: (Upto 5 Carbons). Preparation: Catalytic hydrogenation, Wurtz reaction, Kolbe's synthesis, from Grignard reagent. Reactions: Free radical Substitution: Halogenation.

Alkenes: (Upto 5 Carbons) 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, oxymecuration-demercuration, Hydroboration-oxidation.

Alkynes: (Upto 5 Carbons) 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. $KMnO_4$.

INDRODUCTORY REGULAR COURSE PRACTICAL- CHE-IRC 1 LAB (Credits: Practical-01)
Total Marks: 25 (25 Marks End Semester Examination) Total Credit Hours: 60

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 Mohr's 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.

Organic Chemistry

1. Detection of extra elements (N, S, Cl, Br, I) in organic compounds (containing upto two extra elements)

Reference Books:

1. J. D. Lee: *A new Concise Inorganic Chemistry,* E L. B. S.
2. F. A. Cotton & G. Wilkinson: *Basic Inorganic Chemistry*, John Wiley.
3. Douglas, McDaniel and Alexader: *Concepts and Models in Inorganic Chemistry,* John Wiley.
4. James E. Huheey, *Ellen Keiter and Richard Keiter: Inorganic Chemistry: Principles of Structure and Reactivity*, Pearson Publication.
5. T. W. Graham Solomon: *Organic Chemistry, John Wiley and Sons*.
6. Peter Sykes: *A Guide Book to Mechanism in Organic Chemistry,* Orient Longman.
7. E. L. Eliel: *Stereochemistry o f Carbon Compounds*, Tata McGraw Hill.
8. I. L. Finar: *Organic Chemistry* (Vol. I & II), E. L. B. S.
9. R. T. Morrison & R. N. Boyd: *Organic Chemistry*, Prentice Hall.
10. Arun Bahl and B. S. Bahl: *Advanced Organic Chemistry,* S. Chand
11. Vogel's Qualitative Inorganic Analysis, A.I. Vogel, Prentice Hall, 7th Edition.
12. Vogel's Quantitative Chemical Analysis, A.I. Vogel, Prentice Hall, 6th Edition.
13. Textbook of Practical Organic Chemistry, A.I. Vogel , Prentice Hall, 5th edition.
14. Practical Organic Chemistry, F. G. Mann. & B. C. Saunders, Orient Longman, 1960.

SEMESTER II

Chemical Thermodynamics: 14 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. Adiabatic flame temperature, explosion temperature. *Second Law:* Concept of entropy; thermodynamic scale of temperature, statement of the second law of thermodynamics; molecular and statistical interpretation of entropy. Calculation of entropy change for reversible and irreversible processes. *Third Law:* Statement of third law, concept of residual entropy, calculation of absolute entropy of molecules. *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; Maxwell relations; thermodynamic equation of state.

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 reactions. 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 *Kp* , *Kc* and *Kx*. Le Chatelier principle (quantitative treatment); equilibrium between ideal gases and a pure condensed phase.

Solutions and Colligative Properties: Dilute solutions;

(i) Lowering of vapour pressure, Raoult's and Henry's Laws and their applications.

(ii) Elevation of boiling point,

(iii) Depression of freezing point,

(iv) Osmotic pressure applications in calculating molar masses of normal, dissociated and associated solutes in solution.

MAJOR PRACTICAL- CHE- MJ 2 LAB (Credits: Practical-02)

Total Marks: 25 (25 Marks End Semester Examination) (Total Credit Hours: 60)

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. Determination of boiling point of liquid compounds. (boiling point lower than and more than 100 °C by distillation and capillary method)

5. Thermochemistry

(a) 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).

(b) Determination of heat capacity of the calorimeter and enthalpy of neutralization of hydrochloric acid with sodium hydroxide.

(c) Calculation of the enthalpy of ionization of ethanoic acid.

(d) Determination of heat capacity of the calorimeter and integral enthalpy (endothermic and exothermic) solution of salts.

(e) 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.

(f) Determination of enthalpy of hydration of copper sulphate.

(g) Study of the solubility of benzoic acid in water and determination of *H*.

Reference Books

1. Peter, A. & Paula, J. de. Physical Chemistry 9th Ed., Oxford University Press (2011).
2. Castellan, G. W. Physical Chemistry 4th Ed., Narosa (2004).
3. Engel, T. & Reid, P. Physical Chemistry 3rd Ed., Prentice-Hall (2012).
4. McQuarrie, D. A. & Simon, J. D. Molecular Thermodynamics Viva Books Pvt. Ltd.: New Delhi (2004).
5. Assael, M. J.; Goodwin, A. R. H.; Stamatoudis, M.; Wakeham, W. A. & Will, S. Commonly Asked Questions in Thermodynamics. CRC Press: NY (2011).
6. Levine, I .N. Physical Chemistry 6th Ed., Tata Mc Graw Hill (2010).
7. Metz, C.R. 2000 solved problems in chemistry, Schaum Series (2006)
8. Khosla, B. D.; Garg, V. C. & Gulati, A., Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
9. Athawale, V. D. & Mathur, P. Experimental Physical Chemistry New Age International: New Delhi (2001).
10. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)
11. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012)

INDRODUCTORY REGULAR COURSE-CHE- IRC-2 (Credits: Theory-02)
Total Marks: 75 (15 Marks Internal Examination + 60 Marks End Semester Examination)

Chemical Energetics: Review of thermodynamics and the Laws of Thermodynamics. Important principles and definitions of thermochemistry. Concept of standard state and standard enthalpies of formations, integral and differential enthalpies of solution and dilution. Calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data. Variation of enthalpy of a reaction with temperature – Kirchhoff's equation.

Chemical Equilibrium: Free energy change in a chemical reaction. Thermodynamic derivation of the law of chemical equilibrium. Distinction between G and G^{o}, Le Chatelier's principle. Relationships between K_p, K_c and K_x for reactions involving ideal gases.

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.

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-Craft's reaction (alkylation and acylation) (upto 4 carbons on benzene). Side chain oxidation of alkyl benzenes (upto 4 carbons on benzene).

Alkyl and Aryl Halides Alkyl Halides (Upto 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.

Aryl Halides *Preparation:* (Chloro, bromo and iodo-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 $NaNH_2/NH_3$).

Alcohols and Phenols (Upto 5 Carbons)

Alcohols: *Preparation:* Preparation of 1o, 2o and 3o 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. KMnO4, acidic dichromate, conc. HNO_3). Oppeneauer oxidation *Diols:* (Upto 6 Carbons) oxidation of diols. Pinacol-Pinacolone rearrangement.

Phenols: (Phenol case) *Preparation:* Cumene hydroperoxide method, from diazonium salts. *Reactions:* Electrophilic substitution: Nitration, halogenation and sulphonation. Reimer-Tiemann Reaction, Gattermann-Koch Reaction, Houben– Hoesch Condensation, Schotten – Baumann Reaction.

INDRODUCTORY REGULAR COURSE PRACTICAL-CHE- IRC 2 LAB (Credits: Practical-01)
Total Marks: 25 (25 Marks End Semester Examination) Total Credit Hours: 60

Thermochemistry

1. Determination of heat capacity of calorimeter for different volumes.
2. Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide.

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.

Organic Chemistry

1. Purification of organic compounds by crystallization (from water and alcohol) and distillation.

2. Criteria of Purity: Determination of melting and boiling points.
3. Preparations: 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:

1. T. W. Graham Solomons: *Organic Chemistry, John Wiley and Sons*.
2. Peter Sykes: *A Guide Book to Mechanism in Organic Chemistry,* Orient Longman.
3. I.L. Finar: *Organic Chemistry* (Vol. I & II), E. L. B. S.
4. R. T. Morrison & R. N. Boyd: *Organic Chemistry*, Prentice Hall.
5. Arun Bahl and B. S. Bahl: *Advanced Organic Chemistry,* S. Chand.
6. G. M. Barrow: *Physical Chemistry* Tata McGraw-Hill (2007).
7. G. W. Castellan: *Physical Chemistry* 4th Edn. Narosa (2004).
8. J. C. Kotz, P. M. Treichel & J. R. Townsend: *General Chemistry* Cengage Lening India Pvt. Ltd., New Delhi (2009).
9. B. H. Mahan: *University Chemistry* 3rd Ed. Narosa (1998).
10. R. H. Petrucci: *General Chemistry* 5th Ed. Macmillan Publishing Co.: New York (1985).
11. A.I. Vogel: Textbook of Practical Organic Chemistry, 5th edition, Prentice-Hall.
12. F. G. Mann & B. C. Saunders, Practical Organic Chemistry, Orient Longman (1960).
13. B.D. Khosla, Senior Practical Physical Chemistry, R. Chand & Co.