Indrashil University

योगः कर्मसु कौशलम्

Department of Chemistry
School of Science

B.Sc. 2024-2028
Sem V-VI

Chemistry

Course Profile

Academic Year 2026-2027

B.Sc. Chemistry Semester V
Course Structure

Course Code	Course Name	Course Type	L-T-P	Credits
CH3 101	Organic Chemistry-V: Heterocyclic Chemistry	Major Discipline Core (**MDC**)	3-0-0	3
CH3 102	Inorganic Chemistry-IV: Chemistry of d and f-Block Elements		3-0-0	3
CH3 103	Physical Chemistry-IV: Electrochemistry		3-0-0	3
CH3 104	Organic Chemistry-V Laboratory		0-0-2	1
CH3 105	Inorganic Chemistry - IV Laboratory		0-0-2	1
CH3 106	Physical Chemistry – IV Laboratory		0-0-2	1
CH3 107	Semiconducting Materials for Photonics	Multi-Disciplinary (**MDE**)	3-0-0	3
CH3 108	Semiconducting Materials for Photonics Laboratory		0-0-2	1
CH3 109	Basic Spectroscopy		3-0-0	3
CH3 110	Basic Spectroscopy Laboratory		0-0-2	1
CH3 111	Chemistry for Sustainability	Skill Enhancement Course (**SEC**)	2-0-0	2
Total			**17L+0T+ 10P = 27h**	**22**

B.Sc. Chemistry Semester VI
Course Structure

Course Code	Course Name	Course Type	L-T-P	Credits
CH3 201	Bioorganic Chemistry	Major Discipline Core (**MDC**)	3-0-0	3
CH3 202	Organometallics and Catalysis		3-0-0	3
CH3 203	Chemical Kinetics and Catalysis		3-0-0	3
CH3 204	Heterocyclic Chemistry Laboratory		0-0-2	1
CH3 205	Organometallic and Catalysis Laboratory		0-0-2	1
CH3 206	Chemical Kinetics and Catalysis Laboratory		0-0-2	1
CH3 207	Advanced Spectroscopy	Minor Discipline Elective (**MDE**)	3-0-0	3
CH3 208	Advanced Spectroscopy Laboratory		0-0-2	1
		Multi-Disciplinary (**MDS**)		
CH3 209	Personality Development	Ability Enhancement Course (**AEC**)	2-0-0	2
CH3 210	Research Project/On-the-Job Training (OJT)	Skill Enhancement Course (**SEC**)	0-0-8	4
Total			**14L+0T+ 16P = 30h**	**22**

B.Sc. Chemistry Semester V
Detailed Syllabus
CH3 101: Organic Chemistry – V: Heterocyclic Chemistry (L-T-P-C: 3-0-0-3)

Program: B. Sc. Chemistry	**Semester:** V
Course code: CH3 101	**Course Name:** Organic Chemistry – V: Heterocyclic Chemistry

Lecture (Hours)	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Passing %
3/week	-	3	45	Lecture	CCE, ESE	75	40

Course Objectives:
- Course covers the fundamentals of heterocyclic chemistry, including structure, nomenclature, and aromaticity.
- Students learn IUPAC naming, classification, and electronic effects in heterocycles. Focus areas include five-membered rings.
- Course focuses on bicyclic systems such as quinoline.

Course Outcomes: At the end of this course, students will be able to

CO 1: Classify and name heterocyclic compounds using IUPAC

CO 2: Explain aromatic and heteroaromatic systems.

CO 3: Compare the structures and reactivity of pyrrole, furan, and thiophene.

CO 4: Apply appropriate synthetic methods for five-membered heterocycles.

CO 5: Analyze substitution patterns and basicity in pyridine and its derivatives.

CO 6: Describe the synthesis and relevance of condensed heterocycles like quinoline and isoquinoline.

Syllabus

Units	Content	Hours
Unit I: Fundamentals of Heterocyclic Chemistry	Introduction and nomenclature of heterocyclic compounds (Trivial and Systematic) Three membered heterocyclic compounds: Preparation and properties of Aziridine, Oxirane, Azetidine compounds. Four membered heterocyclic compounds: Preparation and properties of azetines, azetidines, and oxetane.	**15**
Unit II: Five Membered Heterocycles with One Heteroatom	Introduction of five-membered heterocyclic compounds with one heteroatom: Preparation and properties of pyrroles, furans and thiophenes. Preparation and properties of pyrazoles, & imidazoles. Introduction and properties of triazole and tetrazoles. Bicyclic ring system of five membered heterocyclic compounds: indoles, benzofuran, benzothiophene.	**15**
Unit III: Six- Membered and Condensed Heterocycles	Six-membered heterocyclic compounds with one heteroatom: Preparation and properties of pyridines and pyrans. Six-membered heterocyclic compounds with two heteroatoms: Preparation of pyrimidine, and its substitution reactions. Bicyclic ring system of six membered heterocyclic compounds: Preparation and properties of quinolines and their substitution reactions. Preparation, properties and applications of Benzimidazoles.	**15**

Reading References:

1. David R. Klein. *Organic Chemistry.* Wiley Publications, USA. 2015, 2nd Ed. *(or)* 2017, 3rd Ed.
2. Peter Sykes. *A Guidebook to Mechanism in Organic Chemistry.* Pearson Education, New Delhi. 2005, 6th Ed.

3. J. A. Joule; K. Mills. *Heterocyclic Chemistry.* Wiley Publications, UK. 2010, 5th Ed.
4. T. L. Gilchrist. *Heterocyclic Chemistry.* Pearson Education, UK. 1997, 3rd Ed.
5. R. T. Morrison; R. N. Boyd. *Organic Chemistry.* Pearson Education, New Delhi. 2011, 7th Ed.
6. IUPAC. *Nomenclature of Organic Chemistry: IUPAC Recommendations and Preferred Names 2013.* IUPAC Publications, Cambridge. 2014, 1st Ed.

CH3 102: Inorganic Chemistry-IV: Chemistry of d and f-Block Elements (L-T-P-C: 3-0-0-3)

Program: B. Sc. Chemistry	**Semester:** V
Course code: CH3 102	**Course name:** Inorganic Chemistry-IV: Chemistry of d and f-Block Elements

Lecture (Hours)	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Passing %
3/week	-	3	45	Lecture	CCE, ESE	75	40

Course Description:
This course deals with basics of coordination chemistry, transitional metal chemistry and lanthanides/actinides. From this course students will learn several fundamental concepts of coordination chemistry along with unique properties of d and f block elements. Gradually they come to know the importance of d and f block elements.

Course Outcomes: At the end of this course students will be able to
CO 1: Understand terms: ligand, denticity of ligands, chelate, coordination number, understand the terms inner and outer orbital complex.
CO 2: Systematically name coordination compounds. Various types of isomerism possible in Octahedral and Tetrahedral coordination compounds.
CO 3: Meaning of the terms $\Delta o.$, Δt, pairing energy, CFSE, high spin and low spin and how CFSE affects thermodynamic properties like lattice enthalpy and hydration enthalpy
CO 4: Understand lanthanides/actinides elements and their properties. Learn magnetic properties and colour of complexes on basis of Crystal Field Theory as well as 18-electron rule.

Syllabus

Units	Content	Hours
Unit I: Ligand Field Concepts	Werner's theory, valence bond theory (inner and outer orbital complexes), Basic terminologies and introduction to Crystal Field Theory and Ligand Field Theory, Crystal Field Stabilization Energy (CFSE), Measurement of 10 Dq (Δo). CFSE in weak and strong fields, pairing energies, Factors affecting the magnitude of Δo and Δt. Octahedral versus tetrahedral coordination, Tetragonal distortions from octahedral geometry. Jahn-Teller theorem, square planar geometry. Spectrochemical series and factors affecting ligand field strength. Magnetic properties of coordination compounds and spin-only magnetic moment.	15
Unit II: Coordination Chemistry	IUPAC nomenclature of coordination compounds, Isomerism in coordination compounds. Stereochemistry of complexes with 4 and 6 coordination numbers. Chelate effect, Labile and inert complexes. Applications of coordination compounds in medicine and industry.	15
Unit-III: Transition Elements and Lanthanides	General group trends with special reference to electronic configuration, colour, variable valency, magnetic and catalytic properties, and ability to form complexes. Stability of various oxidation states. Difference between the first, second and third transition series. Electronic configuration, oxidation states, colour, lanthanide contraction. Applications of transition metals and lanthanides in catalysis and materials chemistry.	15

Reading References:

1. Puri, B. R.; Sharma, L. R.; Kalia, K. C. *Principles of Inorganic Chemistry.* Vishal Publications, Jalandhar. 1996, 23rd Ed.
2. J. D. Lee. *Concise Inorganic Chemistry.* Oxford University Press, New Delhi. 1996, 3rd Ed.
3. F. A. Cotton; G. Wilkinson; Paul L. Gaus. *Basic Inorganic Chemistry.* Wiley India, New Delhi. 1995, 3rd Ed.
4. N. N. Greenwood; A. Earnshaw. *Chemistry of the Elements.* Pergamon Press, Oxford. 1989, 1st Ed.
5. D. F. Shriver; P. W. Atkins. *Inorganic Chemistry.* Oxford University Press, Oxford. 1999, 3rd Ed.

6. James E. Huheey; E. A. Keiter; R. L. Keiter. *Inorganic Chemistry: Principles of Structure and Reactivity.* Pearson Education, New Delhi. 1993, 4th Ed.
7. R. Gopalan. *Textbook of Inorganic Chemistry.* Universities Press, Hyderabad. 2009, 1st Ed.
8. R. D. Madan; G. D. Tuli; D. M. Malik. *Selected Topics in Inorganic Chemistry.* S. Chand Publications, New Delhi. 2006, 18th Ed.

CH3 103: Physical Chemistry-IV: Electrochemistry (L-T-P-C: 3-0-0-3)

Program: B. Sc. Chemistry	**Semester:** V
Course code: CH3 103	**Course name:** Physical Chemistry-IV: Electrochemistry

Lecture (Hours)	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Passing %
3/week	-	3	45	Lecture	CCE, ESE	75	40

Course Objectives:
This course aims to provide students with a fundamental understanding of electrochemistry and surface chemistry, including ionic conductance, transport phenomena, electrolysis, electrode potentials, electrochemical cells, and adsorption processes. Students will learn the principles governing electrolytic and electrochemical systems, conductometric and EMF measurements, fuel cells, and surface reactions. The course also develops analytical and problem-solving skills for interpreting electrochemical behaviour and understanding their applications in industry, energy systems, metallurgy, and chemical processes.

Course Learning Outcomes: At the end of this course, students will be able to
CO 1: Describe the fundamental concepts of electrochemistry and surface chemistry, including electrolytic dissociation, conductance, electrochemical cells, electrode potentials, and adsorption phenomena.
CO 2: Apply electrochemical principles, Faraday's laws, Nernst equation, and conductance measurements to solve problems related to ionic equilibria, EMF, electrolysis, and electrochemical systems
CO 3: Analyze ionic transport, transference phenomena, cell reactions, adsorption isotherms, and factors affecting electrochemical and surface processes.
CO 4: Evaluate the applications of electrochemistry and surface chemistry in industrial processes, fuel cells, metallurgy, analytical chemistry, and energy systems.

Syllabus

Units	Content	Hours
Unit I: Electrolyte Conductance and Ionic Transport	Arrhenius theory of electrolytic dissociation.Conductivity, equivalent and molar conductivity, and their variation with dilution for weak and strong electrolytes. Molar conductivity at infinite dilution. Kohlrausch law of independent migration of ions. Ionic velocities, mobilities, and their determinations, transference numbers and their relation to ionic mobilities, determination of transference numbers using Hittorf and Moving Boundary methods.	**15**
Unit II: Electrochemical Processes	Applications of conductance measurement: (i) degree of dissociation of weak electrolyte, (ii) ionic product of water, (iii) solubility and solubility product of sparingly soluble salts, (iv) conductometric titration, and (v) hydrolysis constants of salts. Applications of conductance measurements in water quality monitoring and industrial analysis. Quantitative aspects of Faraday's laws of electrolysis, rules of oxidation/reduction of ions based on half-cell potentials, applications of electrolysis in metallurgy and industry. Electroplating, electrorefining, and electrochemical energy storage systems. Corrosion prevention through electrochemical principles.	**15**
Unit III: Redox Systems, EMF, and Electrochemical Energy Devices	Chemical cells, reversible and irreversible cells with examples. Electromotive force of a cell and its measurement, Nernst equation; Standard electrode (reduction) potential and its application to different kinds of half-cells. Application of EMF measurements in determining (i) free energy, enthalpy and entropy of a cell reaction, (ii) equilibrium constants, and (iii) pH values, using hydrogen, quinone-hydroquinone, glass electrodes. Concentration cells. Fuel Cell: Principle, types and their functioning. Primary and secondary batteries; electrochemical energy storage and sustainability applications	**15**

CO-PO Mapping Table

	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	**3**	**1**	**1**	**-**	**-**
CO 2	**3**	**3**	**2**	**-**	**1**
CO 3	**2**	**2**	**3**	**-**	**1**
CO 4	**2**	**3**	**3**	**1**	**2**
Average	**2.5**	**2.25**	**2.25**	**0.25**	**1.0**

Correlation levels:
1 - Low, 2 - Moderate, 3 - High

Justification for CO-PO Mapping

CO	Justification
CO 1	This CO develops fundamental understanding of electrochemistry and surface chemistry concepts, strengthening scientific knowledge and basic analytical understanding (**PO1, PO2, PO3**).
CO 2	This CO enhances the application of electrochemical principles and quantitative problem-solving skills, contributing to technical and analytical competency (**PO1, PO2, PO3**).
CO 3	This CO develops analytical and critical thinking abilities through the study of ionic transport, electrochemical processes, and adsorption phenomena (**PO2, PO3**).
CO 4	This CO enables students to evaluate industrial and energy-related applications of electrochemistry and surface chemistry, promoting problem-solving and multidisciplinary understanding (**PO2, PO3, PO5**).

Reading References:

1. Dr. R. L. Madan. *Chemistry for Degree Students.* S. Chand Publications, New Delhi. 2022, 1st Ed.
2. B. R. Puri; L. R. Sharma; Madan S. Pathania. *Principles of Physical Chemistry.* Vishal Publishing, Jalandhar. 2011, 46th Ed.
3. R. Gurdeep Raj. *Advanced Physical Chemistry.* Krishna Prakashan Media, Meerut. 2018, 4th Ed.
4. Samuel Glasstone. *An Introduction to Electrochemistry.* D. Van Nostrand Company, New York. 1965, 10th Ed.

CH3 104: Organic Chemistry-V Laboratory (L-T-P-C: 0-0-2-1)

Program: B. Sc. Chemistry	**Semester:** V
Course code: CH3 104	**Course name:** Organic Chemistry-V Laboratory

Lecture (Hours)	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Passing %
-	2/week	1	30	Practical	CCE, ESE	25	40

Course Objectives:

- This is a practical course which involves the synthesis and characterization of heterocyclic compounds,
- This is a practical course which emphasizes on the use of common laboratory techniques and understanding of reaction mechanisms.
- This course also enables students to learn analytical techniques such as purification and characterization of compounds.

Course Outcomes: At the end of this course, students will be able to
C0 1: Remember reactions and reagents used in heterocyclic compound synthesis
C0 2: Understand the reaction mechanisms involved in the formation of heterocyclic rings
C0 3: Perform synthetic procedures for heterocycles using standard lab techniques
C0 4: Analyze the melting point, TLC, and spectral data to confirm product identity.

Syllabus

Sr. No.	Name of the Experiment	Hours
1	Synthesis and characterization of 2-aminothiophenes by reaction between elemental sulfur, ethyl acetoacetate and an ethyl cyanoacetate (Gewald reaction).	**6**
2	Synthesize and characterization of quinoline by Skraup synthesis	**6**
3	perform the Electrophilic substitution on pyrrole (e.g., nitration or bromination)	**6**
4	Synthesis of dihydropyridine by Hantzsch Synthesis	**6**
5	To synthesize the pyrimidines from urea and β-dicarbonyl compounds	**6**
6	Synthesis and characterization of 2-aminothiophenes by reaction between elemental sulfur, ethyl acetoacetate and an ethyl cyanoacetate (Gewald reaction).	**6**

Reading References:

1. N. K. Vishnoi. *Advanced Practical Organic Chemistry.* Vikas Publishing House, New Delhi. 2009, 3rd Ed.
2. J. A. Joule; K. Mills. *Heterocyclic Chemistry.* Wiley-Blackwell, Oxford. 2010, 5th Ed.
3. T. L. Gilchrist. *Heterocyclic Chemistry.* Pearson Education, Harlow. 1997, 3rd Ed.
4. L. A. Paquette. *Principles of Modern Heterocyclic Chemistry.* W. A. Benjamin, New York. 1968, 1st Ed.
5. B. S. Furniss; A. J. Hannaford; P. W. G. Smith; A. R. Tatchell. *Vogel's Textbook of Practical Organic Chemistry.* Pearson Education, Harlow. 2008, 5th Ed.

CH3 105: Inorganic Chemistry-IV Laboratory (L-T-P-C: 0-0-2-1)

Program: B. Sc. Chemistry	**Semester:** V
Course code: CH3 105	**Course name:** Inorganic Chemistry - IV Laboratory

Lecture (Hours)	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Passing %
-	2/week	1	30	Lab	CCE, ESE	25	40

Course Objectives:
To develop practical skills in the synthesis and characterization of coordination compounds, spectrophotometric and volumetric analysis, and the application of analytical techniques such as UV–Visible spectroscopy for the qualitative and quantitative determination of chemical species. The course aims to enhance students' understanding of coordination chemistry, Beer–Lambert law, electronic transitions, spectral interpretation, and redox titrations, while fostering competence in experimental design, data analysis, and the determination of physicochemical properties of inorganic compounds and solutions.

Course Learning Outcomes: At the end of this course students will be able to
CO 1: Learn the basics of complex compound preparation
CO 2: Different estimation techniques.
CO 3: Detail Spectrophotometric technique.
CO 4: Analysis skill to determine (qualitative and quantitative) the concentration of metal ion in a given sample.

Syllabus

Sl. No.	Name of Experiment	Hours
1	Preparation of complex compounds; such as tetramminecopper(II) sulphate/Nickel (II) dimethylglyoxime/trithioureacopper(I) sulphate.	5
2	Preparation of tetraamminecopper (II) sulphate, $[Cu(NH_3)_4]SO_4.H_2O$, Acetylacetonate complexes of Cu2+/Fe3+, Tetraamminecarbonatocobalt (III) nitrate, Potassium tri(oxalato)ferrate(III).	5
3	Verify Lambert-Beer’s law and determine the concentration of CuSO4/KMnO4/K2Cr2O7 in a solution of unknown concentration.	4
4	Study the 200-500 nm absorbance spectra of $KMnO_4$ and $K_2Cr_2O_7$ (in 0.1 M H_2SO_4) and determine the λ_{max} values. Calculate the energies of the two transitions in different units (J $molecule^{-1}$, kJ mol^{-1}, cm^{-1}, eV).	4
5	Spectrophotometric determination of Fe (II) using 1, 10-Phenanthroline /EDTA or Estimation of iron as Fe_2O_3 by precipitating iron as $Fe(OH)_3$.	4
6	To determine the concentration of Cu(II) ions and potassium dichromate using iodometric titration with sodium thiosulphate.	4
7	To investigate the effect of pH on the UV–Visible absorption spectrum of potassium dichromate.	4

Reading References

1. A. K. Cheetham; P. Day. *Solid State Chemistry: 1. Techniques and 2. Applications.* Oxford University Press, Oxford. 1987, 1st Ed.
2. P. A. Cox. *The Electronic Structure and Chemistry of Solids.* Oxford University Press, Oxford. 1987, 1st Ed.
3. K. J. Klabunde (Ed.). *Nanoscale Materials in Chemistry.* Wiley-Interscience, New York. 2001, 1st Ed.
4. N. N. Greenwood. *Ionic Crystals, Lattice Defects and Non-Stoichiometry.* Butterworths, London. 1968, 1st Ed.
5. C. N. R. Rao; J. Gopalakrishnan. *New Directions in Solid State Chemistry.* Cambridge University Press, Cambridge. 1997, 2nd Ed.

CH3 106: Physical Chemistry-IV Laboratory (L-T-P-C: 0-0-2-1)

Program: B. Sc. Chemistry	**Semester:** V
Course code: CH3 106	**Course name:** Physical Chemistry - IV Laboratory

Lecture (Hours)	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Passing %
-	2/week	1	30	Practical	CCE, ESE	25	40

Course Objectives:
To develop practical skills in conductometric and potentiometric measurements, electrochemical analysis, and data interpretation for the determination of physicochemical parameters and the study of electrolyte behavior.

Course Outcomes: At the end of this course students will be able to
CO 1: Explain the principles of conductometric and potentiometric measurements used in electrochemical analysis.
CO 2: Perform conductometric and potentiometric experiments to determine physicochemical parameters of electrolytes and solutions.
CO 3: Apply electrochemical concepts to analyze experimental data and evaluate equilibrium and solution properties.

Syllabus

Sr. No.	Name of the Experiment	Hours
1.	To determine the Molar Conductivity and verifyf Kohlrausch's Law	**6**
2.	To perform the Conductometric Titration of a (i) Strong Acid vs. Strong Base, (ii) Weak acid vs. Strong base.	**6**
3.	To determine the Degree of Ionization and Ka of Acetic Acid Using Conductance Measurements	**4**
4.	To determine the Solubility Product (Ksp) of a Sparingly Soluble Salt by Conductance Method	**4**
5.	To determine the pH of a Solution Using EMF Measurements	**4**
6.	To determine the following potentiometric titrations: a) Strong acid vs. strong base b) Weak acid vs. strong base	**6**

CO-PO Mapping Table

	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	**2**	**2**	**1**	**-**	**-**
CO 2	**2**	**3**	**2**	**1**	**-**
CO 3	**2**	**3**	**3**	**-**	**1**
Average	**2.0**	**2.67**	**2.00**	**0.33**	**0.33**

Correlation levels:
1 - Low, 2 - Moderate, 3 - High

Justification for CO-PO Mapping

CO	Justification
CO 1	Develops understanding of electrochemical principles and measurement techniques, contributing to scientific knowledge (**PO1**) and analytical skills (**PO2**).

CO 2	Enhances practical competency in electrochemical measurements and experimental techniques, strengthening technical skills (**PO2**) and problem-solving ability (**PO3**).
CO 3	Promotes the application of electrochemical concepts for data analysis and interpretation, contributing to analytical reasoning (**PO3**) and technical competence (**PO2**)

Reading References

1. B. D. Khosla; V. C. Garg; Adarsh Gulati. *Senior Practical Physical Chemistry.* R. Chand & Co., New Delhi. 2018, 1st Ed.
2. B. Viswanathan; P. S. Raghavan. *Practical Physical Chemistry.* Viva Books Private Limited, Navi Mumbai. 2017, 1st Ed.
3. A. K. Nad; B. Mahapatra; A. Ghoshal. *An Advanced Course in Practical Chemistry.* New Central Book Agency Pvt. Ltd., Kolkata. 2022, 1st Ed.
4. B. Viswanathan; P. S. Raghavan. *Practical Physical Chemistry.* Viva Books, New Delhi. 2012, 1st Ed.

CH3 107: Semiconductor Materials for Photonics (L-T-P-C: 3-0-0-3)

Program: B. Sc. Chemistry	**Semester:** V
Course code: CH3 107	**Course name:** Semiconducting Materials for Photonics

Lecture (Hours)	Practical (Hours/week)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Passing %
3/week	-	3	45	Lecture	CCE, ESE	75	40

Course Objectives: This course is designed to provide students with a comprehensive understanding of semiconducting and photonic materials used in modern electronic and optoelectronic devices. It enables learners to develop knowledge of electro-optic, magneto-optic, acousto-optic, piezoelectric, pyroelectric, and polymeric materials and their applications in sensors, actuators, and communication technologies. The course also introduces the fundamentals of solar energy conversion and photovoltaic devices, helping students understand sustainable energy technologies. Furthermore, students gain insight into the working principles and characteristics of various optoelectronic devices, thereby strengthening their ability to analyze, apply, and evaluate semiconductor-based technologies used in real-life applications.

Course Outcomes: At the end of this course students will be able to
CO1: Remember the concept of basics of photovoltaic cell and can be used in various applications.
CO2: Understand the basics of different types of polymeric materials which can be used in different sensor applications.
CO3: Apply the concept of different types semiconducting devices which can help to understand the real-life application.
CO4: Analyze the concept to understand the characteristics of different optoelectronic devices.

Detailed Syllabus

Units	Content	Hours
Unit I: Electronic Devices and Piezoelectric Material	Electro-Optic, Magneto-optic and acousto-optic effect, properties related to get these effects, materials exhibiting electro strictive and magneto strictive effects and their application in sensors and actuator devices, Piezoelectric materials, resonators and filters, high frequency piezoelectric devices, surface acoustic wave devices, pyroelectric effect, inorganic oxide and polymer pyroelectric materials and their applications	**15**
Unit II: Solar Energy	Fundamentals of photovoltaic cell and energy, basic to energy conversion, optical properties of solar cells, types of solar cell, pn junction solar cell single crystal silicon and amorphous silicon solar cell.	**15**
Unit III: Optoelectronic Devices	Bulk and thin film Photoconductive Devices (LDR), Solar cell (open circuit voltage and short circuit current, fill factor), photomultiplier, Photodetectors with external photo effect, photodetectors with internal photo effect, photo conductors and photo resistors, junction photo detectors, diode tester, polarity and voltage tester.	**15**

CO–PO Mapping Table

CO/PO	PO1	PO2	PO3	PO4	PO5
CO1	**3**	**2**	**-**	**-**	**-**
CO2	**3**	**2**	**-**	**-**	**2**
CO3	**-**	**3**	**3**	**-**	**-**
CO4	**-**	**3**	**3**	**2**	**-**
Average	**1.5**	**2.5**	**1.5**	**0.5**	**0.5**

Justification for CO–PO Mapping

COs	Justification

CO1	Knowledge of photovoltaic cells and their applications develop fundamental scientific understanding of semiconductor materials while strengthening technical awareness of energy-conversion technologies. (PO1, PO2)
CO2	Understanding polymeric materials used in sensors builds core scientific knowledge, enhances analytical understanding of material properties, and supports interdisciplinary applications related to sustainable technologies. (PO1, PO2, PO5)
CO3	Application of semiconductor device concepts to real-life situations develops technical competency, analytical skills, and problem-solving abilities required for scientific and industrial applications. (PO2, PO3)
CO4	Analyzing the characteristics of optoelectronic devices strengthens data interpretation and critical thinking skills while enabling students to effectively communicate technical findings and pursue continuous learning. (PO2, PO3, PO4)

Reading References:

1. Ben G. Streetman; S. K. Banerjee. *Solid State Electronic Devices.* PHI Learning Pvt. Ltd., New Delhi. 2006, 6th Ed.
2. Ajoy Ghatak; K. Thyagarajan. *Optical Electronics.* Cambridge University Press, New Delhi. 1991, 1st Ed.
3. S. M. Sze. *Physics of Semiconductor Devices.* Wiley Publications, New York. 1996, 2nd Ed.
4. P. Bhattacharya. *Semiconductor Opto-Electronic Devices.* Prentice Hall of India, New Delhi. 1996, 2nd Ed.
5. M. K. Achuthan; K. N. Bhat. *Fundamentals of Semiconductor Devices.* Tata McGraw-Hill (TMH), New Delhi. 2007, 1st Ed.
6. J. Allison. *Electronic Engineering Materials and Devices.* Tata McGraw-Hill (TMH), New Delhi. 1990, 1st Ed.

CH3 108: Semiconducting Materials for Photonics Laboratory (L-T-P-C: 0-0-2-1)

Program: B. Sc. Chemistry	**Semester:** V
Course code: CH3 108	**Course name:** Semiconducting Materials for Photonics Laboratory

Lecture (Hours)	Practical (Hours/week)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Passing %
-	2/week	1	30	Lab	CCE, ESE	25	40

Course Objectives: This laboratory course is designed to provide hands-on training in the characterization and application of semiconducting and photonic devices. Students gain practical experience with solar cells, laser diodes, LEDs, and sensor design while understanding their operating principles and performance characteristics. The course develops experimental skills, data analysis abilities, and problem-solving competence through the verification of device characteristics and the determination of important semiconductor parameters relevant to real-world technological applications.

Course Outcomes: At the end of this course students will be able to
CO 1: Demonstrate understanding of the working principles, construction and characteristics of semiconductor and photonic devices used in laboratory experiments.
CO 2: Perform experiments to measure, analyze and interpret the characteristics of solar cells, laser diodes and related semiconductor devices.
CO 3: Apply experimental techniques and theoretical concepts to design simple sensor systems and solve practical problems involving semiconductor devices.
CO 4: Evaluate experimental observations and determine relevant device parameters through systematic data collection and analysis.

Detailed Syllabus

Experiment No.	Content	Hours
1	Understanding and identification of the components of a Solar Cell.	06
2	Verification of the characteristics of a solar cell.	06
3	Verification of the temperature dependence of a solar cell.	06
4	Understanding and verification of the characteristics of a laser diode.	06
5	Designing a sensor using solar cell and LED.	06

CO–PO Mapping Table

CO/PO	PO1	PO2	PO3	PO4	PO5
CO1	**3**	**2**	**-**	**-**	**-**
CO2	**-**	**3**	**3**	**-**	**-**
CO3	**-**	**3**	**3**	**2**	**-**
CO4	**-**	**3**	**3**	**-**	**-**
Average	**0.75**	**2.75**	**2.25**	**0.5**	**-**

CO–PO Justification Table

CO	Justification
CO 1	Understanding the principles and characteristics of semiconductor devices develops scientific knowledge and strengthens technical competence required for laboratory-based learning. (**PO1, PO2**)
CO 2	Conducting experiments and interpreting device characteristics enhances analytical skills, experimental proficiency, and scientific problem-solving abilities. (**PO2, PO3**)
CO 3	Application of theoretical and practical knowledge to sensor design promotes technical expertise, critical thinking, teamwork, and continuous learning. (**PO2, PO3, PO4**)

CO 4	Evaluation of experimental data and determination of device parameters require analytical reasoning and systematic problem-solving skills essential for scientific investigations. (**PO2, PO3)**

Reading References:

1. Harnam Singh; P. S. Hemne. *B.Sc. Practical Physics.* S. Chand Publications, New Delhi. 2000, 1st Ed.
2. C. L. Arora. *B.Sc. Practical Physics.* S. Chand Publications, New Delhi. 2010, Revised Ed.
3. P. R. Sasi Kumar. *Practical Physics.* PHI Learning Pvt. Ltd., New Delhi. 2011, 1st Ed.
4. Dinesh V. Kala. *Physics Practical Manual for UG & PG.* Dinesh Publication, New Delhi. 2020, 1st Ed.

CH3 109: Basic Spectroscopy (L-T-P-C: 3-0-0-3)

Program: B. Sc. Chemistry	**Semester:** V
Course code: CH3 109	**Course name:** Basic Spectroscopy

Lecture (Hours)	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Passing %
3/week	-	3	45	Lecture	CCE, ESE	75	40

Course Objectives:

- Tointroduce the principles and techniques of basic spectroscopy, focusing on the interaction of electromagnetic radiation with matter.
- Exploreall fundamental aspects of spectroscopy like rotational, vibrational, and electronic spectra.
- Understand the basic spectroscopic techniques, spectral interpretation with applications in chemical structure determination and analysis.

Course Outcomes: At the end of this course, students will be able to
CO 1: Understand the fundamental principles of molecular spectroscopy
CO 2: Differentiate between various types of molecular spectra, such as rotational, vibrational, electronic, and Raman spectra
CO 3: Apply quantum mechanical principles to interpret spectral transitions
CO 4: Analyse and interpret experimental spectral data to determine molecular structure
CO 5: Utilise spectroscopic techniques in real-world applications such as structure elucidation, chemical identification, and material characterisation.

Syllabus

Unit	Content	Hours
Unit I:	**Molecular spectroscopy**: Interaction of electromagnetic radiation with molecules and various types of spectra; Relative Population: Boltzmann Distribution Formula; Signal-to-Noise Ratio (SNR) Overview of the complete electromagnetic spectrum. Introduction of the spectroscopy associated with different electromagnetic rays, energy level transitions. **Rotation spectroscopy:** Selection rules, intensities of spectral lines, determination of bond lengths of diatomic and linear triatomic molecules, isotopic substitution, and related numerical, Basic instrumentation of rotational spectrocopy and brief overview of its applications	**15**
Unit II:	**Vibrational spectroscopy**: Quantum Approach in vibrational spectroscopy, vibrations of polyatomic molecules; Vibrational Degrees of freedom for Linear and non-linear molecules; Types of Vibrations; Basic principles of IR spectroscopy and its instrumentation.	**15**
Unit III:	**Raman spectroscopy:** Raman Scattering; Rayleigh scattering, Stokes and anti-Stokes lines; Basic principles of Raman spectroscopy and its instrumentation. Differences between IR and Raman methods; Applications of Raman Spectroscopy **Electronic spectroscopy:** Basic principles of UV spectroscopy; electronic transitions, Mathematical Derivation of Beer-Lambert's Law:; Chromophore; Auxophore; singlet and triplet states, Jablonski diagram, fluorescence and phosphorescence, **Mössbauer Spectroscopy:** Principles of Mossbauer spectroscopy, Selection Rules; Mössbauer effect; Doppler effect; Instrumentation and brief overview of its applications	**15**

Reading references:

1. C. N. Banwell. *Fundamentals of Molecular Spectroscopy.* McGraw Hill Education, New Delhi. 2017, 4th Ed.
2. D. L. Pavia; G. M. Lampman; G. S. Kriz. *Introduction to Spectroscopy.* Cengage Learning, Boston. 2015, 5th Ed.
3. D. N. Bajpai. *Advanced Physical Chemistry.* S. Chand Publishers, New Delhi. 1962, 2nd Ed.
4. P. W. Atkins; Julio de Paula. *Atkins' Physical Chemistry.* Oxford University Press, Oxford. 2014, 10th Ed.
5. S. K. Dogra; S. Dogra. *Physical Chemistry Through Problems.* New Age International Publishers, New Delhi. 2015, 2nd Ed.
6. J. Walker; R. F. Straw. *Spectroscopy Vol. I & II.* Chapman and Hall, London. 1976, 2nd Ed.

CH3 110: Basic Spectroscopy Laboratory (L-T-P-C: 0-0-2-1)

Program: B. Sc. Chemistry	**Semester:** V
Course code: CH3 110	**Course name:** Basic Spectroscopy Laboratory

Lectures	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Passing %
-	2 per week	1	30	Lab	CCE, ESE	25	40

Course Objectives:

- Provide hands-on training in the application of molecular spectroscopy techniques to analyze and interpret the structure and properties of organic and inorganic compounds.
- Understand how to perform experiments using UV-Visible, IR, and fluorescence spectroscopy to study absorption characteristics, determine λ max, construct calibration curves, and calculate quantum yield.
- Explore spectroscopic techniques for the detection of food adulterants, fluorescence behavior of molecules, analysis of plant extracts, and interpretation of spectral data.

Course Learning Outcomes: At the end of this course, students will be able to

CO 1: Remember the principles of UV-Visible and fluorescence spectroscopy and NMR

CO 2: Understand the principles of Lambert-Beer's Law, Jablonski Diagram, and their application in spectrophotometric measurements

CO 3: Demonstrate proficiency in operating basic spectroscopic instruments

CO 4: Measure and compare excitation and emission maxima of fluorescent compounds like quinine and fluorescein

CO 5: Evaluate the quantum yield and food adulteration of a sample using the relative method with a known standard

Syllabus

Sr. No.	Name of the Experiment	Hours
1	To verify Lambert-Beer's law using a spectrophotometer	**2**
2	To determine the λ_{max} of given colored compounds:	**4**
3	To determine the concentration of an unknown solution using a calibration curve	**4**
4	To study the fluorescence behaviour of organic molecules. Excitation and Emission Maxima: Fluoresceine and rhodamine	**4**
5	To analyse the Raman, Mossbauer, and FTIR spectra of pollen	**4**
6	To measure the Quantum Yield (Relative Method) – Compare the sample with the standard (e.g., quinine sulfate).	**4**
7	To apply spectroscopy in the detection of adulteration in milk products	**4**
8	To perform the spectroscopic Study of Plant Extracts– UV/Fluorescence analysis of chlorophyll, curcumin, etc.	**4**

Reading References:

1. R. K. Bansal. *Practical Organic Chemistry.* New Age International Pvt. Ltd., New Delhi. 2008, 5th Ed.
2. D. Field; S. Sternhell; J. R. Kalman. *Organic Structures from Spectra.* Wiley & Sons Ltd., UK. 2008, 4th Ed.
3. F. G. Mann; B. C. Saunders. *Practical Organic Chemistry.* Pearson Education India, New Delhi. 2009, 4th Ed.
4. William Kemp. *Organic Spectroscopy.* Macmillan Publishers, London. 1994, 3rd Ed.
5. P. S. Kalsi. *Spectroscopy of Organic Compounds.* New Age International Pvt. Ltd., New Delhi. 2020, 8th Ed.
6. Y. R. Sharma. *Elementary Organic Spectroscopy: Principles and Chemical Applications.* S. Chand Publications, New Delhi. 1992, 5th Ed.

CH3 111: Chemistry for Sustainability (L-T-P-C: 2-0-0-2)

Program: B. Sc. Chemistry	**Semester:** V
Course code: CH3 111	**Course name:** Chemistry for Sustainability

Lect.	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Passing %
2/week	-	2	30	Lecture	CCE, ESE	50	40

Course Objectives:
This course introduces the principles of sustainability and green chemistry, highlighting the role of chemistry in addressing environmental challenges and achieving sustainable development goals. It develops understanding of sustainable technologies, resource-efficient practices, and contemporary applications that promote environmental stewardship and responsible chemical innovation.

Course Learning Outcomes: At the end of this course, students will be able to
CO 1: Remember and explain the fundamental concepts of sustainability, green chemistry, circular economy, environmental footprints, and selected UN Sustainable Development Goals.
CO 2: Understand the role of chemistry in resource conservation, pollution prevention, climate change mitigation, and sustainable technological development.
CO 3: Apply the principles of sustainability and green chemistry to analyze contemporary case studies and evaluate sustainable practices in chemical industries.

Syllabus

Units	Content	Hours
Unit I: Fundamentals of Sustainability and Green Chemistry	Definitions: Sustainability, Green Chemistry, Circular Economy, Life Cycle Analysis (LCA). Principles of Green Chemistry (Anastas and Warner's 12 Principles). Environmental footprints: Carbon footprint, water footprint, chemical toxicity. Chemistry's role in resource efficiency and pollution prevention. Introduction to renewable and non-renewable resources. Introduction to climate change and the chemical industry's role.	**10**
Unit II: Chemistry and the UN Sustainable Development Goals (SDGs)	Overview of the 17 SDGs with emphasis on SDG 6 (Clean Water), SDG 7 (Clean Energy), SDG 12 (Responsible Consumption), SDG 13 (Climate Action). Chemistry's contribution to: 1. Clean water technologies (desalination, water purification, adsorption, membrane technologies, and advanced oxidation processes), 2. Sustainable energy solutions (batteries, solar cells, hydrogen, fuel cells and energy storage materials), 3. Green Manufacturing and Waste Valorization (***catalysis, biomass conversion, waste-to-value chemicals, and industrial symbiosis***), 4. Sustainable chemistry education and ethics Role of chemistry in sustainable agriculture (fertilizers and pesticides).	**10**
Unit III: Case Studies and Contemporary Applications	Case Study 1: Bio-based polymers and biodegradable plastics Case Study 2: Green synthesis in pharmaceuticals Case Study 3: Clean energy – lithium-ion and solid-state batteries Case Study 4: CO_2 capture and utilization (CCU) Case Study 5: Sustainable dyes and pigments in the textile industry Critical review of sustainability reports from chemical companies	**10**

CO-PO Mapping Table

	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	**3**	**1**	**1**	**1**	**2**
CO 2	**3**	**2**	**2**	**1**	**3**
CO 3	**2**	**3**	**3**	**2**	**3**
Average	**2.67**	**2.00**	**2.00**	**1.33**	**2.67**

Correlation levels:
1 - Low, 2 - Moderate, 3 - High

Justification for CO-PO Mapping

CO	Justification
CO 1	This CO develops fundamental knowledge of sustainability and green chemistry concepts (PO 1) and promotes environmental awareness (PO 5).
CO 2	This CO enhances understanding of chemistry's role in addressing environmental challenges and sustainable development (PO 1, PO 5) while strengthening analytical skills (PO 2, PO 3).
CO 3	This CO develops the ability to apply sustainability principles to real-world problems and industrial practices (PO 2, PO 3, PO 5) and supports ethical decision-making (PO 4).

Reading References:

1. P. T. Anastas; J. C. Warner. *Green Chemistry: Theory and Practice.* Oxford University Press, New York. 1998, 1st Ed.
2. M. Lancaster. *Green Chemistry: An Introductory Text.* Royal Society of Chemistry, Cambridge. 2016, 3rd Ed.
3. United Nations. *Sustainable Development Goals.* Available at: https://sdgs.un.org
4. *Journal articles and sustainability reports (to be provided during the course).*

SEMESTER VI
SYLLABUS

CH3 201: Bioorganic Chemistry (L-T-P-C: 3-0-0-3)

Program: B. Sc. Chemistry	**Semester:** VI
Course code: CH3 201	**Course Name:** Bioorganic Chemistry

Lecture (Hours)	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Passing %
3/week	-	3	45	Lecture	CCE, ESE	75	40

Course Objectives:
- Understand the structure and reactivity of biologically important molecules.
- Study chemical roles of amino acids, proteins, carbohydrates, lipids, and nucleic acids.
- Analyze enzyme catalysis and coenzyme function through case studies.
- Study natural biosynthetic pathways.
- Connect organic chemistry and biology to reveal life's chemical logic.

Course Outcomes: At the end of this course, students will be able to
CO 1: Explain the structures and functions of key biomolecules.
CO 2: Elucidate enzyme mechanisms using chemical principles.
CO 3: Analyze bioenergetics and thermodynamics in living systems.
CO 4: Understand molecular recognition and its role in signaling and metabolism.
CO 5: Describe natural biosynthetic pathways for complex molecules.
CO 6: Appreciate nature's strategies for selectivity, catalysis, and atom economy in biological chemistry.

Syllabus

Unit	Content	Hours
Unit I: Biomolecular Structure and Reactivity	**Amino Acids and Peptides**: Structure, properties, and reactivity of amino acids; peptide bond formation and resonance; isoelectric point, zwitterions and protein folding principles **Proteins**: Levels of protein structure; hydrogen bonding, hydrophobic effect, disulfide linkages. **Carbohydrates**: Structure and stereochemistry of mono-, di-, and polysaccharides; mutarotation; glycosidic linkage **Lipids and Membranes**: Fatty acids, triglycerides, phospholipids **Nucleic acids:** structure, hydrogen bonding, and tautomerism, Hydrophobic effect, non-covalent interactions in biology.	**15**
Unit II: Mechanistic Bioorganic Chemistry	**Case Studies of Enzyme Mechanisms: Enolase and aldolase**: C–C bond cleavage and formation mechanisms **Coenzymes and Cofactors**: Structure and function of ATP, NAD+/NADH, FAD/FADH2, thiamine pyrophosphate, biotin, pyridoxal phosphate; **DNA/RNA Chemistry**: Nucleotide structure, base pairing, replication, and transcription.	**15**
Unit III: Learning from nature	Biosynthesis of amino acids, fatty acids, and nucleotides; Terpene biosynthesis; **Selective Catalysis by Nature**: Lessons from biosynthesis for synthetic chemists; Case study: **Chlorophyll**	**15**

Reading References:

1. A. L. Lehninger; D. L. Nelson; M. M. Cox. *Principles of Biochemistry.* W. H. Freeman, New York. 2017, 7th Ed.
2. D. Voet; J. G. Voet. *Biochemistry.* Wiley, Hoboken. 2011, 5th Ed.
3. R. H. Garrett; C. M. Grisham. *Biochemistry.* Cengage Learning, Boston. 2016, 6th Ed.

4. W. P. Jencks. *Catalysis in Chemistry and Enzymology.* Dover Publications, New York. 1987, Reprint Ed.
5. A. Fersht. *Structure and Mechanism in Protein Science.* W. H. Freeman, New York. 1999, 1st Ed.
6. L. Stryer. *Biochemistry.* W. H. Freeman, New York. 2019, 8th Ed.
7. P. A. Frey; A. D. Hegeman. *Enzymatic Reaction Mechanisms.* Oxford University Press, New York. 2007, 1st Ed.
8. J. Kuriyan; B. Konforti; D. Wemmer. *The Molecules of Life: Physical and Chemical Principles.* Garland Science, New York. 2012, 1st Ed.

CH3 202 Organometallics and Catalysis (L-T-P-C: 3-0-0-3)

Program: B. Sc. Chemistry	**Semester:** VI
Course Code: CH3 202	**Course Name:** Organometallic and Catalysis

Lect.	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Passing %
3/week	-	3	45	Lecture	CCE, ESE	75	40

Course Objectives:

- To understand structure and bonding of organometallic compounds.
- To study transition metal carbonyls and their reaction mechanism.
- To study application of organometallic reagents in industrial processes

Course Outcomes: At the end of this course, students will be able to
CO1: Understand the use structure and bonding of organometallic compounds
CO2: Apply the knowledge in understanding reaction mechanism of complexes.
CO3: Analyze the complex structure by analytical data.
CO4: Evaluate the significance of organometallics in industrial processes.

Syllabus

Units	Content	Hours
Unit I: Organometallic Compounds	**Metal Carbonyls:** Organometallic Compounds Definition and classification of organometallic compounds based on bond type. Concept of hapticity of organic ligands. Metal carbonyls: 18 electron rule and electron count of mononuclear, polynuclear, and substituted metal carbonyls of 3d series. General methods of preparation and structure of mono and binuclear carbonyls of 3d series. π-acceptor behaviour of CO, extent of synergic effect back bonding. Zeise's salt: Preparation and structure, **Metal Alkyls:** Important structural features of methyl lithium (tetramer) and trialkyl aluminium (dimer), concept of multicentre bonding in these compounds. Role of triethylaluminium in polymerisation of ethene (Ziegler–Natta Catalyst).	**15**
Unit II: Reaction Mechanism and Kinetics	**Inorganic Reaction Mechanism:** Introduction to inorganic reaction mechanisms. Substitution reactions in square planar complexes, Trans- effect, theories of trans effect, Mechanism of nucleophilic substitution in square planar complexes, Kinetics of octahedral substitution, Mechanism of substitution in octahedral complexes.	**15**
Unit III: Organometallic Catalysis	**Catalysis by Organometallic Compounds:** Study of the following industrial processes and their mechanism: 1. Alkene hydrogenation (Wilkinson's Catalyst) 2. Hydroformylation (Co salts) 3. Wacker Process 4. Synthetic gasoline (Fischer Tropsch reaction) 5. Synthesis gas by metal carbonyl complexes Organometallic and Organic Synthesis (reactions of Cu, Zn and Pd)	**15**

Reading References:

1. R. C. Mehrotra; A. Singh. *Organometallic Chemistry: A Unified Approach.* New Age International, New Delhi. 2007, 2nd Ed.
2. A. J. Pearson. *Metallo-Organic Chemistry.* Wiley, New York. 1985, 3rd Ed.
3. R. C. Mehrotra. *Organometallic Chemistry.* New Age International, New Delhi. 2007, 3rd Ed.

CH3 203 Chemical Kinetics and Catalysis (L-T-P-C: 3-0-0-3)

Program: B. Sc. Chemistry	**Semester:** VI
Course Code: CH3 203	**Course Name: Chemical Kinetics and Catalysis**

Lect.	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Passing %
3/week	-	3	45	Lecture	CCE, ESE	75	40

Course Objective:
This course provides a comprehensive understanding of chemical kinetics and catalysis, including reaction rates, reaction mechanisms, temperature effects, and catalytic processes. It develops the ability to analyze reaction pathways, interpret kinetic behavior, and understand the role of catalysts in chemical and biological systems.

Course Outcomes: At the end of this course students will be able to
CO 1: Remember and explain the fundamental concepts of chemical kinetics, including reaction rates, order, molecularity, and rate laws.
CO 2: Understand the principles of reaction mechanisms, temperature dependence of reaction rates, collision theory, and theories of chemical kinetics.
CO 3: Apply kinetic principles and rate equations to determine reaction parameters and interpret the behavior of simple and complex reactions.
CO 4: Analyze catalytic processes, reaction mechanisms, and factors influencing catalyst performance in chemical and biological systems.

Syllabus

Units	Content	Hours
Unit I: Introduction to Chemical Kinetics	Order and molecularity of a reaction, rate laws in terms of the advancement of a reaction, differential and integrated form of rate expressions up to second order reactions, experimental methods of the determination of rate laws, kinetics of complex reactions (integrated rate expressions up to first order only). Half-life and its applications, pseudo-first-order reactions, determination of reaction order by graphical methods.	**15**
Unit II: Complex Reaction Mechanism	Definition of complex reaction. (i) Opposing reactions (ii) parallel reactions, (iii) consecutive reactions and their differential rate equations (steady-state approximation in reaction mechanisms), (iv) chain reactions. Temperature dependence of reaction rates; Arrhenius equation; activation energy. Collision theory of reaction rates, Lindemann mechanism, qualitative treatment of the theory of absolute reaction rates. Introduction to photochemical reaction kinetics.	**15**
Unit III: Catalysis	Types of catalysts, specificity and selectivity, mechanisms of catalyzed reactions at solid surfaces;. Adsorption Theory of Heterogeneous Catalysis (Langmuir-Hinshelwood mechanism) Effect of particle size and efficiency of nanoparticles as catalysts. Enzyme catalysis, Michaelis-Menten mechanism, acid-base catalysis. Industrial applications of catalysis. Green catalysis and nanocatalysts.	**15**

CO-PO Mapping Table

	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	**3**	**1**	**1**	**-**	**-**
CO 2	**3**	**2**	**2**	**-**	**-**

CO 3	**2**	**3**	**3**	**-**	**1**
CO 4	**2**	**2**	**3**	**1**	**2**
Average	**2.5**	**2**	**2.25**	**0.25**	**0.75**

Correlation levels:
1 - Low, 2 - Moderate, 3 - High

Justification for CO-PO Mapping

CO	Justification
CO 1	This CO develops fundamental knowledge of chemical kinetics, reaction rates, order, molecularity, and rate laws (**PO1**) while introducing basic analytical skills (**PO2, PO3**).
CO 2	This CO strengthens understanding of reaction mechanisms, temperature dependence of reaction rates, and kinetic theories (**PO1**) while enhancing analytical and problem-solving abilities (**PO2, PO3**).
CO 3	This CO develops the ability to apply kinetic principles and rate equations to solve chemical problems and interpret reaction behavior (**PO2, PO3**) while reinforcing scientific knowledge (**PO1**).
CO 4	This CO enhances analytical thinking through the study of catalytic mechanisms, enzyme kinetics, and catalyst performance (**PO3**). It also develops technical understanding of catalytic processes (**PO2**), promotes awareness of sustainable catalytic technologies (**PO5**), and encourages scientific reasoning and ethical application of chemistry (**PO1, PO4**).

Reading References:

1. K. J. Laidler. *Chemical Kinetics.* Pearson Education, Noida. 1987, 3rd Ed.
2. C. Kalidas. *Chemical Kinetic Methods: Principles of Relaxation Techniques and Applications.* New Age International, New Delhi. 2005, 1st Ed.
3. J. H. Espenson. *Chemical Kinetics and Reaction Mechanisms.* McGraw Hill, New York. 2002, 2nd Ed.
4. P. Atkins; J. de Paula. *Physical Chemistry (Selected Chapters).* Oxford University Press, Oxford. 2014, 10th Ed.

CH3 204: Bioorganic Chemistry Laboratory (L-T-P-C: 0-0-2-1)

Program: B. Sc. Chemistry	**Semester:** VI
Course code: CH3 204	**Course name:** Bioorganic Chemistry Laboratory

Lect.	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Passing %
-	2/week	1	30	Lab	CCE, ESE	25	40

Course Objectives:

- Learn basic biochemical lab techniques
- Analyze amino acids, carbohydrates, lipids, and nucleic acids
- Use classical tests, chromatography, titration, and spectrophotometry
- Develop practical skills in biochemical analysis
- Understand biomolecular structure and function through experiments

Course Outcomes: At the end of this course, students will be able to
CO 1: Identify and characterize biomolecules using chemical and physical techniques.
CO 2: Perform enzyme assays and analyze kinetic parameters under varying conditions.
CO 3: Apply spectroscopic and chromatographic methods to quantify biological molecules.
CO 4: Simulate biological transformations through simple synthetic reactions.
CO 5: Demonstrate laboratory safety, precision, and data recording in biochemical experiments.

Syllabus

Sr. No.	Name of the Experiment	Hours
1	To determine the Isoelectric Point (pI) of Glycine by Titration	**4**
2	To perform the qualitative tests for amino acids (ninhydrin, xanthoproteic, etc.)	**4**
3	To perform Paper Chromatography of Amino Acids	**4**
4	To estimate Glucose by Benedict's and Fehling's Methods	**4**
5	To identify Carbohydrates via Molischs, and Iodine Tests	**4**
6	To perform the Saponification of Lipids and Detection of Fatty Acids	**4**
7	To perform the Thin Layer Chromatography (TLC) of Lipids and Pigments	**4**
8	To perform the UV-Visible Spectrophotometric Determination of DNA Concentration	**2**

Reading References:

1. D. T. Plummer. *An Introduction to Practical Biochemistry.* McGraw-Hill Education, New Delhi. 2001, 3rd Ed.
2. K. Wilson; J. Walker. *Principles and Techniques of Biochemistry and Molecular Biology.* Cambridge University Press, Cambridge. 2010, 7th Ed.
3. J. Jayaraman. *Laboratory Manual in Biochemistry.* New Age International Publishers, New Delhi. 2009, 1st Ed.

CH3 205: Organometallics and Catalysis Laboratory (L-T-P-C: 0-0-2-1)

Program: B. Sc. Chemistry	**Semester:** I
Course Code: CH3 205	**Course Name:** Organometallic and Catalysis Laboratory

Lecture (Hours)	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Passing %
-	2/week	1	30	Lab	CCE, ESE	25	40

Course Objectives:

- To separate and analyze two/three three-component mixtures
- To prepare organic compounds using organometallic reagents.
- To analyze the structure of synthesized compounds by spectroscopic techniques.
- To apply organometallic reagents in industrial processes.

Course Outcomes: At the end of this course, students will be able to
CO 1: Describe the separation and purification techniques used in organic synthesis.
CO 2: Illustrate the experimental techniques for metal-mediated synthesis.
CO 3: Apply chromatographic techniques in monitoring and analyzing reaction progress.
CO 4: Evaluate the analytical techniques, line IR and NMR for characterization of products.

Syllabus

Sr. No.	Name of the Experiment	Hours
1	To separate and identify two-component organic mixtures (amines, carboxylic acids, and water-soluble substances)	3
2	To synthesize and characterize ethylbenzene by the hydrogenation of styrene	3
3	To prepare the Grignard reagent (EtMgBr) and perform a reaction with aldehyde	3
4	To prepare and characterize the bibenzyl by reaction with Zn and benzyl bromide	3
5	To prepare and characterize the triazole by reaction with Cu salt with alkyne and azide (CuAAC)	3
6	To prepare and characterize the chalcone by reaction with benzaldehyde and acetophenone	3
7	To reduce the carbonyl compounds by carrots	3
8	To prepare and characterize the benzyl alcohol from benzaldehyde by sodium borohydride	3
9	To prepare and characterize the phenylacetic acid by hydrolysis of phenyl acetonitrile	3
10	To prepare and characterize the benzoic acid by the oxidation of benzaldehyde	3

Reading References:

1. Israel Vogel; B. S. Furniss. *Vogel's Textbook of Practical Organic Chemistry.* Longman Scientific & Technical, London. 1989, 5th Ed.
2. F. G. Mann; B. C. Saunders. *Practical Organic Chemistry.* Longman Scientific & Technical, London. 1960, 4th Ed.
3. N. K. Vishnoi. *Advanced Practical Organic Chemistry.* Vikas Publishing House, New Delhi. 2010, 3rd Ed.
4. R. K. Bansal. *Laboratory Manual of Organic Chemistry.* New Age International Publishers, New Delhi. 1983, 5th Ed.
5. J. S. Yadav; S. Nanda; P. T. Reddy; A. Bhaskar Rao. *Journal of Organic Chemistry.* 2002, 67, 3900-3903.

CH3 206: Chemical Kinetics and Catalysis Laboratory (L-T-P-C: 0-0-2-1)

Program: B. Sc. Chemistry	**Semester:** VI
Course code: CH3 206	**Course name:** Chemical Kinetics and Catalysis Laboratory

Lecture (Hours)	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Passing %
-	2/week	1	30	Practical	CCE, ESE	25	40

Course Objectives:
- Analyze reaction rates and mechanisms using kinetic principles.
- Evaluate the effect of temperature, concentration, and catalysts on reaction rates.
- Compare the efficiency of different types of catalysts.
- Use instruments like polarimeters and potentiometers to study kinetics.

Course Outcomes: At the end of this course, students will be able to

CO 1: Perform experiments to determine reaction rates and rate constants for chemical reactions using appropriate laboratory techniques.

CO 2: Conduct equilibrium experiments to determine equilibrium constants and verify Le Chatelier's principle

CO 3: Learn graph plotting and data interpretation.

CO 4: Demonstrate proficiency in laboratory practices, including accurate measurements, data recording, and safety protocols.

Syllabus

Sr. No.	Name of the Experiment	Hours
1.	To determine the rate constant and energy of activation of hydrolysis of methyl acetate at two different temperatures.	**6**
2.	Saponification of Ethyl Acetate with NaOH	**3**
3.	To determine the relative strengths of the given strong acids by studying the kinetics of inversion of cane sugar using the polarimetric method. (Conductometry)	**3**
4.	To study the Kinetics of the Reaction Between Potassium Persulfate and Potassium Iodide	**3**
5.	To study the Effect of Temperature on the Rate of Reaction Between Sodium Thiosulfate and Hydrochloric Acid	**3**
6.	To Determine the Rate Constant of Iodination of Acetone	**3**
7.	To study the kinetics of the iodine clock reaction and deduce the rate law.	**3**
8.	To Determine the Activation Energy using Arrhenius Plot	**3**
9.	To study the Potentiometric Monitoring of Redox Reaction Kinetics	**3**

Reading References:

1. B. D. Khosla; V. C. Garg. *Senior Practical Physical Chemistry.* R. Chand & Co., New Delhi. 2018, 18th Ed.
2. B. Viswanathan; P. S. Raghavan. *Practical Physical Chemistry.* Viva Books Private Limited, Navi Mumbai. 2017, 1st Ed.
3. A. K. Nad; B. Mahapatra; A. Ghoshal. *An Advanced Course in Practical Chemistry (Paperback).* New Central Book Agency Pvt. Ltd., Kolkata. 2012, 3rd Ed.
4. J. N. Gurtu; Amit Gurtu. *Advanced Physical Chemistry Experiments.* Pragati Prakashan, Meerut. 2008, 1st Ed.

CH3 207: Advanced Spectroscopy (L-T-P-C: 3-0-0-3)

Program: B. Sc. Chemistry	**Semester:** VI
Course code: CH3 207	**Course name:** Advanced Spectroscopy

Lecture (Hours)	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Passing %
3/week	-	3	45	Lecture	CCE, ESE	75	40

Course Objectives:
- Explore the use of different spectroscopic methods to identify and study organic compounds.
- Understand the interpretation of UV-Vis, IR, and NMR spectra to determine the structure of molecules.

Course Outcomes: At the end of this course, students will be able to
CO 1: Understand the fundamental principles of UV, IR and NMR spectroscopy
CO 2: Understand the concept of vibrational frequency in IR, chemical shift in NMR
CO 3: Apply the knowledge of the structure determination of organic compounds
CO 4: Analyze the UV, IR,^{1}H NMR and Mass spectra.

Syllabus

Unit	Content	Hours
Unit I:	**Ultraviolet Spectroscopy**: Origin of UV Spectra, Principle, Lambert-Beer law and derivation, electronic transition relative positions of λmax considering conjugative effect, steric effect, solvent effect, red shift (bathochromic shift), blue shift (hypsochromic shift), hyperchromic effect, hypochromic effect (typical examples). Auxochrome and chromophore, UV Instrumentation: Aromatic and Polynuclear aromatic hydrocarbons. (B) Ultraviolet Spectroscopy Problems of Dienes and Enones using Woodward-Fieser rules. Problems of aromatic ketones, aldehydes and esters.	**15**
Unit II:	**Infrared Spectroscopy:** Introduction, principle of IR spectroscopy, instrumentation, sampling technique, selection rules, types of bonds, absorption of common functional groups. fingerprint region, Factors affecting frequencies, applications. Application of Hooke's law, characteristic stretching frequencies of O-H, N-H, C-H, C-D, C=C, C=N, C=O functions; factors affecting stretching frequencies (H-bonding, mass effect, electronic factors, bond multiplicity, ring size). Applications of IR spectroscopy in the structure elucidation of simple organic compounds. Interpretation of IR Spectra of known organioc compounds with varying functional groups. Identifying the functional groups present in unknown compounds by examining spectra	**15**
Unit III:	**^{I}H NMR:** Principal, Magnetic and non-magnetic nuclei, absorption of radio frequency, number of signals, peak areas, equivalent and nonequivalent protons positions of signals and chemical shift, shielding and deshielding of protons, anisotropic effect, proton counting, splitting of signals and coupling constants relative strength of signals, spin-spin coupling, long-range coupling, coupling constant, Deuterium labelling, Analysing the NMR Spectra and identifying chemical structuresy analyzing NMR spectra **^{13}C NMR Spectroscopy**: ^{13}C NMR, ^{1}H and ^{13}C chemical shifts to structure correlations. Chemical shift and Coupling constants. To identify structure from ^{13}C NMR data; Difference between ^{I}H NMR and ^{13} C NMR	**15**

Reading References:

1. R. M. Silverstein; F. X. Webster; D. J. Kiemle; D. L. Bassler; T. C. Morrill. *Spectroscopic Identification of Organic Compounds.* Wiley, New York. 2014, 8th Ed.
2. Y. R. Sharma. *Elementary Organic Spectroscopy.* S. Chand Publishers, New Delhi. 2007, Revised Ed.

3. Rita Kakkar. *Atomic and Molecular Spectroscopy.* Cambridge University Press, Cambridge. 2015, 1st Ed.
4. William Kemp. *Organic Spectroscopy.* Macmillan, London. 1994, 3rd ESd.
5. D. H. Williams; I. Fleming. *Spectroscopic Methods in Organic Chemistry.* McGraw-Hill Education, New Delhi. 1995, 5th Ed.
6. Andrew B. Derome. *Modern NMR Techniques for Chemistry Research.* Pergamon Press, Oxford. 1987, Reprint Ed.
7. D. L. Pavia; G. M. Lampman; G. S. Kriz. *Introduction to Organic Spectroscopy.* Cengage India Pvt. Ltd., New Delhi. 2015, 5th Ed.

CH3 208: Advanced Spectroscopy Laboratory (L-T-P-C: 0-0-2-1)

Program: B. Sc. Chemistry	**Semester:** VI
Course code: CH3 208	**Course name:** Advanced Spectroscopy Laboratory

Lect.	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Passing %
-	2 per week	1	30	Lab	CCE, ESE	25	40

Course Objectives:

- Understand spectral analysis of various organic compounds which are synthesized in laboratory and chemical industries.
- Understand the various software used in analysis of data in UV and IR spectroscopy.
- Understanding of structural prediction and confirmation.

Course Learning Outcomes: At the end of this course students will be able to

C0 1: Identify the suitable spectroscopic techniques for analysis of organic compounds.
C0 2: Understand the bathochromic shift, hypochromic shift, shielding and deshielding.
C0 3: Demonstrate proficiency in operating basic spectroscopic instruments.
C0 4: Distinguish between different types of spectral shifts, chemical shift, molecular ion and daughter ion peak.

Syllabus

Sr. No.	Name of the Experiment	Hours
1	To study the Bathochromic Shifts Using UV-Visible Spectra 1. Acetone in hexane 2. Acetone in Water 3. Benzene 4. Aniline 5. Alkene 6. Butadiene 7. Hexatriene	**2**
2	To study the Hypsochromic Shifts Using UV-Visible Spectra by adding metallic ions in coordinate complexes 1. Aniline 2. Aniline in Hydrochloride (in acidic medium) 3. Benzoic Acid 4. Benzaldehyde	**2**
3	Recording IR spectra of simple unknown organic compounds and identifying functional groups. Determination. alcohol, carbonyl, nitrile, amine, alkene	**4**
4	To distinguish between butanoic acid and butan-2-one using IR spectroscopy.	**4**
5	**NMR, MS, IR, UV-Vis) at least 4 examples.** (A student will be given UV, IR, PMR, CMR, and Mass spectra of a compound from which preliminary information should be reported within the first half an hour of the exam in at ion without referring to any book/reference material. The complete structure of the compound may	**12**
6	To demonstrate the working principle of the NMR instrument sampling and structure elucidation.	**6**

Reading References:

1. R. K. Bansal. *Practical Organic Chemistry.* New Age International Pvt. Ltd., New Delhi. 2008, 5th Ed.
2. D. Field; S. Sternhell; J. R. Kalman. *Organic Structures from Spectra.* Wiley & Sons Ltd., UK. 2008, 4th Ed.
3. F. G. Mann; B. C. Saunders. *Practical Organic Chemistry.* Pearson Education India, New Delhi. 2009, 4th Ed.

4. William Kemp. *Organic Spectroscopy.* Macmillan Publishers, London. 1994, 3rd Ed.
5. P. S. Kalsi. *Spectroscopy of Organic Compounds.* New Age International Pvt. Ltd., New Delhi. 2020, 8th Ed.
6. Y. R. Sharma. *Elementary Organic Spectroscopy: Principles and Chemical Applications.* S. Chand & Co., New Delhi. 1992, 5th Ed.

CH3 209: Personality Development (L-T-P-C: 2-0-0-2)

Program: B.Sc. Chemistry	**Semester:** VI
Course code: CH3 209	**Course Name:** Personality Development

Lect.	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Passing %
3 per week	--	2	30	Lecture	CCE, ESE	50	40

Course Objectives:

- Understand personality traits, success-failure dynamics, and strategies for personal growth.
- Develop a positive attitude and self-motivation to overcome internal and external challenges.
- Communicate effectively in multicultural settings while respecting diversity and overcoming biases.

Course Learning Outcomes: At the end of this course, students will be able to
C0 1: Understand the key dimensions of personality and apply principles of personality development for personal and professional growth.
C0 2: Analyze the concepts of success and failure, identify hurdles, and formulate strategies for overcoming them.
C0 3: Demonstrate a positive attitude and self-motivation through an understanding of their impact on personal and interpersonal effectiveness.
C0 4: Communicate effectively and respectfully in diverse cultural settings by understanding cross-cultural dynamics.

Syllabus

Unit	Content	Hours
Unit I: Introduction to Personality Development	Concept and dimensions of personality Significance of personality development Understanding success and failure Hurdles in achieving success and strategies to overcome them Factors influencing success and causes of failure	**10**
Unit II: Attitude & Motivation	Attitude: Concept, significance, and influencing factors Positive vs. negative attitude: Characteristics, advantages/disadvantages Developing a positive attitude Motivation: Concept, types (internal and external), and importance, Self-motivation and factors causing de-motivation	**10**
Unit III: Cross-Cultural Communication	Communicating in a multicultural environment Understanding and adapting to cultural differences Respecting and valuing diverse perspectives Overcoming stereotypes and biases	**10**

Reading references:

1. Barun K. Mitra. *Personality Development and Soft Skills.* Oxford University Press, New Delhi. 2011, 1st Ed.
2. Stephen R. Covey. *The 7 Habits of Highly Effective People.* Simon & Schuster, New York. 1989, 1st Ed.
3. Stella Maidment. *Cross-Cultural Communication.* Oxford Business English, Oxford. 2010, 1st Ed.
4. Shiv Khera. *You Can Win.* Macmillan India, New Delhi. 2002, 1st Ed.
5. Carol S. Dweck. *Mindset: The New Psychology of Success.* Ballantine Books, New York. 2006, 1st Ed.

CH3 210: Research Project/On the Job Training (L-T-P-C: 0-0-8-4)

Program: B.Sc. Chemistry	**Semester:** VI
Course code: CH3 210	**Course Name:** Research Project/On-the-Job Training

Lect.	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Passing %
-	8	4	120	Practical	CCE, ESE	100	40

Course Description: This is a compulsory course performed in the sixth semester where the students get a semester-long exposure to research. Students who work on research and industrial projects gain valuable training and experience that can help them in their future careers. Students can work on real-world research projects proposed by industry or public sector sponsors. This course helps to train individuals who contribute to human resources required in the chemical/pharmaceutical industry. The research work may lead to academic research articles as well. They also learn about patents, scientific publications, and literature search tools

Course Outcomes: At the end of this course students will be able to
CO1: Understand the real-world academic/industrial research problems
CO2: Apply the knowledge gained during various theoretical and practical courses
CO3: Design different projects with the knowledge of chemistry to solve existing problems in society
CO4: Understand data interpretation and data analysis
CO5: Learn to reboot any experimental problems.

Detailed syllabus: Lab-specific research topics.

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