Department of Chemistry
Siddharth University, Kapilvastu, Siddharthnagar

Syllabus for B.Sc.
Subject: Chemistry
Modified on August 10, 2023, Board of Studies

Year	Semester	Paper & Code	Paper Name	Credits/Marks
Ist	I	B020101T	Fundamentals of Chemistry	4/**75**
		B020102P	Quantitative Analysis	**2/25**
	II	B020201T	Bioorganic and Medicinal Chemistry	4/**75**
		B020202P	Biochemical Analysis	**2/25**
IInd	III	B020301 T	Chemical Dynamics & Coordination Chemistry	4/**75**
		B020302P	Physical Analysis	**2/25**
	IV	B020401T	Quantum Mechanics and Analytical Techniques	4/**75**
		B020402P	Instrumental Analysis	**2/25**
IIIrd	V	B020501 T	Organic Synthesis-A	4/**75**
		B020501 P	Practical-I	**2/25**
		B020502T	Rearrangements and Chemistry of Group Elements	4/**75**
		B020502P	Practical-II	**2/25**
	VI	B020601T	Organic Synthesis-B	4/**75**
		B020601P	Practical-I	**2/25**
		B020602T	Chemical Energetics and Radiochemistry	4/**75**
		B020602P	Practical-II	**2/25**

Marking Distribution out of 100: - 25 Marks for internal Assessment +25 Marks External Practical Exam+ 50 Marks for theory paper.

Purpose of the Program

The purpose of the undergraduate chemistry program at the university and college level is to provide the key knowledge base and laboratory resources to prepare students for careers as professionals in various industries and research institutions.

Program's Outcomes

1. Students will have a firm foundation in the fundamentals and application of current chemical and scientific theories including those in Analytical, Inorganic, Organic and Physical Chemistry.
2. Students will be able to design and carry out scientific experiments as well as accurately record and analyze the results of such experiments.
3. Students will be skilled in problem solving, critical thinking and analytical reasoning as applied to scientific problems.
4. Students will be able to explore new areas of research in both chemistry and allied fields of science and technology.
5. Students will appreciate the central role of chemistry in our society and use this as a basis for ethical behavior in issues facing chemists including an understanding of safe handling of chemicals, **environmental issues** and key issues facing our society in energy, health and medicine sector.
6. Students will be able to explain why chemistry is an integral activity for addressing social, **economic**, and **environmental problems**.
7. Students will be able to function as a member of an interdisciplinary problem solving team.

	Program Specific outcomes
Ist year	**Certificate in Bioorganic and Medicinal Chemistry** Certificate in Bioorganic and Medicinal Chemistry will give the student a basic knowledge of all the fundamental principles of chemistry like molecular polarity , bonding theories of molecules, periodic properties of more than 111 elements, mechanism of organic reactions, stereochemistry, basic mathematical concepts and computer knowledge, chemistry of carbohydrates, proteins and nucleic acids, medicinal chemistry, synthetic polymers, synthetic dyes, Student will be able to do to qualitative, quantitative and biochemical analysis of the compounds in the laboratory. This certificate course is definitely going to prepare the students for various fields of chemistry and will give an insight into all the branches of chemistry and enable our students to join the knowledge and available opportunities related to chemistry in the government and private sector services particularly in the field of food safety, health inspector, pharmacist etc.

	Have a broad foundation in chemistry that stresses scientific reasoning and analytical problem solving with a molecular perspective
IInd year	**DIPLOMA IN CHEMICAL DYNAMICS AND ANALYTICAL TECHNIQUES**
	Diploma in Chemical Dynamics and Analytical Techniques will provide the theoretical as well as practical knowledge of handling chemicals, apparatus, equipment and instruments. The knowledge about feasibility and velocity of chemical reactions through chemical kinetics, chemical equilibrium, phase kinetic theories of gases, solid and liquid states, coordination chemistry, metal carbonyls and bioinorganic will enable the students to work as chemists in pharmaceutical industries. The knowledge about atomic structure, quantum mechanics, various spectroscopic tools and separation technique will make the students skilled to work in industries: Achieved the skills required to succeed in the chemical industry like cement industries, agro product, paint industries, rubber industries, petrochemical industries, food processing industries, fertilizer industries, pollution monitoring and control agencies etc. Got exposures of a breadth of experimental techniques using modem instrumentation. Learn the laboratory skills and safely measurements to transfer and interpret knowledge entirely in the working environment. **monitoring of environment issues:** monitoring of environmental pollution problems of atmospheric sciences, water chemistry and soil chemistry and design processes that meet the specified needs with appropriate consideration for the **public health** and **safety, cultural, societal, and environmental**
IIIrd Year	**DEGREE IN BACHELOR OF SCIENCE**
	Degree in Bachelor of Science programme aims to introduce very important aspects of modern day course curriculum, namely, chemistry of hydrocarbons, alcohols, carbonyl compounds, carboxylic acids, phenols, amines, heterocyclic compounds, natural products main group elements, qualitative analysis, separation techniques and analytical techniques. It will enable the students to understand the importance of the elements in the periodic table including their physical and chemical nature and their role in the daily life and also to understand the concept of chemistry to inter relate and interact to the other subject like mathematics, physics, biological science etc.

	Upon completion of a degree, chemistry students are able to employ critical thinking and scientific inquiry in the performance, design, interpretation and documentation of laboratory experiments, at a level suitable to succeed at an entry-level position in chemical industry or a chemistry graduate program Various research institutions and industry people in the pharmaceuticals, polymers, and food industry sectors will surely value this course.

Year	Sem.	Course Code	Paper Title	Credits	
Certificate in Bioorganic and Medicinal Chemistry					
1	I	6020101	Fundamentals of Chemistry	Theory	4
		6020102P	Quantitative Analysis	Practical	2
1	II	13020201T	Bioorganic and Medicinal Chemistry	Theory	4
		8020202P	Biochemical Analysis	Practical	2

Semester: I
Paper-I (Theory)
Course Title: Fundamentals of Chemistry

Certificate in Bioorganic and Medicinal Chemistry	Credit: 4
Course Code: B020101T	**Paper Title: Fundamentals of Chemistry**

Course outcome

There is nothing more fundamental to chemistry than the chemical bond. Chemical bonding is the language of logic for chemists. Chemical bonding enables scientists to take the 100-plus elements of the periodic table and combine them in myriad ways to form chemical compounds and materials. Periodic trends, arising from the arrangement of the periodic table, provide chemists with an invaluable tool to quickly predict an element's properties. These trends exist because of the similar atomic structure of the elements within their respective group families or periods, and because of the periodic nature of the elements. Reaction mechanism gives the fundamental knowledge of carrying out an organic reaction in step-by-step manner. This course will provide a broad foundation in chemistry that stresses scientific reasoning of an analytical problem solving with a molecular perspective. Students will gain an understanding of Molecular geometries, physical and chemical properties of the molecules.

- Current bonding models for simple inorganic and organic molecules in order to predict structures and important bonding parameters.
- The chapter recapitulation of basics of organic chemistry gives the most primary and utmost important knowledge and concepts of organic chemistry.
- This course gives a broader theoretical picture in multiple stages in an overall chemical reaction. It describes reactive intermediates, transition states and states of all the bonds broken and formed. It enables to understand the reactants, catalyst, stereochemistry and major and minor products of any organic reaction.
- It describes the types of reactions kinetic and thermodynamic aspects one should know for carrying out any reaction and the ways how the reaction mechanism can be determined.
- The chapter's stereochemistry gives the clear picture of two-dimensional, three-dimensional structure of the molecules, and their role in reaction mechanism.

Syllabus

Unit I: Molecular polarity and Weak Chemical Forces:

Resonance, resonance energy, formal charge, dipole moment and molecular Structure (diatomic and polyatomic molecules), Percentage ionic character from polarizing power and polarizability. Fajan's rules and consequences of polarization. Hydrogen bonding, Van der Waals forces, ion-dipole forces, dipole-dipole interactions, induced dipole interaction. Effects of weak chemical forces, melting and boiling points, solubility, energetics of dissolution process. Lattice energy and Born-Haber cycle, solvation energy, and solubility of ionic solids.

Unit II: Simple Bonding theories of Molecules

Atomic orbitals, Aufbau principle, multiple bonding (σ and π bond approach) and bond lengths, the valence bond theory (VBT), concept of hybridization, hybrid orbitals and molecular geometry, Bent's rule, Valence shell electron pair repulsion theory (VSEPR), shapes of the following simple molecules and ions containing lone pairs and bond pairs of electrons: H_2O, NH_3, PCI_5, SF_6, SF_4, CIF_3, I_3^- CIF_2^-, SO_4^{2-} and H_3O^+. Molecular orbital theory (MOT). Molecular orbital diagrams, bond orders of homonuclear and heteronuclear diatomic molecules and ions (N_2, O_2, C_2, B_2, F_2, CO, NO, and their ions)

Unit III: Periodic properties of Atoms (with reference to S & P-block):

Brief discussion, factors affecting and variation trends of following properties in groups and periods. Effective nuclear charge, shielding or screening effect, Slater rules, Atomic and ionic radii, electronegativity, Pauling's/ Allred Rochow's scales, ionization enthalpy, electron gain enthalpy.

Unit IV: Recapitulation of basics of Organic Chemistry: Hybridization, bond lengths and bond angles, bond energy, localized and delocalized chemical bonding, van der waals interactions, inclusion compounds, clatherates, charge transfer complexes, hyperconjugation, dipole moment; electronic, displacements: inductive, electromeric, resonance/ mesomeric effects and their applications

Unit V: Mechanism of Organic Reactions: Curved arrow notation, drawing electron movements with allows, half-headed and double-headed arrows, homolytic and heterolytic bond fission, types of reagents-electrophiles and nucleophiles, types of organic reactions, energy considerations. r**e**active 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).

Unit VI: Stereochemistry- concepts of isomerism, Types of isomerism-

Elements of Symmetry, molecular chirality, enantiomers, stereogenic center, optical activity, properties of enantiomers, chiral and achiral molecules with two stereogenic centers, disastereorners, threo and erythro diastereomcrs, meso compounds, resolution of enantionrner, inversion, retention a 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 mono substituted cyclohexane derivatives, Newman, projection and Sawhorse formulae, Fischer and flying wedge formulae, difference between configuration and conformation.

Unit VII: Basic Computer System (in brief)-

Hardware and Software; Input devices, Storage devices, Output devices, Central Processing Unit (Control Unit and Arithmetic Logic Unit); Number system (Binary, octal and Hexadecimal Operating System); Computer Codes (BCD and ASCII); Numeric/String Constants and variables Operating Systems (DOS, WINDOWS, and Linux); Software languages: low level and High Level languages (Machine language, Assembly language; QBASIC, FORTRAN and C^{++}); Software Products (Office, chemsketch, scilab, rnatlab, hyperchem, etc:), internet application.

Unit VIII: Mathematical Concepts for Chemistry

Logarithmic relations, curve sketching, linear graphs and calculation of slopes, differentiation of functions like Kx; e^x, X^n sin x, log x, maxima and minima, partial differentiation and reciprocity relations, integration of some useful/relevant functions; permutations and combinations, factorials, probability

Suggested Readings:

1.Lee, J.D. Concise Inorganic Chemistry, Pearson Education 2010
2.Huheey, J.E., Keiter, E.A.Keiter, R. L., Medhi, O.K. Inorganic Chemistry, Principles of Structure and Reactivity, Pearson Education 2006.
3. Douglas, B.E. and Mc Daniel, D.H., Concepts & Models of Inorganic Chemistry, Oxford, 1970
4.Shriver, D.D. & P. Atkins, *Inorganic Chemistry 2nd Ed.,* Oxford University Press, 1994.

5.Day, M.C. and Selbin, J. Theoretical Inorganic Chemistry, ACS Publications 1962.
6.Singh J.,Yadav L.D.S.,Advanced Organic Chemistry,Pragati Edition
7.Morrison, R. N. & Boyd, R. N. *Organic Chemistry,* Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
8.Carey, F. A., Guiliano, R. *M.Organic Chemistry,* Eighth edition, McGraw Hill Education, 2012.
9.Loudon, G. M. *Organic Chemistry,* Fourth edition, Oxford University Press, 2008.
10.Clayden, J., Greeves, N. &Warren, S. *Organic Chemistry,* 2- edition, Oxford University Press,2012 .
11. Graham Solomons, T.W., Fryhle, C. B. *Organic Chemistry,* John Wiley & Sons, Inc.
12.Sykes, P. *A guidebook to Mechanism in Organic Chemistry,* Pearson Education, 2003
13.Francis, P. G. Mathematics for Chemists, Springer, 1984

Semester-I
Paper-2 (Practical)
Course Title: Quantitative Analysis

Certificate in Bioorganic and Medicinal Chemistry	**Credit: 2**
Course Code: B020102P	**Course Title: Quantitative Analysis**

Course outcomes:

Upon completion of this course the students will have the knowledge and skills to: understand the laboratory methods and tests related to estimation of metals ions and estimation of acids and alkali contents in commercial products.

- Potability tests of water samples.
- Estimation of metal ions in samples
- Estimation of alkali and acid contents in samples
- Estimation of inorganic salts and hydrated water in samples

Unit I: Water Quality analysis

1. Estimation of hardness of water by EDTA.
2. Determination of chemical oxygen demand (COD).
3. Determination of Biological oxygen demand (BOD).

Unit II: Estimation of Metals ions

1. Estimation of ferrous and ferric ion by dichromate method.
2. Estimation of copper ion using thiosulphate.

Unit III: Estimation of acids and alkali contents

1. Determination of acetic acid in commercial vinegar using NaOH.
2. Determination of alkali content - antacid tablet using HCI.
3. Estimation of oxalic acid by titrating it with $KMnO_4$.

Unit IV: Estimation of inorganic salts and hydrated water

1. Estimation of sodium carbonate and sodium hydrogen carbonate present in a mixture.
2. Estimation of calcium content in chalk as calcium oxalate by permanganometry.
3. Estimation of water of crystallization in Mohr's salt by titrating with $KMnO_4$.

Suggested Readings:

1. Mendham, J. Vogel's Quantitative Chemical Analysis, Pearson, 2009_
2. Harris, D. C. Quantitative Chemical Analysis. 6th Ed., Freeman (2007) Chapters 3-5.
3. Harris, *D.C. Exploring Chemical Analysis,* 9th Ed. New York, W.H. Freeman, 2016**.**
4. Khopkar, S.M. *Basic Concepts of Analytical Chemistry.* New Age International Publisher, 2009.
5. Skoog, D.A. Holler F.J. and Nieman, T.A. *Principles of Instrumental Analysis,* Cengage Learning India Edition.

Semester-II
Paper-1
Course Title: Bioorganic and Materials Chemistry

Certificate in Bioorganic and Medicinal Chemistry	**Credit: 4**
Course Code: B020201T	**Course Title: Bioorganic and Materials Chemistry**

Course outcomes:

Biomolecules are the important for the functioning of living organisms. These molecules perform or trigger important biochemical reactions in living organisms. When studying biomolecules, one can understand the physiological function that regulates the proper growth and development of a human body. This course aims to introduce the students with basic experimental understanding of carbohydrates, amino acids, proteins, nucleic acids and medicinal chemistry. Upon completion of this course students may get job opportunities in food, beverage and pharmaceutical industries.

Syllabus

Unit I: Chemistry of Carbohydrates:

Classification of carbohydrates, reducing and non-reducing sugars, general properties of glucose and fructose, their open chain structure. Epimers, mutarotation and anomers. Mechanism of mutarotation, determination of configuration of glucose (Fischer's proof). Cyclic structure of glucose. Haworth projections. Cyclic structure of fructose. Inter conversions of sugars (ascending and descending of sugar series, conversion of aldoses to ketoses). Lobry de Bruyn-van Ekenstein rearrangement; stepping-up (Kiliani Fischer method) and stepping-down (Ruff's &Wohl's methods) of aldoses; end-group interchange of aldoses, Linkage between monosachharides, structure of disacharrides (sucrose, maltose, lactose) and polysacharrides (starch and cellulose) excluding their structure elucidation.

Unit II: **Chemistry of Proteins:**

Classification of amino acids, zwitter ion structure and Isoelectric point. Overview of primary, secondary, tertiary and quaternary structure of proteins. Determination of primary structure of peptides, determination of N-terminal amino acid (by DNFB and Edman method) and C-terminal amino acid (by thiohydantoin and with carboxypeptidase enzyme). Synthesis of simple peptides (upto dipeptides) by N-protection & C-activating groups and Merrifield solid phase synthesis. Protein denaturation/ renaturation Mechanism of enzyme action, factors affecting enzyme action, Coenzymes and cofactors and their role in biological reactions, specificity of enzyme action (Including stereospecifity), enzyme inhibitors and their importance, phenomenon of inhibition (Competitive and Non -competitive inhibition including allosteric inhibition).

Unit III: **Chemistry of Nucleic Acids:**

Constituents of Nucleic acids: Adenine, guanine, thymine and cytosine (Structure only), Nucleosides and Nucleotides (nomenclature), Synthesis of nucleic acids, Structure of polynucleotides, structure of DNA (Watson-Crick model) and RNA (types of RNA), Genetic Code, Biological roles of DNA and RNA: Replication, transcription and translation.

Unit IV: **Introductory Medicinal Chemistry:**

Drug discovery, design and development; basic retrosynthetic approach. Drug action-receptor theory. Structure -activity relationships of drug molecules, binding role of -OH group, $-NH_2$ group, double bond and aromatic ring. Synthesis of the representative drugs of the following classes: analgesics agents, antipyretic agents, anti inflarmmatory agents (Aspirin, paracetamol); antibiotics (Chloramphenicol); antibacterial and antifungal agents (Sulphonamides; Sulphanethoxazol, Sulphacetamide); antiviral agents (Acyclovir), Central Nervous System

agents (Phenobarbital, Diazepam), Cardiovascular (Glyceryl trinitrate),HIV-AIDS related drugs (AZT-Zidovudine) .

Unit V: solid State:

Definition of space lattice, unit cell. Laws of crystallography - (i) Law of constancy of interfacial angles, (ii) Law of rationality of indices and iii) Symmetry elements in crystals and law of symmetry, X-ray diffraction by crystals. Derivation of Bragg equation, Determination of crystal structure of NaCI, KC1 and CsCl (Laue's method and powder method).

Unit VI: **Introduction to Polymer**:

Monomers, Oligomers, Polymers and their characteristics, Classification of polymers: Natural synthetic, linear, cross linked and network, plastics, elastomers, fibres, Homopolymers and Co-polymers, Bonding in polymers: Primary and secondary bond forces in polymers; cohesive energy, and decomposition of polymers. Determination of molecular mass of polymers: number average molecular mass (Mn) and weight average molecular mass (Mw) of polymers and determination by (i) Viscosity (ii) Light scattering method (iii) Gel permeation chromatography (iv) Osmometry and Ultracentrifugation.

Silicones and Phosphazencs: Silicones and Phosphazencs as examples of inorganic polymers, nature of bonding in triphosphazenes.

Unit VII: Kineties and Mechanism of Polymerization:

Polymerization techniques, Mechanism and kinetics of copolymerization, 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 polyurethane, Natural and synthetic rubbers, Elementary idea of organic conducting polymers.

Unit VIII: 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.

Suggested Readings:

1. Davis, B. G., Fairbanks, A. J., Carbohydrate Chemistry, Oxford Chemistry Primer ,Oxford University Press.
2 Finar, I. L. Organic Chemistry (Volume 2), Dorling Kindersley (India) Pvt.Ltd.(Pearson Education).
3. Nelson, D. L. & Cox, M. M. Lehninger's Principles of Biochemistry 7th ED.,W.H. Freeman.
4. Berg, J. M., Tymoczko, J. L. & Stryer, L. Biochemistry 7th ED.,W.H. Freeman.

5. Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt.Ltd .(Pearson Education).
6. Patrick, G. L. Introduction to Medicinal Chemistry, Oxford University Press, UK,2013.
7. Singh, H. & Kapoor, V.K. Medicinal and Pharmaceutical Chemistry ,Vallabh Prakashan ,Pitampura ,New Delhi 2012.
8. Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry Ed., Oxford University Press 13 (2006).
9. Ball, D. W. Physical Chemistry Thomson Press, India (2007).
10. Castellan, G. W**.** Physical Chemistry 4th Ed. Narosa (2004).
11. R.B. Seymour **&** C.E. Carraher: Polymer Chemistry: An Introduction ,Marcel Dekker Inc.New York,1981.
12. G. Odian: Principles of Polymerizaiion, 4th Ed. Wiley, 2004.
13. F.W. Billmeyer: Textbook of Polymer Science, 2. Ed,Wiley Interscience,1971.
14. P. Ghosh: Polymer Science & Technology, Tata McGraw-Hill Education ,1991.

Semester-II
Paper-2 (Practical)
Course Title: Biochemical Analysis

Certificate in Bioorganic and Medicinal Chemistry	**Credit: 2**
Course Code: B020202P	**Course Title: Biochemical Analysis**

Course outcomes:

This course will provide basic qualitative and quantitative experimental knowledge of biomolecules such as carbohydrates, proteins, amino acids, nucleic acids as drug molecules. Upon successful completion of this course students may get job opportunities in food, beverage and pharmaceutical industries.

Syllabus

Unit I: Qualitative and Quantitative analysis of Carbohydrates:

1. Separation of a mixture of two sugars by ascending paper chromatography
2. Differentiate between a reducing/ non-reducing sugar
3. Synthesis of osazones.

Unit II: Qualitative and Quantitative analysis of proteins, amino acids and Fats:

1. Isolation of protein.
2. Determination of protein by the Biuret reaction.
3. TLC separation of a mixture containing 2/3 amino acids
4. Paper chromatographic separation of a mixture containing 2/3 amino acids
5. Action of salivary amylase on starch

6. To determine the concentration of glycine solution by formylation method.
7. To determine the saponification value of an oil/fat.
8. To determine the iodine value of an oil/fat

Unit III: Determination and identification of Nucleic Acids:

1. Determination of nucleic acids
2. Extraction of DNA from onion/cauliflower

Unit IV: Synthesis of Simple drug molecules:

1. To synthesize aspirin by acetylation of salicylic acid and compare it with the ingredient of an aspirin tablet by TLC.
2. Synthesis of barbituric acid
3. Synthesis of propranolol

Suggested Readings:

1. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012).
2. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education.
3. Vogel's Qualitative Inorganic Analysis, Revised by G. Svehla.
4. Vogel, A.I. A Textbook- of-Quantitative Analysis, ELBS, 1986
5. Furniss, B.S.; Hannaford, A.J.; Rogers, V.; Smith, P.W.G.; Tatchell, A.R. Vogel 's Textbook of Practical Organic Chemistry, ELBS.
6. Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry, Universities Press.
7. Cooper, T.G. Tool of Biochemistry. Wiley-Blackwell (1977).
8. Wilson, K. & Walker, J. Practical Biochemistry. Cambridge University Press (2009).
9. Varley, H., Gowenlock, A.H & Bell, M: Practical Clinical Biochemistry, Heinemann,

Year II	Sem.	Course Code	1 Paper Title	Credits	
Diploma in Chemical Dynamics and Analytical Techniques					
	III	B020301 T	Chemical Dynamics & Coordination	Theory	4
		B020302P	Physical Analysis	Practical	2
	IV	B020401 T	Quantum Mechanics and Analytical	Theory	4
		B020402P	Instrumental Analysis	Practical	2

Semester-III
Paper-I Theory
Course Title: Chemical Dynamics & Coordination Chemistry

Diploma in Chemical Dynamics and Analytical Techniques	Credits:4
Course Code : B020301 T	Course Title: Chemical Dynamics & Coordination Chemistry

Course outcomes: Upon successful completion of this course students should be able to describe the characteristic of the three states of matter and describe the different physical properties of each state of matter. kinetic theory of gases, laws of crystallography, liquid state and liquid crystals, conductometric, potentiometric, optical methods, polarimetry and spectrophotometer technique to study chemical kinetics and chemical equilibrium. After the completion of the course, Students will be able to understand. metal- ligand bonding in transition metal complexes, thermodynamic and kinetic aspects of metal complexes.

Syllabus

Unit I: Chemical Kinetics:

Rate of a reaction, molecularity and order of reaction, concentration dependence of rates, mathematical characteristic 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, half-life method and isolation method. Brief outline of experimental methods of studying 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 (no derivation).

Unit II: 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 III: Phase Equilibrium:

Statement and meaning of the terms-phase, component and degree of freedom, derivation of Gibbs phase rule, phase equilibria of one component system— water, CO_2 systems. Phase equilibria of two components Systems Solid - liquid equilibria, simple eutectic — Bi-Cd, Pb- Ag systems.

Unit IV: Kinetic theories of gases:

Gaseous State: 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: Qualitative discussion of the Maxwell's distribution of molecular velocities, collision number, mean free path and collision diameter. Liquefaction of gases (based on Joule-Thomson effect).

Unit V: Liquid State:

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 cholesterol phases. Thermography and seven segment cell.

Liquids in solids (gels): Classification, preparation and properties, inhibition, general application

Unit VI: Coordination Chemistry:

Coordinate bonding: double and complex salts. Werner's theory of coordination complexes, classification of ligands, ambidentate ligands, chelates, coordination numbers, IUPAC nomenclature of coordination complexes (up to two metal centers), Isomerism in coordination compounds, constitutional and stereo isomerism, geometrical and optical isomerism in square planar and octahedral complexes.

Unit VII: Theories of Coordination Chemistry:

(i) Metal- ligand bonding in transition metal complexes: limitations of valance bond theory, an elementary idea of crystal field theory, crystal field splitting in octahedral, tetrahedral and square planner 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 VIII: inorganic Spectroscopy and Magnetism:

(I) 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.

(II) magnetic properties of transition metal complexes, types of magnetic behaviour. 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. 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 ferromagnetism, magnetic susceptibility; its measurements and its importance.

Suggested Readings:

1. Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry Ed., Oxford University Press 13 (2006)
2. Ball, D. W. Physical Chemistry Thomson Press, India (2007).
3. Castellan, G. W. Physical Chemistry 4th Ed. Narosa (2004).
4. Cotton,F.A, Wilkinson,G and Gaus,P. L ,Basic Inorganic Chemistry ,3rd Edition ,Wiley 1995.
5. Lee,J.D, Concise Inorganic Chemistry 4th Edition ELBS,1977.
6. Douglas,B, McDaniel ,D and Alexander,J ,Concepts of Model of Inorganic Chemistry ,John Wiley & Sons ; 3rd edition , 1994
7. Shriver,D.E Atkins,P.W and Langford,C .H , Inorganic Chemistry ,Oxford University Press,1994.
8. Porterfield ,WW, Inorganic Chemistry ,Addison Wesley 1984.

9. Sharpe,A .G, Inorganic Chemistry, ELBS,3rd edition ,1993

Miessler,G.L,Tarr,D.A, Inorganic Chemistry, 2nd edition, Prentice Hall ,2001.

Semester - III
Paper –II (Practical)
Course Title: Physical Analysis

Diploma in Chemical Dynamics and Analytical Techniques	Credits:2
Course Code : B020302P	**Course Title: Physical Analysis**

Course Outcomes: Upon successful completion of this course students should be able to calibrate apparatus and prepare solutions of various concentrations, estimation of components through volumetric analysis; to perform dilatometric experiments: one and two component phase equilibrium experiments.

Syllabus

Unit I: Strengths of Solution

Calibration of fractional weights, pipettes and burettes. Preparation of standards solutions. Dilution -0.1 M to 0.001 M solutions.

Mole Concept and Concentration: Mole Concept, molecular weight, formula weight, and equivalent weight. Concentration units: Molarity, Formality, Normality, Molality, Mole fraction, Percentage by weight, Percentege by volume, Parts per thousand, Parts per million, Parts per billion, pH, pOH, milli equivalents, Milli moles

Unit II: Surface Tension and Viscosity:

1. Determination of surface tension of pure liquid or solution
2. Determination of viscosity of pure liquid or solution

Unit III: Boiling point and Transition Temperature:

1. Boiling point of common organic liquid compounds [**ANY FIVE]** n-butylalcohol, cyclohexanol, ethyl methyl. ketone, cyclohexanone, acetylacetone, isobutyl methyl ketone, isobutyl alcohol, acetonitrile, benzaldehyde and acetophenone. [Boiling points of the chosen organic compounds should preferably be within 180°C].

2.Transition Temperature, Determination of the transition temperature of the given substance by thermometric /dialometric method (e.g. $MnCl_2.4H_2O$/$SrBr_2.$ **7**H_2O**)**

Unit IV: Phase Equilibrium:
1.To study the effect of a solute e.g. NaCI. 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 **2.**To construct the phase diagram of two component (e.g. diphenylamine — benzophenone) system by cooling curve method.
Suggested Readings: 1. Skoog.D.A., West.D.M and Holler.F.J., "Analytical Chemistry: An Introduction ,7th edition, Saunders College publishing, Philadelphia, (2010). **2.** Larry Hargis.G" Analytical Chemistry: Principles and Techniques, Pearson 1988.

Semester-IV
Paper-I Theory
Course Title: Quantum Mechanics and Analytical Techniques

Diploma in Chemical Dynamics and Analytical Techniques	**Credits:4**
Course Code : B020401T	**Course Title: Quantum Mechanics and Analytical Techniques**
Course Outcomes: Upon successful completion of this course students should be able to describe atomic structure, elementary quantum mechanics, wave function and its significance; Schrodinger wave equation and its applications; Molecular orbital theory, basic ideas — Criteria for forming molecular orbital from atomic orbitals, molecular spectroscopy, rotational spectrum, vibrational electronic spectrum: photo chemistry and kinetics of photo chemical reaction. Analytical chemistry plays an enormous role in our society, such as in drug manufacturing, process control in industry, environmental monitoring, medical diagnostics, food production, and forensic. surveys. it is also of great importance in different research areas. analytical chemistry is a science that is directed towards creating new knowledge so that chemical analysis can be improved to respond to increasing or new demands. • Students will be able to explore new areas of research in both chemistry and allied fields of science and technology.	

- Students will be able to function as a member of an interdisciplinary problem solving team.
- Students will be skilled in problem solving, critical thinking and analytical reasoning as applied to scientific problems.
- Students will gain an understanding of how to determine the structure of organic molecules using IR and NMR spectroscopic techniques.
- To develop basic skills required for purification, solvent extraction, TLC and column chromatography.

Syllabus

Unit I: Atomic Structure: Idea of de-Broglie matter waves, Heisenberg uncertainty principle, atomic orbitals, Schrodinger 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.

Unit II: Elementary Quantum Mechanics: Black-body radiation, Planck's radiation law, photo-electric effect, heat capacity of solids, Bohr's model of hydrogen atom (no derivation) and its defects, Compton effect. de-Broglie hypothesis. Heisenberg uncertainty principle. Hamiltonian Operator. Schrodinger wave equation (time dependent and time independent) and its importance, physical interpretation of the wave function, postulates of quantum mechanics, particle in a one dimensional box. Schrodinger 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 MO from AO, construction of MO by LCAO – H_2 + ion, calculation of energy levels from wave functions, physical picture of bonding and anti-bonding wave functions, concept of σ, σ^*, π, π^* orbitals and their characteristics.

Unit III: Molecular Spectroscopy: Introduction: Electromagnetic radiation, regions of the spectrum, basic features of different spectrometers, 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 antibonding molecular orbitals, qualitative description of selection rules and Franck-Condon principle.

Unit IV: UV-Visible Spectroscopy:

Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules. Types of electronic transitions, λ_{max}, chromophores and auxochromes, bathochromic and hypsochromic shifts, Intensity of absorption; application of Woodward Rules for calculation of λ_{max} for the conjugated dienes: alicyclic, homoannular and heteroannular; extended conjugated systems distinction between cis and trans isomers.

Unit V: Infrared Spectroscopy:

IR Spectroscopy: Fundamental and non-fundamental molecular vibrations; Hooke's law selection rule, IR absorption positions of various functional groups; Effect of H-bonding, conjugation, resonance and ring size on IR absorptions; Fingerprint region and its significant application in functional group analysis and and interpretation of I.R. spectra of simple organic compounds

Unit VI: ^{1}H-NMR Spectroscopy (PMR):

NMR Spectroscopy: introduction; nuclear spin; NMR active molecules; basic principles of Proton Magnetic Resonance; choice of solvent and internal standard; equivalent and non.--equivalent protons; chemical shift and factors influencing it; ring current effect; significance of the terms: up/downfield, shielded and deshielded protons; spin coupling and coupling constant (1^{st} order spectra); relative intensities of first-order multiplets: Pascal's triangle; chemical and magnetic equivalence in NMR; anisotropic effects in alkene, alkyne, aldehydes and aromatics; NMR peak area, integration; relative peak positions with coupling patterns of common organic compounds; interpretation of NMR spectra of simple

compounds. Applications of IR, UV and NMR spectroscopy for identification of simple organic molecules.

Unit VII: Introduction to Mass Spectrometry:

Principle of mass spectrometry, the mass spectrum, mass spectrometry diagram, molecular ion, metastable ion, fragmentation process, McLafferty rearrangement.

Unit VIII: Separation Techniques:

Solvent extraction: Classification, principle and efficiency of the technique. Mechanism of extraction: extraction by solvation and chelation. Technique of extraction, batch, continuous and counter current extractions. Qualitative and quantitative aspects of solvent extraction, extraction of metal ions from aqueous solution, extraction of organic species from the aqueous and non-aqueous media.

Chromatography: Classification, principle and efficiency of the technique. Mechanism of separation: adsorption, partition & ion exchange. Development of chromatograms: frontal, elution and displacement methods.

Suggested Readings:

1. Alberty,R A, Physical Chemistry,4 th editionWiley Eastern Ltd ,2001.
2. Atkins,P W,the elements of physical chemistry,Oxford ,1991.
3. Barrow,G.M,International student Edition .McGraw Hill, McGraw-Hi11,1973.
4. Cotton,F.A, Wilkinson,G and Gaus,P. L ,Basic Inorganic Chemistry,3rd Edition ,Wiley 1995.
5. Lee,J.D, Concise Inorganic Chemistry 4th Edition ELBS,1977.
6. Clayden, J., Greeves, N., Warren, S., *Organic Chemistry*, Second edition, Oxford University Press 2012.
7. Silverstein, R. M., Bassler, G. C., Morrill, T. C. *Spectrometric Identification of Organic Compounds,* John Wiley and Sons, INC, Fifth edition.
8. Pavia, D. L. *et al. Introduction to Spectroscopy*, 5th Ed. Cengage Learning India Ed.
9. Willard, H.H. *et al.: Instrumental Methods of Analysis,* 7th Ed. Wardsworth Publishing Company, Belmont, California, USA, 1988.
10. Christian, G.D. *Analytical Chemistry,* 6th Ed. John Wiley & Sons, New York, 2004.
11. Harris, D.C.: *Exploring Chemical Analysis*, 9th Ed. New York, W.H. Freeman, 2016.
12. Khopkar, S.M. *Basic Concepts of Analytical Chemistry.* New Age International Publisher, 2009.

Semester IV
Paper-2 (Practical)
Course Title: Instrumental Analysis

Diploma in Chemical Dynamics and Analytical Techniques	Credit:2
Course Code: B020402P	**Course Title: Instrumental Analysis**

Course outcomes: Upon completion of this course, chemistry majors are able to employ critical thinking and scientific inquiry in the performance, design, interpretation and documentation of laboratory experiments at a level suitable to succeed at an entry-level position in chemical industry or a chemistry graduate program.

- Students will be able to explore new areas of research in both chemistry and allied fields of science and technology.
- Students will be able to function as a member of an interdisciplinary problem solving team.
- Students will be skilled in problem solving, critical thinking and analytical reasoning as applied to scientific problems.
- Students will gain an understanding of how to determine the structure of organic molecules using IR and NMR spectroscopic techniques.
- To develop basic skills required for purification, solvent extraction, TLC and column chromatography.

Unit I: Molecular Weight Determination

1.Determination of molecular weight of a non-volatile solute by Rast method/ Beckmann freezing point method.

2.Determination of the apparent degree of dissociation of an electrolyte (e.g., NaC1) in aqueous solution at different concentrations by ebullioscopy.

Unit II: Spectrophotometry

1.To verify Beer - Lambert Law for $KMnO_4/K_2Cr_2O_7$ and determining the concentration of the given solution of the substance from absorption measurement.

2.Determination of pKa values of indicator using spectrophotometry.

3.Determination of chemical oxygen demand (COD).

4. Determination of Biological oxygen demand (BOD).

Unit: III spectroscopy

1. Assignment of labelled peaks in the IR spectrum of the same compound explaining the relative frequencies of the absorptions (C-H, O-H, N-H, C-O, C-N, C-X, C=C, CO, -N=O C=C, C=N stretching frequencies; characteristic bending vibrations are included Spectra to be provided).
2. Assignment of labelled peaks in the ^{1}H NMR spectra of the known organic compounds explaining the relative values and splitting pattern.
3. Identification of simple organic compounds by IR spectroscopy and NMR. spectroscopy (Spectra to be provided).

Unit IV: Chromatographic Separations

1. Paper chromatographic separation of following metal ions:
   (i) Ni (II) and Co (II). (ii) Cu(II) and Cd(II)
2. Separation of a mixture of o-and p-nitrophenol or o-and p-aminophenol by thin layer Chromatography (TLC)
3. Separation and identification of the amino acids present in the given mixture by paper chromatography. reporting the Rf values
4. TLC separation of a mixture of dyes (fluorescein and methylene blue)

Suggested Readings:

I . Mendham, J., A. I. Vogel 's Quantitative Chemical Analysis 6th Ed., Pearson, 2009.
2. Willard, H.H. et at.: Instrumental Methods of Analysis, 7th Ed. Wardsworth Publishing Company, Belmont, California, USA, 1988.
3. Christian, G.D. Analytical Chemistry, 6th Ed. John Wiley & Sons, New York, 2004.
4. Harris, D.C.Exploring Chemical Analysis, 9th Ed. New York, W.H. Freeman, 2016.
5. Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age International Publisher, 2009.
6. Skoog, D.A. Holler F.J. and Nieman, T.A. Principles of Instrumental Analysis, Cengage Learning India Edition.
7. Mikes, 0. & Chalmes, R.A. Laboratory Handbook of Chromatographic & Allied Methods, Elles Harwood Ltd. London.
8. Ditts, R.V. Analytical Chemistry: Methods of separation. Van Nostrand, New York, 1974.

Year 3	Sem.	Course Code	1 Paper Title		Credit
Degree in Bachelor of Science					
3	V	B020501 T	Organic Synthesis-A	Theory	4
		B020501P	Qualitative Analysis	Practical	2
		B020502T	Rearrangements and Chemistry of Group Elements	Theory	4
		B020502P	Chemistry Practical	Practical	
	VI	B020601T	Organic Synthesis-B	Theory	4
		B020601P	Analytical Methods	Practical	2
		B020602T	Chemical Energetics and Radiochemistry	Theory	4
		B020602P	Analytical Methods	Practical	2

Semester V,
Paper-1 (Theory)
Course Title: Organic Synthesis-A

Degree in Bachelor of Science	**Credit:4**
Course code: B020501T	**Organic Synthesis-A**

Course outcomes: Hydrocarbons are the principal constituents of petroleum and natural gas. They serve as fuels and lubricants as well as raw materials for the production of plastics, fibers, rubbers, solvents and industrial chemicals. This course will provide a broad foundation for the synthesis of hydrocarbons. Hydroxy and carbonyl compounds are industrially important compounds The industries of plastics, fibers, petroleum and rubbers will specially recognize this course.

- Students will gain an understanding of which are used as solvents and raw material for synthesis of drug and other pharmaceutically important compound&
- Synthesis and chemical properties of aliphatic and aromatic hydrocarbons.
- Synthesis and chemical properties of alcohols, halides carbonyl compounds, carboxylic acids and esters.
- How to design and synthesize aliphatic and aromatic hydrocarbons.
- How to convert aliphatic and aromatic hydrocarbons to other industrially important compounds.

- ❖ Functional group interconversion.

Unit I: Chemistry of Alkanes and Cycloalkanes:

A) Alkanes: Classification of carbon atom in alkanes, General methods of preparation, physical and chemical properties of alkanes: Wurtz Reaction, Wurtz-Fittig Reactions, Free radical substitutions: Halogenation -relative reactivity and selectivity.

B) Cycloalkanes: Nomenclature, methods of formation, chemical reactions, Baeyer's strain theory and its limitations. Chair, Boat and Twist boat forms of cyclohexane with energy diagrams ring strain in small rings, theory of strain less rings. The case of cyclopropane ring, banana bonds.

Unit II: Chemistry of Alkenes:

Methods of formation of alkenes. Addition to (−C≡C−): mechanism (with evidence wherever applicable), reactivity, regioselectivity (Markownikoff and anti-Markownikoff additions) and stereoselectivity; reactions: hydrogenation, halogenation, hydrohalogenation, hydration, oxymercuration, demercuration, hydroboration-oxidation, epoxidation, syn and anti-hydroxylation, ozonolysis, addition of singlet and triplet carbenes; Simmons-Smith cyclopropanation reaction; electrophilic addition to diene (conjugated dienes and allene); radical addition: HBr addition: mechanism of allylic and benzylic bromination in competition with brominations across C=C; use of NBS; interconversion of E- and Z- alkenes; contra-thermodynamic isomerization of internal alkenes.

Unit III: Chemistry of Alkynes:

Methods of formation of alkynes, Addition to C=C, mechanism reactivity, regioselectivity and stereoselectivity, reactions: hydrogenation, halogenations, hydrohalogenation, hydration, oxymercuration demercuration, hydroboration-oxidation, dissolving metal reduction of alkynes (Birch), reactions of terminal alkynes by exploring its acidity, inter conversion of terminal and non-terminal alkynes.

Unit IV: Aromaticity and Chemistry of Arenes:

Nomenclature of benzene derivatives, MO picture of benzene, Aromaticity: Huckel's rule, aromatic character of arenes, cyclic carbocations/carbanions. Electrophilic aromatic substitution: halogenation, nitration, sulphonation and Friedel-Craft's alkylation/acylation with their mechanism. Directing effects of the groups. Birch reduction, Methods of formation and

chemical reactions of alkylbenzenes, alkynylbenzenes and biphenyl, naphthalene and anthracene.

Unit V: Chemistry of 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 [$Pb(OAc)_4$ and HIO_4] and pinacol pinacolone rearrangement, trihydric alcohols - nomenclature, methods of formation, chemical reactions of glycerol.

Unit VI: Chemistry of 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 reactio

Unit VII: Chemistry of 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 organolithium reagents with epoxides.

Unit VIII: Chemistry of Organic Halides

Nomenclature and classes of alkyl halides, methods of formation, chemical reactions, mechanisms of nucleophilic substitution reactions of alkyl halides, SN^2 and SN^1 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.

Suggested Readings:

1. Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Sykes, P. A guidebook to Mechanism in Organic Chemistry, Pearson Education, 2003.

3. Carey, F. A., Guiliano, R. M Organic Chemistry, Eighth edition, McGraw Hill Education, 2012.
4. Loudon, G. M. Organic Chemistry, Fourth edition, Oxford University Press, 2008,
5. Clayden, J., Greeves, N. &Warren, S. Organic Chemistry, 2' edition, Oxford University Press, 2012.
6. Graham Solomons, T.W., Fryhle, C. B. Organic Chemistry, John Wiley & Sons, Inc.
7. Smith, J. G. Organic Chemistry, Tata McGraw-Hill Publishing Company Limited.
8. March, J. Advanced Organic Chemistry, Fourth edition, Wiley.

Semester V,
Paper-III (Practical -I)
Course Title: Qualitative Analysis

Degree in Bachelor of Science	**Credit: 2**
Course Code: B020501P	**Course Title: Qualitative Analysis**

Course outcomes:

Upon completion of this course the students will have the knowledge and skills to: understand the laboratory methods and tests related to inorganic mixtures and organic compounds.

- Separation of two components of organic mixture.
- Elemental analysis in organic compounds.
- Identification of functional group in organic compounds.
- Identification of organic compound.

Unit I: Elemental analysis and identification of functional groups

1.Detection of extra elements (N, S and halogens) in a given organic compound.

2. Functional groups analysis (phenolic, carboxylic, carbonyl, esters, in simple organic compounds.

Unit II: Separation and identification of binary organic mixture.

1. Separation of binary organic mixture containing two solid components using water.
2. Identification of organic compounds in the given binary mixture.
3. Determination of melting point and preparation of suitable derivatives of given compounds.

Unit III. Preparation of the following compounds:

1. Soap from linseed oil or mahua oil or neem oil or coconut oil.
2. Phenyl benzoate from phenol.

Unit IV. Preparation of the following compounds:

1. Oxalic acid from cane sugar.
2. Benzoic acid from ethyl or methyl benzene.

Suggested Readings: •

1. Svehla, G. Vogel's Qualitative Inorganic Analysis, Pearson Education, 2012.
2. Mendham, J. Vogel's Quantitative Chemical Analysis, Pearson, 2009.
3. 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.
4. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry Orient-Longman, 1960.. .
5 Harris, D.C.Exploring Chemical Analysis, 9Ed. New York, W.H. Freeman, 2016.
6. Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age InterEnvironment Publisher, 2009.

Semester-V
Paper-2 (Theory)
Course Title: Rearrangements and Chemistry of Group Elements

Degree in Bachelor of Science	**Credit: 4**
Course Code: B020502T	**Title: Rearrangements and Chemistry of Group Elements**

Course outcomes:

This paper provides detailed knowledge of synthesis of various class of organic compounds and functional groups inter conversion. Organic synthesis is the most important branch of organic chemistry which provides jobs in production & QC departments related to chemicals, drugs, medicines, FMCG industries etc.

- ❖ It relates and gives an analytical aptitude for synthesizing various industrially important compounds.

- ❖ This paper also provides a detailed knowledge on the elements present in our surroundings, their occurrence in nature. Their position in periodic table, their physical and chemical properties as well as their extraction.
- ❖ This paper also gives detailed understanding of the s, p, d and f block elements and their characteristics

Syllabus

Unit I: Rearrangements:

A detailed study of the following rearrangements: Pinacol-pinacolone, Demjanov, Benzil Benzilic acid, Favorskii, Hofman, Curtius, Schmidt, Baeyer-Villiger and Fries rearrangement .

Unit II: Catalysis:

General principles and properties of catalysts, homogenous catalysis (catalytic steps and examples) and heterogenous catalysis (catalytic steps and examples) and their industrial applications, Deactivation or regeneration of catalysts. Phase transfer catalysts, application of zeolites as catalysts. Enzyme catalysis; Michaelis-Menten equation, Lineweaver-Burk plot, turn-over number.

Unit III: Chemistry of Main Group Elements:

S-Block Elements: Comparative study, diagonal relationship, salient features of hydrides, solvation, and complexation tendencies including their function in bio-systems, an introduction to alkyls and aryls.

p-Block Elements: Comparative study (including diagonal relationship) of groups 13-17 elements, compounds like hydrides, oxides, oxyacids and halides of group I 3-16, 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.

Chemistry of Noble Gasses: Chemical properties of the noble gases, chemistry of xenon, structure and bonding in xenon compounds.

Unit IV: Chemistry of Transition Elements:

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.

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 V: Chemistry of Lanthanides:

Electronic structure, oxidation states and ionic radii and lanthanide contraction, complex formation, occurrence and isolation, ceric ammonium sulphate and its analytical uses.

Unit VI: Chemistry of Actinides: Electronic configuration, oxidation states and magnetic properties, chemistry of separation of Np, Pu and Am from U.

Unit VII: Metal Carbonyls:

Metal carbonyls: 18-electron rule, preparation, structure and nature of bonding in the mononuclear and dinuclear carbonyls.

Unit VIII: Bioinorganic Chemistry:

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

Suggested Readings:

1. Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Sykes, P. A guidebook to Mechanism in Organic Chemistry, Pearson Education, 2003.
3. Carey, F. A., Guiliano, R. M.Organic Chemistry, Eighth edition, McGraw Hill Education, 2012.
4. Loudon, G. M. Organic Chemistry, Fourth edition, Oxford University Press, 2008.
5. Clayden, J., Greeves, N. &Warren, S. Organic Chemistry, 2' edition, Oxford University Press, 2012.
6. Graham Solomons, T.W., Fryhle, C. B. Organic Chemistry, John Wiley & Sons, Inc.
7. Smith, J. G. Organic Chemistry, Tata McGraw-Hill Publishing Company Limited.
8. March, J. Advanced Organic Chemistry, Fourth edition,Wiley.
9. Lee, J.D. Concise Inorganic Chemistry, Pearson Education 2010.
10. Huheey, J.E., Keiter, E.A., Keiter, R. L., Medhi, O.K. Inorganic Chemistry, Principles of Structure and Reactivity, Pearson Education 2006.
11. Douglas, B.E. and Mc Daniel, D.H., Concepts & Models of Inorganic Chemistry ,Oxford ,1970.
12. Shriver,D.D. & P. Atkins, Inorganic Chprnivtry 2nd Ed, Oxford University Press,1994.
13. Day, M.C. and Selbin, J. Theoretical Inorganic Chemistry,ACS Publications 1962.
14. Francis, P. G. Mathematics for Chemists, Springer, 1984
15. Prakash Satya,Tuli G.D.,Basu S.K.Madan R.D.,Advanced Inorganic Chemistry ,S.Chand publishing.

Semester V,
Paper-4 (Practical-II)
Course Title: Qualitative & Quantitative Analysis

Degree in Bachelor of Science	Credit: 2
Course Code: B020502P	Course Title: Qualitative & Quantitative Analysis

Course outcomes:

Upon completion of this course the students will have the knowledge and skills to understand the laboratory methods and tests related to Qualitative & Quantitative analysis of inorganic metal ion and mixtures and students should be able to quantify the product obtained through gravimetric Analysis;

- ❖ Qualitative Inorganic Analysis.
- ❖ Gravimetric Analysis.
- ❖ Volumetric Analysis.

Syllabus

Unit I: Semi microanalysis analysis of cation

cation analysis**,** separation and identification of ions from Groups I, II, III, IV, V and VI,

Unit II: Semi microanalysis analysis of anion

anion analysis, mixture containing 6 radicals -2, -4 or +4, -3 or +3

Unit III: Gravimetric analysis-

(i) Estimation of Zn as zinc oxide from the zinc chloride or zinc sulphate solution.

(ii) Estimation of copper as cupric oxide in a solution of copper sulphate.

Unit IV: Volumetric analysis-

(i)To determine the strength in gm/litre of a given solution of Ferrous ammonium sulphate (Mohrs salt) being provided with approx. N/30 $KMnO_4$ solution.

Suggested Readings:

1. Svehla, G. Vogel's Qualitative Inorganic Analysis, Pearson Education, 2012.
2. Mendham, J. Vogel's Quantitative Chemical Analysis, Pearson, 2009.
3. 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.

Semester-VI
Paper-I
Course Title: Organic Synthesis B

Degree in Bachelor of Science	Credit:4
Course Code:B020601T	Course Title: Organic Synthesis B

Course outcomes:

This paper provides detailed knowledge of synthesis of various class of organic compounds and functional groups inter conversion. Organic synthesis is the most important branch of organic chemistry which provides jobs in production & QC departments related to chemicals, drugs, medicines, FMCG industries.

The study of natural products and heterocyclic compounds offers an excellent strategy toward identifying novel biological probes for a number of diseases. Historically, natural products have played an important role in the development of pharmaceutical drugs for a number of diseases including cancer and infection.

• It relates and gives an analytical aptitude for synthesizing various industrially important compounds.

• Learn the different types of alkaloids, terpenes and their chemistry and medicinal importance.

• Explain the importance of natural compounds as lead molecules for new drug discovery.

Unit I: Reagents in Organic Synthesis:

A detailed study of the following reagents in organic transformations: Oxidation with DDQ, CAN and SeO_2, mCPBA, Jones Oxidation, PCC, PDC, PFC, Collins reagent and ruthenium tetraoxide. Reduction with $NaBH_4$, $LiA1H_4$, Meerwein-Ponndorf-Verley (MPV) reduction, Wilkinson's catalyst, Birch reduction, DIBAL-H .

Unit 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.

Unit III: Chemistry of 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 nucleophillic additions to carbonyl group with particular emphasis on benzoin, aldol, Perkin and Knoevenagel condensations, Condensation with ammonia and its derivatives. Wittig reaction, Mannich reaction. Oxidation of aldehydes, Cannizzaro reaction, MPV, Clemmensen, Wollf-Kishner, $LiAlH_4$ and $NaBH_4$ reductions. Halogenation of enolizable ketones, An introduction to ά, β unsaturated aldehydes and ketones.

Unit IV: Carboxylic acids and their Functional Derivatives:

Nomenclature and classification of aliphatic and aromatic carboxylic acids. Preparation and, reactions. Acidity (effect of substituents on acidity) and salt formation, Reactions: Mechanism of reduction, substitution in alkyl or aryl group. Preparation and properties of dicarboxylic acids such as oxalic, malonic, succinic, glutaric, adipic and phthalic acids and unsaturated carboxylic acids such as acrylic, crotonic and cinnamic acids reactions. Action of heat on hydroxy and amino acids, and saturated dicarboxylic acids, stereospecific addition to maleic and fumaric acids. Preparation and reactions of acid chlorides, acid anhydrides, amides and esters, acid and alkaline hydrolysis of ester, transesterification.

Unit V: Organic Synthesis via Enolates:

Acidity of α-hydrogens, alkylation of diethyl malonate and ethyl acetoacetate, Synthesis of ethyl acetoacetate: the Claisen condensation, Keto-enol tautomerism of ethyl acetoacetate. Alkylation of 1, 3-dithianes, Alkylation and acylation of enamines.

Unit VI: 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, Halonitroarenes: reactivity, Structure and nomenclature of amines, physical properties, Stereochemistry of amines, Separation of 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, nitrities), reductive amination of aldehydic and ketonic compounds, Gabriel phthalimide reaction, Hofmann bromamide reaction. Reactions of amines, electrophilic aromatic substituton in aryl amines, reactions of amines with nitrous acid. Synthetic transformations of aryl diazonium salts, azo coupling.

Unit VII: Heterocyclic Chemistry:

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 elcetrophilic 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, quinolone and isoquinoline with special reference to Fisher indole synthesis, Skraup synthesis and Bischler-Nepieralski synthesis, Mechanism of electrophilc substitution reactions of indole, quinoline and isoquinoline.

Unit VIII: Natural Products:

Alkaloids & Terpenes: Natural occurrence, General structural features, their physiological action, Hoffmann's exhaustive methylation, Emde's modification; Medicinal importance of Nicotine, Hygrine, Quinine, Morphine, Cocaine, and Reserpine, natural Occurrence and classification of terpenes, isoprene rule.

Suggested Readings:

16. Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
17. Sykes, P. A guidebook to Mechanism in Organic Chemistry, Pearson Education, 2003.
18. Carey, F. A., Guiliano, R. M.Organic Chemistry, Eighth edition, McGraw Hill Education, 2012.
19. Loudon, G. M. Organic Chemistry, Fourth edition, Oxford University Press, 2008.
20. Clayden, J., Greeves, N. &Warren, S. Organic Chemistry, 2nd edition, Oxford University Press, 2012.
21. Graham Solomons, T.W., Fryhle, C. B. Organic Chemistry, John Wiley & Sons, Inc.
22. Smith, J. G. Organic Chemistry, Tata McGraw-Hill Publishing Company Limited.
23. March, J. Advanced Organic Chemistry, Fourth edition, Wiley.
24. Acheson, R.M. Introduction to the Chemistry of Heterocyclic compounds, John Welly& Sons (1976).
25. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
26. Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products),
27. Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
28. Singh, J.; Ali, S.M. & Singh, J. Natural Product Chemistry, Pragati Prakashan (2010).

Semester VI
Paper-3 (Practical -I)
Course Title: Organic Synthesis B

Degree in Bachelor of Science	Credit: 2
Course Code:B020601T	**Course Title: Organic Synthesis**

Course Outcomes:

Upon successful completion of this course students should be able to know the synthesis of organic compounds in the laboratory and to estimate the product yield. The obtained product will be identified by the different tool.

Unit I: Elemental analysis and identification of functional groups:

1. Detection of extra elements (N, S and halogens) in a given organic compound.
2. Functional groups analysis (carbohydrates, amines, amides, nitro and aniline) in simple organic compounds.

Unit II: Preparation of p- nitro acetanilide from Aniline.

Unit III: Preparation of phenyl benzoate from phenol by acetylation reaction.

Unit IV: Preparation of Benzil from Benzaldehyde.

Suggested Readings:

1. Skoog D.A., West D.M. and Holler F.J., "Analytical Chemistry: An introduction", 7th edition, Saunders college publishing, Philadelphia (2010).
2. Larry Hargis G "Analytical Chemistry: Principles and Techniques" Pearson (1988)

Semester-VI
Paper-2
Course Title: Chemical Energetics and Radio Chemistry

Degree in Bachelor of Science	Credit :4
Course Code: B020602T	**Course Title: Chemical Energetics and Radio Chemistry**

Course outcomes: Upon successful completion of this course students should be able to describe laws of thermodynamics and its applications, phase equilibria of one and two component system, electro chemistry, ionic equilibrium applications of conductivity and potentiometric measurements.

Syllabus

Unit I: Thermodynamics-I

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, dU & dH 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 thermo-chemical data, temperature dependence of enthalpy, Kirchhoffs equation.

Unit II: Thermodynamics II

Second Law of Thermodynamics, Need for the law, different statements of the law, Carnot cycle and its efficiency. Carnot 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 criterion of spontaneity and equilibrium. Entropy change in ideal gases and mixing of gases. Gibbs and Helmholtz Functions, Gibbs function (G) and Helmholtz function (A) as thermodynamic quantities. A & Gas 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: Electrochemistry:

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 conductances with dilution. Migration of ions and Kohlrausch law Arrhenius theory of electrolyte dissociation and its limitations. Weak and strong electrolytes. Ostwald's dilution law, its uses and limitations. Debye-Huckel-Onsager equation for strong electrolytes (elementary treatment only). Transport number, definition and determination by Hittorf method and moving boundary method.

Unit IV: Ionic Equilibrium:

Types of reversible electrodes — Gas-metal ion, metal-metal ion, metal insoluble salt-anion and redox electrodes. Electrode reactions, Nernst equation, derivation of cell EMF and single electrode potential, standard hydrogen electrode-reference electrodes and their applications,

standard electrode potential, sign conventions, Electrolytic and Galvanic cells—Reversible and irreversible cells, conventional representation of electrochemical cells. EMF of a cell and its measurement. Calculation of thermodynamic quantities of cell reactions (dG, dH and K). Definition of pH and Pk_a, determination of pH using hydrogen, quinhydrone and glass electrodes by potentiometric methods. Buffers Mechanism of buffer action, Henderson-Hazel equation, application of buffer solution. Hydrolysis of salts.

Unit V: Photo Chemistry:

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 photochemical reaction.

Unit VI: 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, law of osmotic pressure and its measurement, 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.

Unit VII: Surface Chemistry:

Adsorption: Physical and chemical adsorption; Freundlich and Langmuir adsorption isotherms; multilayer adsorption and BET isotherm (no derivation required); Gibbs adsorption isotherm and surface excess, heterogenous catalysis (single reactant).

Colloids: Lyophobic and lyophilic sols, Origin of charge and stability of lyophobic colloids, Coagulation and Schultz-Hardy rule, Zeta potential and Stern double layer (qualitative idea) Tyndall effect, Electrokinetic phenomena (qualitative idea only); Stability of colloids and zeta potential; Micelle formation.

Dipole moment and polarizahility: Polarizability of atoms and molecules, dielectric constant and polarisation, molar polarisation for polar and non-polar molecules; Clausius-Mosotti

equation and Debye equation (both without derivation) and their application; Determination of dipole moments.

Unit VIII: Radiochemistry:

Natural and induced radioactivity; radioactive decay-α-decay, β-decay, ϒ -decay; neutron emission, positron emission, electron capture; unit of radioactivity (Curie); half-life period; Geiger-Nuttal rule, radioactive displacement law, radioactive series, measurement of radioactivity: ionization chamber, Geiger counters, scintillation counters. Applications: energy tapping, dating of objects, neutron 'activation analysis, isotopic labelling studies, nuclear medicine-99 radiopharmaceuticals

Suggested Readings:

1. Foye, W.O., Lemke, T.L. & William, D.A.: Principles of Medicinal Chemistry, 4th ed., B.I. Waverly Pvt. Ltd. New Delhi.
2. Peter Atkins & Julio De Paula, Physical Chemistry 9th Ed., Oxford University Press (2010).
3. Metz, C. R. Physical Chemistry 2nd Ed., Tata McGraw-Hill (2009).
4. Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry Ed., Oxford University Press 13 (2006).
5 Ball, D. W. Physical Chemistry Thomson Press, India (2007).
6. Castellan, G. W. Physical Chemistry 4th Edn. Narosa (2004).
7. Allen Bard ,J Larry . Faulkner R, Fundamentals of Electrochemical methods — fundamentals and applications ,new York John ,Wiley &sons , 2001
8. H. J. Arnikar, Essentials of Nuclear Chemistry, 4th ed., New Age International, New Delhi, 1995.

Semester VI
Paper-4 (Practical-II)
Course Title: Analytical Methods

Degree in Bachelor of Science	**Credit: 2**
Course Code: B020602P	**Course Title: Analytical Methods**

Course Outcomes: Upon successful completion of this course students should be able to quantify the product obtained through gravimetric method; determination of R_f values and identification of organic compounds through paper and thin layer chromatography laboratory techniques: perform thermo chemical reactions

Unit I: Gravimetric Analysis:

1. Analysis of Ni as Ni (dimethylgloxime)

2. Analysis of Ba as $BaSO_4$

Unit II: Paper Chromatography:

Ascending and Circular, Determination of R_f values and identification of organic compounds: Separation of a mixture of phenylalanine and glycine. Alanine and aspartic acid Leucine and glutamic acid, spray reagent- ninhydrin.

Unit III: Thin Layer Chromatography:

Determination of R_f values and identification of organic compounds, separation of green leaf pigments (spinach leaves may be used)

Unit IV: Thermochemistry:

1. To determine the solubility of benzoic acid at different temperatures and to determine ΔH 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

Suggested Readings:

3. Skoog D.A., West D.M. and Holler F.J., "Analytical Chemistry: An introduction", 7th edition, Saunders college publishing, Philadelphia (2010).
4. Larry Hargis G "Analytical Chemistry: Principles and Techniques" Pearson (1988)