SYLLABUS FOR THE

BACHELOR OF SCIENCE (B.Sc.)

CHEMISTRY

(4-Year Program)

DEPARTMENT OF CHEMISTRY

FACULTY OF SCIENCE

SIDDHARTH UNIVERSITY, KAPILVASTU,

SIDDHARTHNAGAR (U.P.)

2025

B.Sc. (Honours) Chemistry Syllabus
Semester-wise Titles of the Papers in B.Sc. Chemistry

Cumulative Minimum Credits required for the award of certificate/ diploma/degree	Year	Sem.	Papers	Total Credit
Certificate in Chemistry	1	I*	Fundamentals Of Chemistry (4 Credits)	6
			Quantitative Analysis (2 Credits)	
		II	Bio-organic And Medicinal Chemistry (4 Credits)	6
			Biochemical Analysis (2 Credits)	
Diploma in Chemistry	2	III	Chemical Dynamics & Coordination Chemistry (4 Credits)	6
			Inorganic Chemistry Practical (2 Credits)	
		IV	Quantum Mechanics And Analytical Techniques (4 Credits)	6
			Instrumental Analysis (2 Credits)	
B.Sc.	3	V	Organic Synthesis-A (4 Credits)	10
			Rearrangements and Chemistry of Group Elements (4 Credits)	
			Organic Chemistry Practical (2 Credit)	
		VI	Organic Synthesis-B (4 Credits)	10
			Chemical Energetics and Radiochemistry (4 Credits)	
			Physical Chemistry Practical (2 Credit)	
Fourth Year				
B.Sc. (Apprenticeship)	4	VII VIII	12 months Apprenticeship/Internship through NATS or from an equivalent organization/Industry/Institution	40
OR				
120-40-160 4 years **B.Sc. (HONS.) (Chemistry)**	4	VII	Paper 1: Molecular Symmetry and Molecular Vibrations (4 Credits)	20
			Paper 2: Physical Chemistry (Quantum Chemistry) (4 Credits)	
			Paper 3: Inorganic Chemistry (Main Group Elements) (4 Credits)	
			Paper 4: Organic Chemistry Aromaticity and Reaction Mechanism (4 Credits)	
			Paper 5: Chemistry Practical- I (4 Credits)	
		VIII	Paper 1: Analytical Chemistry (4 Credits)	20
			Paper 2: Physical Chemistry (Thermodynamics and Electrochemistry (4 Credits)	
			Paper 3: Inorganic Chemistry (Transition elements) (4 Credits)	
			Paper 4: Organic Chemistry (Pericyclic reactions and Stereochemistry (4 Credits)	
			Paper 5: Chemistry Practical-II (4 Credits)	
OR				
120-40-160 4 years **B.Sc. (HONS. With Research) (Chemistry)**	4	VII	Paper 1: Molecular Symmetry and Molecular Vibrations (4 Credits)	20
			Paper 2: Physical Chemistry (Quantum Chemistry) (4 Credits)	
			Paper 3: Inorganic Chemistry (Main Group Elements) (4 Credits)	
			Paper 4: Organic Chemistry (Aromaticity and Reaction Mechanism) (4 Credits)	
			Paper 5: Research Project-I/Dissertation-I (4 Credits)	

A student who secures 75 % in the first 6 semesters		VIII	Paper 1: Analytical Chemistry (4 Credits)	**20**
			Paper 2: Physical Chemistry (Thermodynamics and Electrochemistry) (4 Credits)	
			Paper 3: Inorganic Chemistry (Transition elements) (4 Credits)	
			Paper 4: Organic Chemistry (Pericyclic reactions and Stereochemistry) (4 Credits)	
			Paper 5: Research Project-II/Dissertation-II (4 Credits)	

Passing Marks: 40% for major/minor/Vocational/Co-Curricular.

***Note:** **This syllabus will also be considered a minor subject for students in the first semester.**

Purpose of the Program

The purpose of this undergraduate B.Sc. Chemistry program at the university and college level is to provide the key knowledge and laboratory resources. This preparation equips students for successful careers as professionals in various industries and research institutions, ensuring the practical relevance and applicability of our program.

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 and accurately record and analyse the results of such experiments.
3. Students will be skilled in critical thinking, and analytical reasoning as applied to solving 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 behaviour in issues facing chemists. This includes an understanding of safe handling of chemicals, environmental issues, and key issues facing our society in the field of energy, health, and medicine, reinforcing our commitment to responsible scientific practice.
6. Students will be able to explain why Chemistry is an integral activity for addressing social, economic, and environmental problems, such as developing new drugs for diseases, designing eco-friendly materials, and finding solution to prohibited climate change.
7. Students will be able to function as integral members of an interdisciplinary problem-solving team, understanding the crucial role of teamwork in addressing complex scientific challenges.

Program Specific Outcomes

I[st] year **Certificate in Chemistry**

This certificate course in Chemistry is a comprehensive program that will give the student a thorough understanding of all the fundamental principles of Chemistry, like molecular polarity, bonding theories of molecules, periodic properties of elements, mechanism of fundamental organic reactions, stereochemistry, basic mathematical concepts and computer knowledge, etc. Chemistry of carbohydrates, proteins and nucleic acids: Medicinal Chemistry, synthetic polymers, synthetic dyes. Students will be able to do qualitative and biochemical analysis of the compounds in the laboratory. This certificate course is going to prepare students for various fields of Chemistry, offering a broad insight into all the branches of Chemistry. It will enable our students to explore the diverse and exciting career opportunities related to Chemistry in the government and private sector services, particularly in the field of food safety, health inspector, pharmacist, etc. The course will provide a broad foundation in Chemistry that stresses scientific reasoning and analytical problem solving with a molecular perspective, instilling a sense of excitement and hope for the future of our students.

II[nd] year **Diploma in Chemistry**

A Diploma course in Chemistry will provide theoretical as well as practical knowledge of handling chemicals, apparatus, equipment, and instruments. The knowledge about feasibility and 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. Knowledge of atomic structure, quantum mechanics, and various spectroscopic and separation techniques will enable students to work in industries. All these skills and knowledge facilitate industries like cement industries, agro-products, paint industries, rubber industries, petrochemical industries, food processing industries, fertilizer industries, pollution monitoring and control agencies, etc. Students' exposure to experimental techniques using modern instrumentation will facilitate better opportunities. They learn the laboratory skills and safe measurements to transfer and interpret knowledge entirely in

the working environment. Monitoring of environmental issues: monitoring of

environmental pollution problems of atmospheric sciences, water and soil chemistry, and design processes that meet the specified needs with appropriate consideration for public health and safety, and the cultural, societal, and environmental considerations

III[rd] Year **B.Sc. (Chemistry)**

The B.Sc. program aims to introduce key 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 role in daily life, and to understand the concept of Chemistry to interrelate and interact with other subjects like Mathematics, Physics, Biological science, etc. Upon completion of a degree program, Chemistry students can 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 the chemical industry or a Chemistry graduate program. Various research institutions and industries, people in the pharmaceuticals, polymers, and food industry sectors, find this course worthwhile.

Evaluation of a theory paper

Each theory and practical paper have 100 marks.

1. **Internal 25 marks** (10 marks on a mid-term written test, 10 marks on an assignment, and five marks for student attendance and discipline. Internal Marks will be fed on the website by the department based on student performance.
2. **Theory Exam 75 marks.**

Pattern of paper

(i). The paper contains five questions of 15 marks each. The exam will be 3 hours.

(ii). Question no. 1 is compulsory and divided into 5 parts (a, b, c, d, and e), each worth 3 marks.

(iii). Questions 2 and 3 will be the long questions and have 15 marks each.

(iv). Questions 4 and 5 are divided into two parts (a and b), and having 7 and 8 marks, respectively.

Evaluation of a Practical Paper

i. **Internal 25 marks** (10 marks of a mid-term written test, 10 marks on an assignment, and 5 marks on student attendance and discipline).

ii. Practical exam 75 marks

1. Practical Time: 6h
2. Practical Examination will be conducted in the department as per the university rules.
3. Each practical will be 15 marks.
4. Viva-voce will be 20 marks.
5. A practical record will be 10 marks.
6. Internal & Practical marks feed on the website after the completion of the practical exam, based on student's performance.

Evaluation of Project Paper

1. Based on research projects done in both semesters, the prepared project report/dissertation will be evaluated by external and internal examiners for 50 marks separately. The student will be evaluated for 25 marks based on the viva voce examination of his research project.
2. The remaining 25 marks will be awarded to the student only when he publishes his research paper related to his research project in a UGC care listed journal.

Year	Sem.	Paper Title		Credit
Certificate in Bioorganic and Medicinal Chemistry				
1	**I**	**Fundamentals of Chemistry**	**Theory**	**4**
		Quantitative Analysis	**Practical**	**2**
1	**II**	**Bioorganic and Medicinal Chemistry**	**Theory**	**4**
		Biochemical Analysis	**Practical**	**2**

Semester: I
Paper-I
Course Title: Fundamentals of Chemistry

Certificate in Bioorganic and Medicinal Chemistry	**Credit: 4**
Course Code: BCHC-101	**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 organic reactions in a step-by-step manner. This course will provide a broad foundation in Chemistry that stresses scientific reasoning and 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 are used to predict structures and important bonding parameters.

The chapter recapitulation of basics of organic Chemistry provides the most fundamental and crucial knowledge and concepts of organic Chemistry.

This course gives a broader theoretical picture of multiple stages of an overall chemical reaction. It describes reactive intermediates, transition states, and states of all the broken bonds and formed bonds. It enables us to understand the reactants, catalysts, stereochemistry, and primary and minor products of any organic reaction.

It describes the types of reactions and the kinetic and thermodynamic aspects one should know about carrying out any reaction, and how the reaction mechanism can be determined.

The chapter stereochemistry gives a clear picture of the two-dimensional and three-dimensional structure of molecules and their role in the reaction mechanism.

Syllabus

Unit I: Molecular Polarity and Weak Chemical Forces

Vander Waals forces, ion-dipole forces, dipole-dipole interactions, induced dipole interaction, dipole moment, and molecular structure (diatomic and polyatomic molecules), percentage ionic character from dipole moment, polarizing power, and polarizability. Fajan's rules and the consequences of polarization. Hydrogen bonding.

Unit II: Simple Bonding Theories of Molecules

Atomic orbitals, Aufbau principle, bond lengths, the valence bond theory (VBT), Concept of hybridization, hybrid orbitals, molecular geometry, Bent's rule, Valence shell electron pair repulsion theory (VSEPR), shapes of simple molecules and ions, Molecular orbital theory (MOT). Molecular orbital diagrams, bond orders of homonuclear and heteronuclear diatomic molecules and ions.

Unit III: Periodic properties of Atoms (with reference to s & p-block):

Brief discussion, factors affecting, and variation trends of the following properties in groups and periods. Effective nuclear charge, shielding or screening effect, Slater rules, Atomic and ionic radii, Electronegativity, Pauling's, Ionization enthalpy, Electron gain enthalpy.

Unit IV: Recapitulation of basics of Organic Chemistry: Hybridization, bond lengths bond angles and bond energy, Van der Waals interactions, hyper-conjugation, Dipole moment; Electronic Displacements: Inductive, electromeric, resonance- mesomeric effects and their applications.

Unit V: Mechanism of Organic Reactions: Homolytic and heterolytic bond fission, Types of reagents- electrophiles and nucleophiles, Types of organic reactions, Reaction intermediates — carbocations, carbanions and free radicals. Assigning formal charges to intermediates and other ionic species.

Unit VI: Stereochemistry- concepts of Isomerism,

Symmetry, molecular chirality, enantiomers, stereogenic center, optical activity, chiral molecules with two stereogenic centers, diastereomers, threo and erythro stereoisomers, meso compounds, resolution of enantiomers, inversion, retention, and racemization. Relative and absolute configuration, sequence rules, D & L and R & S systems of Nomenclature, E and Z system of

Nomenclature, Conformational Isomerism — conformational analysis of ethane and n-butane,

Difference between configuration and conformation.

Suggested Readings:

Lee, J.D. Concise Inorganic Chemistry, Pearson Education, 2010
Huheey, J.E., Keiter, R. L., Medhi, O.K. Inorganic Chemistry, Principles of Structure and Reactivity, Pearson Education, 2006.
1 Douglas, B.E. and McDaniel, D.H., Concepts & Models of Inorganic Chemistry, Oxford, 1970
Shriver, D.D. & P. Atkins, *Inorganic Chemistry 2nd Ed.*, Oxford University Press, 1994.
Day, M.C. and Selbin, J. Theoretical Inorganic Chemistry, ACS Publications, 1962.
Singh J., Yadav L.D.S., Advanced Organic Chemistry, Pragati Edition
Morrison, R. N. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
Carey, F. A., Guiliano, R. *M.Organic Chemistry*, Eighth edition, McGraw-Hill Education, 2012.
Loudon, G. M. *Organic Chemistry*, Fourth edition, Oxford University Press, 2008.
Clayden, J., Greeves, N. & Warren, S. *Organic Chemistry*, 2nd edition, Oxford University Press, 2012. 11, Graham Solomons, T.W., Fryhle, C. B. *Organic Chemistry*, John Wiley & Sons, Inc.
Sykes, P. *A guidebook to Mechanism in Organic Chemistry*, Pearson Education, 2003
Francis, P. G. Mathematics for Chemists, Springer, 1984

Note: For the promotion of the Hindi language, course books published in Hindi may be prescribed by the University. Suggested online links:

Semester I, Paper 2 (Practical)

Course Title: Quantitative Analysis

Certificate in Bioorganic and Medicinal Chemistry	**Credit: 2**
Course Code: BCHL-102	**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 the estimation of metal ions and acidity & the 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 the hardness of water by EDTA.
2. Determination of chemical oxygen demand (COD).

Unit II: Estimation of Metal Ions

1. Estimation of ferrous and ferric by the dichromate method.
2. Estimation of copper using thiosulfate.

Unit III: Estimation of acid and alkali contents

1. Determination of acetic acid in commercial vinegar using NaOH.
2. Determination of alkali content - antacid tablet using HCl.
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**

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Semester: I
Paper III: Chemistry Minor
Course Title: Essential Chemistry

Paper Code: B020103M	**Credit: 4**
Course Title: Essential Chemistry	

Course outcome

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- Molecular geometries, physical, and chemical properties of the molecules.
- Current bonding models for simple inorganic and organic molecules are used to predict structures and important bonding parameters.

It describes the types of reactions and the kinetic and thermodynamic aspects one should know about carrying out any reaction, and how the reaction mechanism can be determined.

Syllabus

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Vander Waals forces, ion-dipole forces, dipole-dipole interactions, induced dipole interaction, dipole moment, and molecular structure (diatomic and polyatomic molecules), percentage ionic character from dipole moment, polarizing power, and polarizability. Fajan's rules and the consequences of polarization. Hydrogen bonding.

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Brief discussion, factors affecting, and variation trends of the following properties in groups and periods. Effective nuclear charge, shielding or screening effect, Slater rules, Atomic and ionic radii, Electronegativity, Pauling's, Ionization enthalpy, Electron gain enthalpy.

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Unit V: Mechanism of Organic Reactions: Homolytic and heterolytic bond fission, Types of reagents- electrophiles and nucleophiles, Types of organic reactions, Reaction intermediates carbocations, carbanions and free radicals.

Unit VI: Stereochemistry- concepts of Isomerism,

Symmetry, molecular chirality, enantiomers, stereogenic center, optical activity, chiral molecules with two stereogenic centers, diastereomers, threo and erythro stereoisomers, meso compounds, resolution of enantiomers, inversion, retention, and racemization. Relative and absolute configuration, sequence rules, D & L and R & S systems of Nomenclature, E and Z system of

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).

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,.

Suggested Readings: Lee, J.D. Concise Inorganic Chemistry, Pearson Education, 2010
Huheey, J.E., Keiter, R. L., Medhi, O.K. Inorganic Chemistry, Principles of Structure and Reactivity, Pearson Education, 2006.
1 Douglas, B.E. and McDaniel, D.H., Concepts & Models of Inorganic Chemistry, Oxford, 1970
Shriver, D.D. & P. Atkins, *Inorganic Chemistry 2nd Ed.,* Oxford University Press, 1994.
Day, M.C. and Selbin, J. Theoretical Inorganic Chemistry, ACS Publications, 1962.
Singh J., Yadav L.D.S., Advanced Organic Chemistry, Pragati Edition
Morrison, R. N. & Boyd, R. N. *Organic Chemistry,* Dorling Kindersley (India) Pvt. Ltd

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

Certificate in Bioorganic and Medicinal Chemistry	**Credit: 4**
Course Code: BCHC-201	**Course Title: Bioorganic and Medicinal Chemistry**

Course outcomes:

Biomolecules are 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 the human body. This course aims to introduce students to the basic experimental understanding of carbohydrates, amino acids, proteins, nucleic acids, and medicinal Chemistry. Upon completion of this course, students may get job opportunities in the food, beverage, and pharmaceutical industries.

Syllabus

Unit I: Chemistry of Carbohydrates: Classification of carbohydrates, reducing and non-reducing sugars, general properties of Glucose, and their open-chain structure. Epimers, mutarotation, and anomers. Mechanism of mutarotation: Determination of the configuration of Glucose (Fischer's proof). Cyclic structure of glucose. Haworth projections. 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.

Unit II: **Chemistry of Proteins:** Classification of amino acids, zwitterion structure, and isoelectric point. 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 (up to dipeptides) by N-protection & D-protection protein denaturation/ renaturation,

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, Biological roles of DNA and RNA

Unit IV: **Introductory Medicinal Chemistry:** Drug discovery, Basic retrosynthetic approach. Drug action-receptor theory_: 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: analgesic agents, antipyretic agents, anti-inflammatory agents (Aspirin, paracetamol); antibiotics (Chloramphenicol); antibacterial and antifungal agents (Sulphonamides, Sulfamethoxazole, Sulphacetamide).

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) X-ray diffraction by crystals. Derivation of the Bragg equation, Determination of the crystal structure of NaCl, and KCl

Unit VI: **Introduction to Polymer**s: Monomers, Oligomers, Polymers and their characteristics, Classification of polymers: natural, synthetic, linear, cross-linked, and network, plastics, elastomers, fibers, 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 (w) of polymers, and Determination by (i) Viscosity (ii) Light scattering method.

Silicones and Phosphazenes -Silicones and Phosphazenes as examples of inorganic polymers.

Unit VII: Kinetics and Mechanism of Polymerization

Polymerization techniques, 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, 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 and Indigo.

Suggested Readings:

1. Davis, B. G., Fairbanks, A. *J., Carbohydrate Chemistry*, Oxford
2. Finar, I. L. *Organic Chemistry (Volume 2),* Dorling Kindersley
3. Nelson, D. L. & Cox, M. M. *Lehninger's Principles of Biochemistry*
4. Berg, J. M., Tymoczko, J. L. & Stryer, L. *BioChemistry 7th*
5. Morrison, R. T. & Boyd, R. N. *Organic Chemistry,* Dorling

.Patrick, G. L. Introduction to Medicinal Chemistry, Oxford

7. Singh, H. & Kapoor, V.K. Medicinal and Pharmaceutical 2012.
8. Atkins, P. W. & Paula, J. de Atkins' Physical Chemistry Ed.,
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:* 1981.
12. G. Odian: *Principles of Polymerization,* 4th Ed. Wiley,
13. F.W. Billmeyer: *Textbook of Polymer Science,* 2. Ed.
14. P. Ghosh: Polymer Science & Technology, Tata McGraw-Hill

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

Certificate in Bioorganic and Medicinal Chemistry	**Credit: 2**
BCHL-202	**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, and drug molecules. Upon successful completion of this course, students may get job opportunities in the 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 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 213 amino acids
5. Action of salivary amylase on starch
6. To determine the concentration of glycine solution by the 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 ingredients 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, FIFIS, 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 Bio Chemistry. Wiley-Blackwell (1977).
8. Wilson, K. & Walker, J. Practical Bio Chemistry. Cambridge University Press (2009).
9. Varley, H., Gowenlock, A. L. & Bell, M: Practical Clinical Bio Chemistry, Heinemann,

Year II	Sem.	Course Code	Paper Title	I Theory/Practical	Credits
Diploma in Chemical Dynamics and Analytical Techniques					
2	**III**	**BCHC-301**	**Chemical Dynamics & Coordination**	**Theory**	**4**
		BCHL-302	**Physical Analysis**	**Practical**	**2**
	IV	**BCHC-401**	**Quantum Mechanics and Analytical**	**Theory**	**4**
		BCHL-402	**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: BCHC-301	**Course Title: Chemical Dynamics & Coordination Chemistry**

Course outcomes: Upon successful completion of this course, students should be able to describe the characteristics 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 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 reaction, molecularity and order of reaction, concentration dependence of rates, mathematical characteristics of simple chemical reactions — zero order, first order, second order, pseudo-order, half-life, and mean life. Determination of the order of reaction — differential method, method of integration, half-life method, and isolation method. Brief outline of experimental methods of studying chemical kinetics.

Theories of chemical kinetics: Effect of temperature on rate of reaction, Arrhenius equation, Concept of activation energy. Simple collision theory based on the complex sphere model, transition state theory (equilibrium hypothesis). Expression for the rate constant based on the equilibrium constant and thermodynamics. Aspects (no derivation).

Unit II: Chemical Equilibrium: Equilibrium constant and free energy, thermodynamic derivation of the 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 systems— water and CO_2 systems. Phase equilibria of two-component systems - Solid-liquid equilibria.

Unit IV: Kinetic theories of gases 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 the Vander Waals equation, relationship between critical constants and Vander Waals constants.

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

Unit V: 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.

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 valence bond theory, an elementary idea of crystal field theory, crystal field splitting in octahedral, tetrahedral, and square planar complexes, factors affecting the crystal-field parameters.

(ii) Thermodynamic and kinetic aspects of metal complexes: A brief outline of the thermodynamic stability of metal complexes and factors affecting the stability.

Unit VIII: Inorganic Spectroscopy and Magnetism I) Electronic spectra of transition metal complex, types of electronic transitions, selection rules for d-d transitions, spectroscopic ground states, spectrochemical series, Orgel-energy level diagram.

II) Magnetic properties of transition metal complexes, types of magnetic behaviour. Methods of determining magnetic susceptibility, spin-only formula, and L-S coupling.

Physical properties and molecular structure: 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, General magnetic properties: paramagnetism, diamagnetism and ferromagnetism, magnetic susceptibility;

Suggested **Readings:**

1. Atkins, P. W. & Paula, J. de Atkins' Physical Chemistry Ed.,
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
5. Lee, J.D., Concise Inorganic Chemistry 4th Edition ELBS,1
6. Douglas, B., McDaniel, D., and Alexander, Concepts of 3rd edition, 1994
7. Shriver, D.E., Atkins, P.W., and Langford, C.H., Inorganic Chemistry
8. Porterfield, WW, Inorganic Chemistry, Addison Wesley
9. Sharpe, A. G., Inorganic Chemistry, ELBS,31D edition,1993
10. Miessler, G.L., Tarr, D.A., Inorganic Chemistry, 2nd

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

Course Code: BCHL-302	**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, estimate components through volumetric analysis to perform experiments: one and two-component phase equilibrium experiments.

Syllabus

Unit I: Strength of Solution

Calibration of fractional weights, pipettes, and burettes. Preparation of standard 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, Percent by weight, Percent by volume, Parts per thousand, Parts per million, Parts per billion.

Unit II: Surface Tension and Viscosity

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

Unit III: Boiling Point and Transition Temperature

1. Boiling point of common organic liquid compounds [**ANY FIVE]:** n-butyl alcohol**,** cyclohexanol, and ethyl methyl. Ketone, cyclohexanone, acetyl acetone, isobutyl methyl ketone, isobutyl alcohol, acetonitrile and benzaldehyde, [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/dilatometric Method.

Unit IV: Phase Equilibrium

1. To study the effect of a solute. (NaCI. succinic acid) on the critical solution temperature of two partially miscible liquids (e.g., phenol-water system)

2. To construct the phase diagram of a two-component system (e.g., benzophenone) by the cooling curve method.

Suggested Readings:

1. Skoog, D.A., West, D.M., and Holler, F.J., "Analytical Chemistry, Philadelphia (2010). Larry Hargis. G" Analytical Chemistry: Principles

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

Diploma in Chemical Dynamics and Analytical Techniques	**Credits:4**
Course Code: BCHC-401	**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; Schrödinger 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 members 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 learn 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, Schrödinger wave equation, significance of ψ and is ψ^2, quantum numbers,

radial and angular wave functions and probability distribution curves, shapes of s, p, d orbitals.

Unit II: Elementary Quantum Mechanics: Black-body radiation, Planck's radiation law, photoelectric Effect, heat capacity of solids, Bohr's model of the hydrogen atom (no derivation) and its defects, Compton effect and Hamiltonian operator.

Schrödinger 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. Schrödinger wave equation for H-atom, separation into three equations (without derivation), quantum numbers and their importance, hydrogen-like wave functions, radial wave functions, angular wave functions.

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 election rules, pure vibrational spectrum, intensity, Determination of force constant and qualitative relation of force constant and bond energies.

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, 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, λmax, 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 significance in functional group analysis and interpretation of IR spectra of simple compounds

Unit VI: 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 NW, anisotropic effects in alkene, alkyl, aldehydes and aromatic, integration; interpretation of NMR spectra of organic compounds. Applications of IR, UV, and NMR spectroscopy for the 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. Techniques 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 aqueous and non-aqueous media.

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

Suggested Readings:

1. Alberts, R A, Physical Chemistry, 4th edition, Wiley Eastern Ltd,2001.
2. Atkins, P W, The Elements of Physical Chemistry, Oxford,1991
3. Barrow, G M International student Edition. McGraw-Hill, 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, 4^{th} Edition, ELBS,1977

6. Clayden, J., Greeves, N., Warren, S., *Organic Chemistry,* Second edition, Oxford University Press, 2012.
7. Silverstein, R. M., Sassier, 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: BCHL-402	**Course Title: Instrumental Analysis**

Course outcomes: Upon completion of this course, Chemistry majors can 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 the 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 members 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 learn 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 the Rast method/ Beckmann freezing point method.

2. Determination of the apparent degree of dissociation of an electrolyte (e.g., NaCl) 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 determine the concentration of the given solution of the substance from absorption measurement

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. Identification of simple organic compounds by IR spectroscopy.

Unit IV: Chromatographic Separations

1. Paper chromatographic separation of the 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 R_F values

Suggested Readings:

1. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009.

2. Willard, H.H. et al.: Instrumental Methods of Analysis, 7th Ed. Wordsworth 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 VI, and Nieman, T.A. Principles of Instrumental Analysis, Cengage Learning India Edition.
7. Mikes, 0. & Chalmes, R.A. Laboratory Handbook of Chromatographic & Allied Methods, Elsevier Harwood Ltd., London.
8. Ditts, R.V. Analytical Chemistry: Methods of separation. Van Nostrand, New York, 1974.

B.Sc. III Years

Year 3	Sem.	Course Code	Paper Title	Theory/ Practical	Credits
Degree in Bachelor of Science					
3	V	**BCHC-501**	Organic Synthesis-A	Theory	4
		BCHC-502	Rearrangements and Chemistry of Group Elements	Theory	4
		BCHL-503	Qualitative Analysis	Practical	2
	VI	**BCHC-601**	Organic Synthesis-B	Theory	4
		BCHC-602	Chemical Energetics and Radiochemistry	Theory	4
		BCHL-603	Analytical Methods	Practical	2

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

Degree in Bachelor of Science	Credit:4
BCHC-501	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. Hydroxyl and carbonyl compounds are industrially important compounds. The industries of plastics, fibers, petroleum, and rubbers will especially recognize this course. Students will gain an understanding of the types of solvents and raw materials used for the synthesis of drugs and other pharmaceutically important compounds.

- 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: 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. The case of the 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; electrophilic Addition to diene (conjugated dienes); radical Addition: HBr addition: Mechanism of allylic and benzylic bromination in competition with bromination across C-C; Use of NBS;

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 reduction)

Unit IV: Aromaticity and Chemistry of Arenes

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 biphenyl and naphthalene.

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. Oxidative cleavage [$Pb(OAc)_4$] and pinacol pinacolone rearrangement.

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.

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 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; Methods of formation of alkyl halides, nuclear and side chain

reactions; The addition-elimination and the elimination-addition mechanisms of nucleophilic aromatic substitution reactions; Synthesis and uses of DDT and BHC.

Suggested Readings:

1. Morrison, R. N. & Boyd, R. N. Organic Chemistry, Darling 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. &Wan-en, S. Organic Chemistry, 2nd 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-2 (Theory)
Course Title: Rearrangements and Chemistry of Group Elements

Degree in Bachelor of Science	**Credit: 4**
Course Code: BCHC-502	**Title: Rearrangements and Chemistry of Group Elements**

Course outcomes: This paper provides detailed knowledge of the synthesis of various classes of organic compounds and the interconversion of functional groups. Organic synthesis is the most important branch of organic Chemistry, which provides jobs in production and QC departments related to chemicals, drugs, medicines, FMCG, etc. industries.

- ❖ It relates and gives an analytical aptitude for synthesizing various important industrial compounds.
- ❖ This paper also provides detailed knowledge on the elements present in our surroundings and their occurrence in nature. Their position in the periodic table, their physical and chemical properties, and their extraction.

- ❖ This paper also gives a 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, Hofmann, Curtius, Schmidt, Baeyer-Villinger, and Fries rearrangement

Unit II: Catalysis

General principles and properties of catalysts, homogenous catalysis (catalytic steps and examples), 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, turnover 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.

p-Block Elements: Comparative study (including diagonal relationship) of groups 13-17 elements, compounds like hydrides, oxides, oxyacids, and halides of group 13-16, hydrides of boron-diborane and higher boranes, borazine, borohydrides, fullerenes, carbides, fluorocarbons, silicates, tetrasulfur tetranitride,

Chemistry of Noble Gases: 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 concerning the 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, Nb/Ta, Mo/W in respect of ionic radii, oxidation states, magnetic behavior.

Unit V: Chemistry of Lanthanides: Electronic structure, oxidation states, ionic radii, and lanthanide contraction, complex formation, occurrence, and isolation.

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 hemoglobin and myoglobin. Biological role of alkali and alkaline earth metal ions with special reference to Ca^{2+} and Mg^{2+}.

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, 2nd edition, Oxford University Press, 2012.
6. Graham Solomons, T.W., Fryhle, C. 11 Organic Chemistry, John Wiley & Sons, Inc.
7. Smith, J. G. Organic Chemistry, Tata McGraw-Hill Publishing
8 March, J. Advanced Organic Chemistry, Fourth edition,
9. Lee, J.D. Concise Inorganic Chemistry, Pearson Education
10. Huheey, J.E., Keiter, E.A., Keiter, R. L., Medhi, O.K. Inorganic Reactivity, Pearson Education, 2006
11. Douglas, B.E. and McDaniel, D.H., Concepts & Models
12. Shriver, an. & P. Atkins, Inorganic Chemistry 2nd Ed,
13. Day, M.C. and Selbin, J. Theoretical Inorganic Chemistry,
14. Francis, P. G. Mathematics for Chemists, Springer, 1984
15. Prakash Satya, Tuli G.D., Basu S.K., Madan R.D., Advanced

Semester V,
Paper-3 (Practical)
Course Title: Qualitative Analysis

Degree in Bachelor of Science	**Credit: 2**
Course Code: BCHL-503	**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.

- Identification of acidic and basic radicals in inorganic mixtures
- Separation of organic compounds from a mixture
- Elemental analysis in organic compounds
- Identification of functional groups in organic compounds
- Identification of an organic compound

Unit I: Inorganic Qualitative Analysis

Semi Analysis — cation analysis, separation and identification of ions from Groups II, III, IV, V, VI, Anion analysis and I. Mixture containing 6 radicals

Unit II: Elemental analysis and identification of functional groups

Detection of extra elements (N, S, and halogens) and functional groups (phenolic, Carboxylic, carbonyl, esters, carbohydrates, amines, amides, nitro, and anilides) in simple organic compounds.

Unit III: Separation of Organic Mixtures

Analysis of an organic mixture containing two solid components using water, $NaHCO_3$, NaOH for the separation and Preparation of suitable derivatives

Unit IV: Identification of organic compounds

Identification of an organic compound through functional group analysis, Determination of melting point and Preparation of suitable derivatives.

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, Al, 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. Harris, D.C. Exploring Chemical Analysis, %Ed. New York, W.H. Freeman, 2016.
6. Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age International Publisher, 2009. For the promotion of the Hindi language, course books published in Hindi may be prescribed by the University.

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

Degree in Bachelor of Science	Credit:4
Course Code: BCHC-601	**Course Title: Organic Synthesis B**

Course outcomes: This paper provides detailed knowledge of the synthesis of various classes of organic compounds and the interconversion of functional groups. Organic synthesis is the most important branch of organic Chemistry, which provides jobs in production and QC departments related to chemicals, drugs, medicines, FMCG, etc. industries.

The study of natural products and heterocyclic compounds offers an excellent strategy toward identifying novel biological probes for several diseases. Historically, natural products have played an important role in the development of pharmaceutical drugs for several 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, etc., 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, SeO_2, mCPBA, Jones Oxidation, PCC, PDC. Reduction with $NaBH_4$, $LiA1H_4$, Meerwein-Ponndorf-Verley (MPV) reduction, Wilkinson's catalyst, Birch reduction, DIBAL-H

Unit II: Organometallic Compounds- Organo-magnesium compounds the Grignard reagents, formation, structure, and chemical reactions. Organo-zinc compounds: formation and chemical reactions. Organo-Lithium compounds: formation and chemical reactions.

Unit III: Chemistry of Aldehydes and Ketones: Synthesis of aldehydes and ketones with particular reference to the synthesis of aldehydes from acid chlorides, Physical properties. Mechanism of nucleophilic additions to carbonyl group with particular emphasis on benzoin, aldol, Perkin, and Knoevenagel condensations, Condensation with ammonia and its derivatives. Wittig reaction, Mannich reaction. Oxidation of aldehydes, Cannizzaro reaction, MPV, Clemmensen, Wollf-Kishner, $LiAlH_4$, and $NaBH_4$ reductions.

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 and succinic.

Unit V: Organic Synthesis via Enolates

Acidity of a-hydrogens, alkylation of diethyl malonate and ethyl acetoacetate, Synthesis of ethyl acetoacetate: the Claisen condensation, Keto-enol tautomerism of ethyl acetoacetate.

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 mixtures of primary, secondary, and tertiary amines. Structural features affecting the basicity of amines. Preparation of alkyl and aryl amines (reduction of nitro compounds, nitrites), reductive amination of aldehydic and ketonic compounds, Gabriel phthalimide reaction, Hofmann bromamide reaction.

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 electrophilic substitution, Mechanism of nucleophilic substitution reaction in pyridine derivatives. 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 electrophilic 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, Quinine and Morphine. Natural Occurrence and Classification of Terpenes: The Isoprene Rule.

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, 2nd 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. Acheson, R.M. Introduction to the Chemistry of Heterocyclic Compounds, John Welly& Sons (1976).
10. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
11. Finar, I. L. Organic Chemistry (Volume 2: Stereo Chemistry and the Chemistry of Natural
12. Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
13. Singh, J.; Ali, S.M. & Singh, J. Natural Product Chemistry, Pragati Prakashan (2010).

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

Degree in Bachelor of Science	Credit:4
Course Code: BCHC-602	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 their applications, phase equilibria of one and two-component systems, electrochemistry, 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 a 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 constant volume. Enthalpy of neutralization. Bond dissociation energy and its calculation from thermochemical data, temperature dependence of enthalpy, Kirchhoff's 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, entropy as a criterion of spontaneity and equilibrium. Entropy changes 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.

Unit III: Electrochemistry:

Electrical transport: - Conduction in metals and electrolyte solutions, specific conductance, molar and 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 pKa, Determination of pH using hydrogen, quinhydrone, and glass electrodes by potentiometric methods. Henderson-Hazel equation.

Unit V: Photo Chemistry:

Interaction of radiation with matter, Difference between thermal and photochemical processes, Laws of photochemistry: Grothus-Draper 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),

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. 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, Micelle formation.

Dipole moment and polarizability: Polarizability of atoms and molecules, dielectric constant and polarization, molar polarization for polar and non-polar molecules; Clausius-Mosotti equation and Debye equation (both without derivation), and their application.

Unit VIII: Radio Chemistry:

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. Atkins' 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.

Paper-3 (Practical)
Course Title: Analytical Methods

Degree in Bachelor of Science	Credit: 2
Course Code: BCHL-603	**Course Title: Analytical Methods**

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

Unit I: Gravimetric Analysis:

Analysis of Ni as Ni (dimethylglyoxime)

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. Amino acids: Alanine, aspartic acid, leucine, glutamic acid. Spray reagent: ninhydrin.

Unit III: ThermoChemistry (A)

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

Unit III: ThermoChemistry (B)

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

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)

B.Sc. VII Semester or fourth year

B.Sc. VII Semester

Paper-I	**BCHC-701**

Molecular Symmetry and Molecular Vibrations

Objectives: The overall objective is to acquaint students with the fundamentals of symmetry and group theoretical methods and how to apply them to vibrational and electronic spectroscopy and the study of molecular structure, bonding, and chemical reactivity.

Outcomes: Proficiency in using concepts of molecular symmetry to identify physical properties, Proficiency in applications of symmetry and group theory to various types of chemical systems, Classification of molecules into symmetry point groups, and Use of character tables. Proficiency in constructing molecular orbitals and understanding their role in determining molecular properties and reactivity, Understanding of principles and applications of spectroscopic techniques for the Determination of molecular structure, Basic Understanding of solid-state group theory.

Syllabus

1. **Molecular Symmetry:**
   - **a)** Symmetry elements and symmetry operations with special reference to water, ammonia, and ethane.
   - **b)** Classification of molecules/ions based on their symmetry properties.
   - **c)** Derivation of matrices for rotation, reflection, rotation-reflection, and inversion operations.
   - **d)** Direct products.
   - **e)** Symmetry point groups applied to all types of molecules (C_{nh}, D_{nh}, C_{nv}, T_d, O_h, and I_h).
2. **Group in Molecular Symmetry:**
   - **a)** Group multiplication basis, matrix representation, character of an operation, orthogonality, projection and shift operators, character tables, reducible and irreducible representations, groups, subgroups, and classes.
   - **b)** Symmetry of orbital: orbital symmetry properties, projection to get symmetry orbitals, projection operators, basis functions, and hybrid orbitals with examples.

3. **Molecular Vibrations:**
   - **a)** Internal and symmetry coordinates, symmetry adapted linear combinations (SALCs), symmetry of normal vibrations, mixing of internal coordinates in normal modes, Determination of symmetrical types of the normal modes.
   - **b)** Polyatomic molecular vibrations, vibrational spectroscopy, analysis of vibration spectra of 1,2 1,2-dichloroethylene.
4. **Symmetry and Chemical Reactivity**
   - **a)** Symmetry considerations: electrocyclic and cycloaddition reactions.

Books Recommended:

1. DM Bishop, "Group Theory and Chemistry," Dover Publications.
2. Cotton, “Chemical Applications of Group Theory”, John Wiley.
3. M. Hamaresh, "Group theory and its Applications to Physical Problems," Addison-Wisley
4. R.L. Flurry, “Symmetry Groups”
5. Hanna, "Quantum Mechanics in Chemistry”.
6. McWeeny, “Symmetry - An Introduction to Group Theory”, Pergamon Press.
7. Lowell H. Hall, "Group Theory and Symmetry in Chemistry", McGraw-Hill Book Company, New York.

B.Sc. VII Semester

Paper II	**BCHC-702**

Physical Chemistry (Quantum Chemistry)

Objective: Quantum Mechanics is a branch of science that deals with discrete, indivisible units of energy called quanta. It is an interfacial subject between Physics, Chemistry, and Mathematics. Hence, the objective of this course in Chemistry is to understand clearly the microscopic and inner details of any reactions from a Chemistry viewpoint.

Outcome: This is an interfacial subject between Physics, Chemistry, and Mathematics, which provides a better scientific understanding and inner details of any physical or chemical reaction.

Syllabus

Unit-1 Fundamental concepts:

a. Quantum mechanical operators and classical variables
b. Linear operator in quantum mechanics
c. Vector Operators, Laplacian Operator, and Hamiltonian Operator
d. Hermitian Operators, concept of normalization and orthogonality in wave function
e. Postulates of quantum mechanics
f. Schrödinger equation
g. Eigen value problem in quantum mechanics
h. Wave function and probability
i. Particle in a one and three-dimensional box and degeneracy of states.

Unit 2 Quantum mechanical treatments:

a. Quantum mechanical treatment of a harmonic oscillator, One-dimensional Harmonic oscillator (Classical and quantum mechanical treatments), Energy levels of harmonic and anharmonic oscillators
b. Quantum mechanical treatment of a rigid rotor

Unit 3 Quantum mechanical treatments of molecules:

a. Rigid rotor model of a diatomic molecule, Energy levels of a rigid rotor, rigid rotor, selection rule, A non-rigid rotor.
b. Schrödinger equation for H atom: Transformation of coordinates, Separation of Variables, φ, Θ, and R equations and their solutions, spherical harmonics, electron spin.

Unit 4 Approximation methods:

The variation method, the Perturbation method, and first-order perturbation theory

Books recommended:

1. Modern quantum Chemistry: An introduction to Advanced Electronic Structure Theory by A. Szabo and N.S. Ostland
2. Quantum Chemistry by Donald A. McQuarrie
3. Molecular Quantum Mechanics by P.W. Atkins and R.S. Friedman

B.Sc. VII Semester

Paper III	**BCHC-703**

INORGANIC CHEMISTRY (Main Group Elements)

Objective: The Objective of the first part (Main group Chemistry) is to provide basic concepts on synthesis, structure, bonding, and properties of some selected main group elements. The second part (Transition metal Chemistry) will help build a conceptual framework for understanding the principles and theories that account for the physicochemical properties of coordination compounds.

Outcome: Students will gain the fundamental knowledge about the synthesis, structure, bonding, and properties of some selected main group elements. Exposure to the fundamental concepts of different bonding theories and their relation to the properties of transition metal coordination compounds will clarify the role of this class of compounds in various fields, such as Organometallic Chemistry or Bioinorganic Chemistry, for future study.

Syllabus

1. **Stereo Chemistry of Bonding Main Group Components**
   Walsh diagram, dπ-pπ bonds, Bent rule, Energetics of hybridization
2. **Preparation, Structure, Bonding, and Technical Applications of**

(a) Polyether complexes of alkali and alkaline earth metals

(b) Polyphasphazenes

(c) Thiazyl and its polymers, tetrasulfurdinitride.

3. Classification, Structure, and Bonding of Borane & Carborane
4. Structure, Bonding, Properties, and Technical Applications of Silicon and Silicates

Books Recommended:

1. Advanced Inorganic Chemistry, 6th Edition, Cotton and Wilkinson
2. Inorganic Chemistry, 4th Edition, Principles of Structure and Reactivity by J.F. Huheey, E.A. Keiter, and R.L. Keiter, 1993
3. Chemistry of Elements by N.N. Greenwood and A. Earnshaw, Butterworths, 1997
4. Organometallic Chemistry: A Unified Approach by R.C. Mehrotra and A.K. Singh
5. Comprehensive Coordination Chemistry Vol. 3 by G. Wilkinson, R.D. Gillard, And J.A. McCleverty, Pergamon Press, 1987.

B.Sc. VII Semester

Paper IV	**BCHC-704**

ORGANIC CHEMISTRY (Reaction Mechanism)

Objective: The Primary aim of this course is to develop interest and skill for generating a mechanistic path for organic transformations in the students. The focus of this course is to provide a detailed understanding of organic reaction mechanisms and to understand the Physical Chemistry of organic reactions, including nucleophilic substitution reactions, elimination reactions, and addition reactions on carbon-carbon double bonds.

Outcome: After completion of the course, students will understand the mechanistic pathways of the various organic reactions. Students will become competent to predict the chemo-, regio-, and stereoselective outcome of such reactions.

Syllabus

UNIT 1: Basic Principles of organic reaction mechanism: Methods of Determination of organic reaction mechanism, Kinetic isotopic Effect, and its importance in the reaction mechanism.

UNIT 2: Substitution Reaction: Aliphatic Nucleophilic Substitution at Saturated Carbon Atom: Mechanism and stereochemistry of SN_1, SN_2, and SN_i reactions. Role of structure of substrate, nucleophile, leaving group, and solvent on SN reactions, Nucleophilic

Substitution in bridged systems, Neighboring Group Participation: Evidence for NGP, Participation by phenyl group, π and σ bonds, and Anchimeric assistance.

UNIT 3: Elimination Reaction: E_1, E_2, and E_{1Cb} Mechanism, orientation (Saytzeff and Hoffman Rule), stereochemistry of E_2 elimination, E_1, E_2, and E_{1Cb} spectrum, factors affecting E_1, E_2, and E_{1Cb} reactions, competition between substitution and elimination.

UNIT 4: Addition of Carbon-Carbon double bond: Mechanism and stereochemistry of the addition of halogen acids to alkenes, 1,2-bishydroxylation, epoxidation, hydroboration, and oxymercuration-demercuration. Addition to Carbon-hetero bond: Mechanism of addition to C=O bonds, Cram's rule.

Books Recommended:

1. Advanced Organic Chemistry – Structure and Mechanism, J. March, John Wiley
2. Advanced Organic Chemistry_FACarey and RJSundberg_A
3. Advanced Organic Chemistry_FACarey and RJSundberg_B
4. Modern Methods of Organic Synthesis-W. CARRUTHERS & I. COLDHAM-
5. Modern Organic Synthesis-Zweifel & Nantz

B.Sc. VII Semester

Paper -V	**BCHL-705**

CHEMISTRY PRACTICAL

Objective: To enable students to carry out and interpret measurements within the context of the fundamental technological problem with which they are presented.

The aim and objective of the practical course is to develop practical skills, confidence, and compliance for qualitative and quantitative analysis, preparation, separation techniques, isolation, extraction, and characterization using chemical, spectral, and other modern techniques. Besides, it fosters a vision of the scope in R&D, self-reliance through actual performance.

Outcome: Student will acquire practical skills to perform, analyze, and optimize necessary process parameters in kinetic and thermodynamic processes.

Students acquire all essential practical skills and learn techniques through multistep preparations, estimations, extractions, separations, isolations, distillations, chemical and spectral characterization, which provides a deeper understanding of the subject and confidence for the implementation of newer ideas, helping them to pursue higher education and R&D activities.

Syllabus

Physical practical exercises:

1. Determine the distribution coefficient of benzoic acid between benzene and water.
2. Determine the distribution coefficient of acetic acid between benzene and water.
3. Study the adsorption of acetic acid on charcoal and draw the Freundlich isotherm.
4. Show that the order of reaction between acetone and iodine is zero concerning iodine.

Inorganic exercises

1. Qualitative analysis of an inorganic mixture of seven radicals, including Tl, W, Se, Te, V, Be, U, Ti, Zr, Th, Ce, and Li, in Addition to the radicals prescribed for the B.Sc. Course. Semi-micro analysis is to be done.
2. Chromatographic separation of metal ions given in any one of the following combinations:
   (a) Pb^{2+}, Ag^{+}, Hg_2^{2+}
   (b) Ba^{2+}, Sr^{2+}, Ca^{2+}

Organic exercises:

1. Analysis of primary binary organic mixture (liquid-liquid, liquid-solid, solid-solid)
2. Determination of the equivalent weight of organic acids by the direct titration method

Recommended books

1. Advanced Physical Chemistry by J.B. Yadav
2. Chemistry Practical by Bajpai and Giri

Semester-VII

Paper VII	**BCHP-706**

Chemistry Project/Dissertation

Project/Dissertation

This course will provide you with guidance and support throughout the writing of your dissertation. From discussing your initial ideas for your dissertation through the process of actually writing the

document, this course will provide you with the information and support required from both the teaching staff and your allocated dissertation supervisor.

B.Sc. VIII Semester

Paper I	**BCHC-801**

Analytical Chemistry

Objective: To provide a basic understanding of the principles, instrumentation, and application of chemical analysis techniques.

Outcome: On completion of the course, students acquire knowledge to select proper techniques and instrumentation for particular sample analysis.

Syllabus

1. **Electroanalytical Techniques:**
   (a) **Conductometric:** Discussion of the nature of the curves of acid-base (including mixtures of acids), precipitation, and complexometric titrations.
   (b) **Potentiometric:** Different types of electrodes, discussion of the nature of the curves for oxidation-reduction and acid-base titrations, comparison with the conductometric method.
   (c) **Voltammetry**, Cyclic voltammetry
   (d) **Polarography:** Dropping mercury electrons and its advantages, polarographically active species, concept of residual, diffusion and limiting current of half-wave potential, Ilkovic equation, and factors affecting diffusion current.
2. **Thermo-analytical Methods:**
   (a) Thermo-gravimetry: apparatus, factors affecting TGA, interpretation of TG curves of $CaC_2O_4.H_2O$ and $MgC_2O_4.2H_2O$
   (b) Differential Thermal Analysis: Apparatus, factors affecting DTA curves with special reference to heating rate, particle size, and packing, measurement of heat of transition, heat of reaction, and heat of dehydration of salts of metal hydrates.
3. **Radiochemical methods:**
   (a) Isotope Method
   (b) Inverse Isotopic Dilution

(c) Neutron Activation Technique.

4. **Chromatographic Method:**

(a) Gas Chromatography: GLC and GC

(b) HPLC

Books Recommended:

1. Fundamentals of Analytical Chemistry, D.A. Skoog, D.M. West, and F.J. Holler
2. Quantitative inorganic analysis, A.I. Vogel
3. Instrumental Methods of Chemical Analysis, B.K. Sharma
4. Instrumental Methods of Chemical Analysis, H. Kaur
5. Analytical Chemistry, Gary D. Christian

B.Sc. VIII Semester

Paper II	**BCHC-802**

PHYSICAL CHEMISTRY (Thermodynamics and Electrochemistry)

Objective: Chemical kinetics is concerned with the study of the dynamics of chemical reactions. The raw data of chemical kinetics are the measurement of rates of reaction; the desired final product is the explanation of these rates in terms of complete reaction mechanisms. The objective of the present course is to introduce the foundation of the subject by studying a series of reactions of increasing complexity and to show how experimentally measured parameters may be used to propose new models (mechanisms) or verify existing models.

Outcome: This course will enable students to calculate the rate of reaction, the desired final product, and the yield of reaction, and to understand the possible reaction mechanism.

Syllabus

Unit-1 Some **important thermodynamic effects and relationships:** Joule Thomson's Effect, temperature dependence of free energy; Gibbs-Helmholtz equation and its application, the Clausius-Clapeyron equation. Thermodynamics relations: Maxwell's relation, Thermodynamic equation of state, Relationship between E or H and P, V, T, Partial molar quantities, Partial molar volume, and Partial molar Gibbs energy.

Unit-2 Chemical Potential and Third Law of Thermodynamics: Chemical potential and its variation with T and P, applications of Chemical Potential, Gibbs-Duhem equation, fugacity and

activity coefficient, and their determination. The third law of thermodynamics, the Nernst heat theorem, and entropy calculations, the residual entropy.

Unit-3 Electrochemistry: Brief description of ion-association, Wein Effect, Debye-Falkenhagen effect, Effect of ionic strength on the rate of ionic reactions. The Electrical double layer,

Unit-4 Electrode Processes: Concentration polarization, deposition and decomposition potentials, Overvoltage, Limiting current density.

Recommended books

1. Electrochemistry by Samuel Gaston
2. Thermodynamics by RP Rastogi
3. Thermodynamics by K.L. Kapoor
4. Physical Chemistry by Atkins

B.Sc. VIII Semester

Paper III	**BCHC-803**

INORGANIC CHEMISTRY (Transition Elements)

Objective: The First part (Organometallics) is designed to provide the basic knowledge of coordinate metal complexes Chemistry with reference to synthesis, structures, bonding, reactivity, and application of organometallic compounds. The second part deals with the role of kinetics and mechanism, stereoisomerism, and Metal-Ligand Equilibria in solution**.**

Outcome: Students will learn the basic features of coordinate metal complexes, Chemistry, kinetics, mechanism, stereoisomerism, and metal-ligand equilibria in solution, which are very important for different applications.

Syllabus

1. **Structures of 2 to 8 Coordinate Metal Complexes**

   Cation-anion radius ratio in various polyhedral, preferred conditions of formation of the complexes of the following geometries:

   C.N.2 -Linear

C.N.3 - Trigonal planar, Trigonalpyramidal

C.N.4 - Tetrahedral, Square planar

C.N.5 - Trigonal bipyramidal, Square pyramidal, pentagonal.

C.N.6 - Octahedral, Trigonal Prism

C.N.7 - Pentagonal bipyramidal, capped octahedral, Capped trigonal prism.

C.N.8 - Cubic, Tetragonal antiprismatic, Dodecahedral, Hexagonal bipyramidal, and Bicapped trigonal prism, Stereochemical non-rigidity in four to eight coordinate Complexes.

2. **Kinetics and Mechanism** of substitution reactions in octahedral Co (III) and square planar Pt (II) complexes.

3. Stereoisomerisms in six coordinate octahedral complexes (Ma_3bcd, Ma_2bcde, Mabcdef and complexes containing bi- and ter-dentate ligands, intermolecular and intramolecular rearrangements (Bailar and Ray Dutta Twist), Mechanism of racemization in tris (chelate) octahedral complexes, methods of resolution of optical isomers.

4. Metal Ligand Equilibria in Solution:

Step-wise and overall formation constants and their relations, Factors affecting the stability of metal complexes concerning the nature of metal ions and ligands, Determination of stability constants by pH-metric and spectroscopic methods.

Books Recommended:

1. Inorganic Chemistry, 4th Edition, Principles of Structure and Relativity by J.E. Huheey, E.A. Keiter and R.L. Keiter, 1993
2. Chemistry of Elements by N.N. Greenwood and A. Earnshaw, Butterworths, 1997
3. Mechanism of Inorganic Reactions: A Study of Metal Complexes in Solution by F. Bosolo and R.G. Pearson
4. Ligand Field Theory and Its Application by B.N. Figgis and M.A. Hitchman, Wiley, New York, 2000.

B.Sc. VIII Semester

PAPER IV	**BCHC-804**

ORGANIC CHEMISTRY (Stereochemistry and Pericyclic Chemistry)

Objective: This course is framed to provide an in-depth understanding of some important aspects of Stereochemistry, Pericyclic reactions, the stereochemistry and reactivity of cyclohexane, and asymmetric synthesis.

Outcome: Upon completing the course, students will understand the basics of organic Photochemistry and Pericyclic reactions. Various theories/rules governing these pericyclic reactions will help them to predict the products with stereochemistry involved in these reactions.

Syllabus

Unit 1: Stereochemistry: Elements of symmetry, chirality, molecules with more than one chiral center, threo and erythro isomers, Interconversion of Fischer, Newmann and Saw-Horse projections, configurational projections, R/S nomenclature, Principle of axial and planar chirality, optical Isomerism of biphenyl, alkenes and spiranes, optical activity due to intramolecular overcrowding, absolute configuration, Topocity Introduction- Homotopic, Enantiotopic and Diastereotopic atoms, groups and faces.

Unit 2: Asymmetric synthesis: Optical Activity, Enantiomeric excess and optical purity, Regioselectivity, stereoselectivity (enantioselectivity and diastereoselectivity) and stereospecificity, Asymmetric synthesis involving chiral auxiliary, chiral reagent and chiral catalysis.

Unit 3: Stereochemistry and reactivity of cyclohexane: Configuration, conformation, and stability of mono and di-substituted cyclohexane and cyclohexanones, chirality of disubstituted cyclohexane.

Unit 4: Pericyclic reactions: Introduction, classification and characteristics, Conservation of Molecular orbital symmetry, Use of correlation diagrams: FMO and PMO approach to study of Electrocyclic reactions of linear conjugated diene, triene and allyl systems., Cycloaddition reactions involving [2+2] and [4+2] systems., Sigmatropic rearrangements ([1,3], [1,5] and [3,3])., Claisen.

Recommended Books

1. Pericyclic Reaction and Organic Photochemistry BY Dr. Vinay Prabha Sharma, Rakesh Kumar
2. Organic Synthesis BY Dr.Jagdamba Singh, Dr. L.O.S. Yadav
3. StereoChemistry By P. S. Kalsi
4. StereoChemistry by D. Nasipuri

B.Sc. VIII Semester

Paper-V **BCHL-805**

Chemistry Practical

Objective: To empower students to carry out and interpret measurements within the context of the fundamental technological problem with which they are presented. The aim and objective of the practical course is to develop practical skills, confidence, and compliance for qualitative and quantitative analysis, preparation, separation techniques, isolation, extraction, and characterization using chemical, spectral, and other modern techniques. Besides, it fosters a vision of the scope in R&D, self-reliance through actual performance.

Outcome: Student will acquire practical skills to perform, analyze, and optimize necessary process parameters in kinetic and thermodynamic processes.

Students acquire all essential practical skills and learn techniques through multistep preparations, estimations, extractions, separations, isolations, distillations, chemical and spectral characterization, which provides a deeper understanding of the subject and confidence for the implementation of newer ideas, helping them to pursue higher education and R&D activities.

Syllabus

Physical practical exercises:

1. Draw the solubility curve for the water-acetic acid-chloroform system.
2. Study the adsorption of oxalic acid on charcoal and draw the Freundlich isotherm.
3. Determine the rate constant of the acid-catalyzed hydrolysis of ethyl acetate at laboratory temperature.
4. Determine the rate constant of the hydrolysis of ethyl acetate by sodium hydroxide at laboratory temperature.
5. Carry out the conductometric titration between the strong acid and strong alkali.
6. Determine the dimerization constant of benzoic acid in benzene medium by the partition method.
7. Determine the solubility of salicylic acid in water at different temperatures and calculate the heat of Solution.

Inorganic

Either both gravimetric or one volumetric estimation of two metal ions from the following mixtures:

(a) Cu^{2+} and Ni^{2+}

(b) Cu^{2+} and Zn^{2+}

(c) Ni^{2+} and Zn^{2+}

(d) Cu^{2+} and Ba^{2+}

Organic Chemistry

Preparation of organic compounds involving two stages, emphasis should be given to the following Processes:

Purification, distillation under reduced pressure, steam distillation, and fractional crystallization

Recommended books

1. Advanced Physical Chemistry Experiments by Dr. J.N. Gurtu, A. Gurtu
2. Advanced Practical Organic Chemistry by O.P. Agarwal

B.Sc. VIII Semester

Paper-VI	**BCHP-806**

Project/Dissertation

This course will provide you with guidance and support throughout the writing of your dissertation. From discussing your initial ideas for your dissertation through the process of actually writing the document, this course will provide you with the information and support required from both the teaching staff and your allocated dissertation supervisor.