Indrashil University

Department of Chemistry
School of Science

B.Sc. 2023-2027
Sem V-VI

Chemistry

Course Profile

Academic Year 2025-2026

B.Sc. Chemistry Semester V
Course Structure

Course Code	Course Name	Course Type	L-T-P	Credits
CH3 101	Organic Chemistry-IV: 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: Chemistry of Electrolytes and Electrochemical Cells		3-0-0	3
CH3 104	Organic Chemistry-IV 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	Heterocyclic Chemistry	Major Discipline Core (**MDC**)	3-0-0	3
CH3 202	Organometallic and Catalysis		3-0-0	3
CH3 203	Chemical Kinetics and Dynamics		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 Dynamics 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) (**4 credits**)	Skill Enhancement Course (**SEC**)	0-0-8	4
Total			**14L+0T+ 16P = 30h**	**22**

B.Sc. Chemistry Semester V Detailed Syllabus with CLO

CH3 101: Organic Chemistry – IV: Heterocyclic Chemistry (L-T-P-C: 3-0-0-3)

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

Lecture (Hours)	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Passing %
3 per 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 like pyrrole, furan, and thiophene.
- Course focuses on Six-membered and condensed systems such as pyridine, quinoline, and isoquinoline, which are also explored. Synthetic methods and reactivity patterns are discussed.

Course Learning Outcomes: At the end of this course, students will be able to
CLO1: Classify and name heterocyclic compounds using IUPAC and Hantzsch-Widman systems.
CLO2: Explain aromaticity and electronic effects in mono- and heteroaromatic systems.
CLO3: Compare the structures and reactivity of pyrrole, furan, and thiophene.
CLO4: Apply appropriate synthetic methods for five-membered heterocycles.
CLO5: Analyze substitution patterns and basicity in pyridine and its derivatives.
CLO6: Describe the synthesis and relevance of condensed heterocycles like quinoline and isoquinoline.

Syllabus

Units	Content	Hours
Unit I: Fundamentals of Heterocyclic Chemistry	**Introduction and Classification** Definition of heterocycles; Classification: based on ring size, number of heteroatoms, saturated vs unsaturated **Nomenclature of Heterocyclic Compounds** IUPAC and common names; Hantzsch-Widman system **Aromaticity in Heterocycles** Concept of aromaticity (Hückel rule); Comparison between benzene and heteroaromatic rings (e.g., pyrrole, furan, thiophene); **Electronic Effects and Resonance Structures** Electron distribution, dipole moments, and lone pair effects; Tautomerism in heterocycles	**15**
Unit II: Five Membered Heterocycles with One Heteroatom	**Pyrrole, Furan, and Thiophene** Structure, aromaticity, and resonance;Physical properties; **Synthesis of Pyrrole, Furan, and Thiophene;** Paal-Knorr synthesis; Knorr pyrrole synthesis; Feist–Benary synthesis; **Electrophilic Substitution Reactions;** Position of substitution; Reactivity order	**15**

Unit III: Six- Membered and Condensed Heterocycles	**Pyridine and its Derivatives:** Structure, aromaticity, **Electrophilic and Nucleophilic** and basicity; Comparison with benzene and aniline; **Substitution in Pyridine;** Orientation and mechanism; **Synthesis of Pyridine Derivatives;** Hantzsch synthesis, Chichibabin synthesis; **Condensed Heterocycles: Quinoline and Isoquinoline;** Structure, synthesis (Skraup and Bischler-Napieralski synthesis); Reactivity and pharmaceutical importance	**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. Peter Sykes. *A Guidebook to Mechanism in Organic Chemistry.* Pearson Education, New Delhi. 2005, 6th Ed. *(Duplicate of Ref. 2)*
7. 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 per week	-	3	45	Lecture	CCE, ESE	75	40

Course Objectives:

- This course covers the basics of coordination chemistry, transition metal chemistry, and lanthanides/actinides.
- This course covers the fundamental concepts of coordination chemistry.
- This course covers the unique properties of d- and f-block elements

Course Learning Outcomes: At the end of this course, students will be able to
CLO1: Understand terms: ligand, denticity of ligands, chelate, coordination number, understand the terms inner and outer orbital complex.
CLO2: Systematically name coordination compounds. Various types of isomerism possible in Octahedral and Tetrahedral coordination compounds.
CLO3: Meaning of the terms Δo., Δt, pairing energy, CFSE, high spin and low spin and how CFSE affects thermodynamic properties like lattice enthalpy and hydration enthalpy
CLO4: Understand lanthanides/actinides elements and their properties.
CLO5: 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 - Crystal and ligand field theories, crystal field stabilization energies, Crystal field theory, measurement of 10 Dq(o), CFSE in weak and strong fields, pairing energies, factors affecting the magnitude of 10 Dq (o, t). Octahedral vs. tetrahedral coordination, tetragonal distortions from octahedral geometry Jahn-Teller theorem, square planar geometry.	**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, polynuclear complexes, Labile and inert complexes.	**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. Chemistry of Ti, V, Cr Mn, Fe and Co in various oxidation states, Electronic configuration, oxidation states, colour, spectral and magnetic properties, lanthanide contraction.	**15**

Self-learning Topics:
Unit I: Scope of Coordination Chemistry and Ligand Field Concepts.
Unit II: Nomenclature and Reactivity of Coordination Compounds.
Unit III: Chemistry of d and f block elements.

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: Chemistry of Electrolytes and Electrochemical Cells (L-T-P-C: 3-0-0-3)

Program: B. Sc. Chemistry	**Semester:** V
Course code: CH3 103	**Course name:** Physical Chemistry-IV: Chemistry of Electrolytes and Electrochemical Cells

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

Course Objectives:

- Introduce key concepts of electrolyte behavior, ion migration, and conductivity.
- Explain theoretical principles of electrolysis, electrochemical cells, and EMF measurement.
- Apply electrochemical methods to determine thermodynamic parameters, pH, solubility, and redox properties.

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

CLO 1: Explain the principles of electrolyte dissociation, ionic mobility, and conductivity variations in strong and weak electrolytes.

CLO 2: Apply electrochemical laws and equations (e.g., Nernst, Kohlrausch, Debye-Hückel-Onsager) to calculate molar conductivity, EMF, and thermodynamic parameters.

CLO 3: Analyze electrochemical cells, transference numbers, and conductometric data to determine dissociation constants, solubility products, and hydrolysis constants.

CLO 4: Evaluate the practical applications of electrolysis, conductometric titrations, and fuel cells in industrial and energy systems.

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. Debye- Hückel-Onsager equation, Wien effect, Debye-Falkenhagen effect, Walden's rules. 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. 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.	**15**
Unit III: Redox Systems, EMF, and Electrochemical Energy Devices	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. 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 with and without transference, liquid junction potential. Fuel Cell: Principle, types	**15**

	and their functioning.	

Syllabus

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 Laboratory-IV (L-T-P-C: 0-0-2-1)

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

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

Course Objectives:

- Practical course involves the synthesis and characterization of heterocyclic compounds,
- Emphasizes the use of common laboratory techniques and understanding of reaction mechanisms.
- Student will learn the application of analytical methods to identify five- and six-membered heterocycles containing nitrogen, oxygen, or sulphur.

Course Learning Outcomes: At the end of this course, students will be able to
CL01: Remembered the fundamental reactions and reagents used in heterocyclic compound synthesis
CL02: Understand the reaction mechanisms involved in the formation of heterocyclic rings
CL03: Perform synthetic procedures for selected heterocycles using standard lab techniques
CL04: Analyze the melting point, TLC, and spectral data to confirm product identity.

Syllabus

Sr. No.	Name of the Experiment	Hours
1	To synthesize and characterize the 2-phenylimidazole from benzil and ammonium acetate.	**10**
2	To synthesize the indole (Fischer indole synthesis) from phenylhydrazine and acetone.	**10**
3	To synthesize the coumarin from salicylaldehyde and acetic anhydride via Pechmann condensation.	**8**
4	To synthesize the quinoline via Skraup synthesis	**8**
5	To perform the Electrophilic substitution on pyrrole (e.g., nitration or bromination)	**8**
6	To prepare oxazoles from α-amino ketones.	**8**
7	To synthesize the Pyrimidines or Triazines from Urea and β-dicarbonyl Compounds under acid/base catalysis.	**8**

Reading References:

1. J. A. Joule; K. Mills. *Heterocyclic Chemistry.* Wiley-Blackwell, Oxford. 2010, 5th Ed.
2. T. L. Gilchrist. *Heterocyclic Chemistry.* Pearson Education, Harlow. 1997, 3rd Ed.
3. L. A. Paquette. *Principles of Modern Heterocyclic Chemistry.* W. A. Benjamin, New York. 1968, 1st Ed.
4. N. K. Vishnoi. *Advanced Practical Organic Chemistry.* Vikas Publishing House, New Delhi. 2009, 3rd 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.
6. A. R. Katritzky; C. W. Rees (Eds.). *Comprehensive Heterocyclic Chemistry,* Vol. 1–9. Pergamon Press, Oxford. 1984, 1st 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 per week	1	30	Lab	CCE, ESE	25	40

Course Objectives:

- This course provides practical knowledge of the chemistry of coordination compounds.
- This course focuses on Spectrophotometric methods to estimate metal ion concentration.
- This course focuses on Complexometric methods to estimate metal ion concentration.
- This course focuses on Colorimetric methods to estimate metal ion concentration.

Course Learning Outcomes: At the end of this course, students will be able to
CLO1: Learn the basics of complex compound preparation
CLO2: Different estimation techniques.
CLO3: Detail Spectrophotometric technique.
CLO4: Analysis skill to determine (qualitative and quantitative) the concentration of metal ion in a given sample.

Syllabus

Sr. No.	Name of the Experiment	Hours
1	To prepare complex compounds, such as tetramminecopper(II) sulphate/Nickel (II) dimethylglyoxime/trithioureacopper(I) sulphate.	**5**
2	To estimate zinc/magnesium/calcium/iron/chromium by any method.	**5**
3	To verify Lambert-Beer's law and determine the concentration of $CuSO_4$/$KMnO_4$/$K_2Cr_2O_7$ in a solution of unknown concentration.	**5**
4	To estimate Copper using CuSCN/thiosulphate.	**5**
5	To estimate Nickel as $[Ni(dmg)_2]$.	**5**
6	To 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).	**5**
7	To prepare tetraamminecopper (II) sulphate, $[Cu(NH_3)_4]SO_4.H_2O$, Acetylacetonate complexes of Cu^{2+}/Fe^{3+}, Tetraamminecarbonatocobalt (III) nitrate, Potassium tri(oxalato)ferrate(III).	**5**

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 per week	1	30	Practical	CCE, ESE	25	40

Course Objectives:

- Develop competence in using electrochemical techniques
- Analyze ionization, conductivity, and pH using lab-based methods.
- Apply theoretical electrochemistry to interpret experimental data.
- Gain practical skills in measuring and calculating electrochemical parameters.

Course Learning Outcomes: At the end of this course students will be able to
CLO1: Measure and interpret molar conductivity and verify Kohlrausch's law using dilution data for strong and weak electrolytes.
CLO2: Perform conductometric titrations and use conductivity measurements to determine dissociation constants, solubility products, and ionization behavior.
CLO3: Use EMF measurements to determine the pH of solutions and understand the working principles of ion-selective electrodes.
CLO4: Conduct potentiometric titrations and analyze titration curves for accurate detection of equivalence points in acid-base reactions.

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**

Syllabus

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 per week	-	3	45	Lecture	CCE, ESE	75	40

Course Objectives:

- About different types of electronic devices which are generally used for fabrication of semiconducting devices.
- The basic concept of photonic devices which can help them for understanding the use in real life.
- The students will learn the use of these devices in designing various types of sensors and actuators.

Course Learning Outcomes: At the end of this course, students will be able to
CLO1: Remember the concept of different electronic devices.
CLO2: Understand the basics of different types of polymeric materials which can be used in sensor applications.
CLO3: Understand the characteristics of different materials which are used to develop these types of electronic devices.
CLO4: Analyze the concept of different fabrication techniques to develop semiconducting devices for real-life applications.

Syllabus

Units	Content	Hours
Unit I: Electronic Devices and Piezoelectric Materials	Electro-Optic, Magneto-optic and acousto-optic effects, properties related to these effects, Liquid crystal and polymeric materials for these devices, materials exhibiting electrostrictive and magnetostrictive 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 cells and energy, basic to energy conversion, optical properties of solids, types of solar cells, PN junction solar cells, single-crystal silicon and amorphous silicon solar cells.	**15**
Unit III: Optoelectronic Devices	Bulk and thin film Photoconductive Devices (LDR), semiconductor laser, 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, circuits with light emitting diodes, diode tester, polarity and voltage tester, measuring instruments with LED indication.	**15**

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 per week	1	30	Lab	CCE, ESE	25	40

Course Objectives:

- The fundamental concepts of a solar cell, LDR and other semiconducting instruments.
- Designing different types of electronic devices using these semiconducting components.
- The use of these devices in real life applications.

Course Learning Outcomes: At the end of this course students will be able to
CLO1: Understand the fundamental of different types of semiconducting devices.
CLO2: Classify the devices according to their properties.
CLO3: Apply the theoretical knowledge of the course for the solving the given problem.
CLO4: Observe characteristics of different devices in different conditions.
CLO5: Determine different parameters for various experiments.

Syllabus

Sr. No.	Name of the Experiment	Hours
1	To understand and identify the components of a Solar Cell.	**10**
2	To verify the characteristics of a solar cell.	**10**
3	To verify the temperature dependence of a solar cell.	**10**
4	To understand and verify the characteristics of a laser diode.	**10**
5	To design a photonic device using an LDR.	**10**
6	To design a sensor using a solar cell and an LED.	**10**

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 per week	-	3	45	Lecture	CCE, ESE	75	40

Course Objectives:

- To introduce the principles and techniques of basic spectroscopy, focusing on the interaction of electromagnetic radiation with matter.
- Explore all 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 Learning Outcomes: At the end of this course, students will be able to
CLO 1: Understand the fundamental principles of molecular spectroscopy
CLO 2: Differentiate between various types of molecular spectra, such as rotational, vibrational, electronic, and Raman spectra
CLO 3: Apply quantum mechanical principles to interpret spectral transitions
CLO 4: Analyse and interpret experimental spectral data to determine molecular structure
CLO 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) **Rotation spectroscopy:** Selection rules, intensities of spectral lines, determination of bond lengths of diatomic and linear triatomic molecules, isotopic substitution, and related numerical	**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; Applications of Mössbauer Spectroscopy	**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

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:

- 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
CLO1: Remember the principles of UV-Visible and fluorescence spectroscopy and NMR
CLO2: Understand the principles of Lambert-Beer's Law, Jablonski Diagram, and their application in spectrophotometric measurements
CLO3: Demonstrate proficiency in operating basic spectroscopic instruments
CLO4: Measure and compare excitation and emission maxima of fluorescent compounds like quinine and fluorescein
CLO5: 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 compounds: $KMNO_4$, acetone, and β-carotene.	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: Quinine, fluorescein	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: 0-0-2-1)

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 %
3 per week	-	2	30	Lecture	CCE, ESE	50	40

Course Objectives:
- Understand foundational concepts of sustainability, green chemistry, circular economy, and life cycle analysis.
- Analyze the role of chemistry in clean water, energy, and responsible production
- Evaluate real-world case studies and industry practices to assess chemical innovations

Course Learning Outcomes: At the end of this course, students will be able to
CLO 1: Define the principles of sustainability and green chemistry and explain their relevance to environmental protection.
CLO 2: Describe the role of chemistry in addressing key UN Sustainable Development Goals (SDGs).
CLO 3: Analyze real-world case studies demonstrating sustainable chemical practices in industry and research.
CLO 4: Evaluate chemical processes and materials based on sustainability metrics such as environmental impact, resource efficiency, and life cycle.

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 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), 2. Sustainable energy solutions (batteries, solar cells, hydrogen), 3. Green Manufacturing and Waste Valorization, 4. Sustainable chemistry education and ethics	**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**

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 WITH COURSE LEARNING OUTCOME (CLO)

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 per 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 Learning Outcomes: At the end of this course, students will be able to
CLO1: Explain the structures and functions of key biomolecules.
CLO2: Elucidate enzyme mechanisms using chemical principles.
CLO3: Analyze bioenergetics and thermodynamics in living systems.
CLO4: Understand molecular recognition and its role in signaling and metabolism.
CLO5: Describe natural biosynthetic pathways for complex molecules.
CLO6: 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 per week	-	2	30	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 Learning Outcomes: At the end of this course, students will be able to
CLO1: Understand the use structure and bonding of organometallic compounds
CLO2: Apply the knowledge in understanding reaction mechanism of complexes.
CLO3: Analyze the complex structure by analytical data.
CLO4: 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 Dynamics (L-T-P-C: 3-0-0-3)

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

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

Course Objective:

- Understand and derive rate laws for simple and complex chemical reactions.
- Analyze the temperature dependence of reaction rates using Arrhenius and collision theories.
- Explore reaction mechanisms using steady-state and transition-state approximations.
- Study principles and applications of catalysis, including heterogeneous and enzyme catalysis.

Course Learning Outcomes: At the end of this course students will be able to
CLO1: To understand the fundamental concepts and rate laws of chemical kinetics.
CLO2: To explore molecular dynamics and reaction pathways.
CLO3: To familiarize students with experimental methods used in kinetics.
CLO4: To relate kinetic principles to industrial and environmental applications.

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):	**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.	**15**
Unit III: Catalysis	Types of catalysts, specificity and selectivity, mechanisms of catalyzed reactions at solid surfaces; Faraday's Theory on Heterogeneous Catalysis. Effect of particle size and efficiency of nanoparticles as catalysts. Enzyme catalysis, Michaelis-Menten mechanism, acid-base catalysis.	**15**

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 per 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 Learning Outcomes: At the end of this course, students will be able to
CLO1: Identify and characterize biomolecules using chemical and physical techniques.
CLO2: Perform enzyme assays and analyze kinetic parameters under varying conditions.
CLO3: Apply spectroscopic and chromatographic methods to quantify biological molecules.
CLO4: Simulate biological transformations through simple synthetic reactions.
CLO5: 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 per 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 Learning Outcomes: At the end of this course, students will be able to
CLO1: Describe the separation and purification techniques used in organic synthesis.
CLO2: Illustrate the experimental techniques for metal-mediated synthesis.
CLO3: Apply chromatographic techniques in monitoring and analyzing reaction progress.
CLO4: 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 Dynamics Laboratory (L-T-P-C: 0-0-2-1)

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

Lecture (Hours)	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Passing %
-	2 per 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 Learning Outcomes: At the end of this course, students will be able to
CLO1: Perform experiments to determine reaction rates and rate constants for chemical reactions using appropriate laboratory techniques.
CLO2:
CLO3: Conduct equilibrium experiments to determine equilibrium constants and verify Le Chatelier's principle
CLO4: Learn graph plotting and data interpretation.
CLO5: 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 per 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 Learning Outcomes: At the end of this course, students will be able to
CLO 1: Understand the fundamental principles of UV, IR and NMR spectroscopy
CLO 2: Understand the concept of vibrational frequency in IR, chemical shift in NMR
CLO 3: Apply the knowledge of the structure determination of organic compounds
CLO 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 using empirical rules and UV application.	**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.	**15**
Unit III:	**^{1}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, Applications to simple structural problems. (B) Problems based on Spectral data, Structural problems based on UV, IR and NMR. **^{13}C NMR Spectroscopy**: ^{13}C NMR, introduction to FT technique, relaxation phenomena, ^{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 ^{1}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

CL01: Identify the suitable spectroscopic techniques for analysis of organic compounds.
CL02: Understand the bathochromic shift, hypochromic shift, shielding and deshielding.
CL03: Demonstrate proficiency in operating basic spectroscopic instruments.
CL04: 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 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 examination 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
CL01: Understand the key dimensions of personality and apply principles of personality development for personal and professional growth.
CL02: Analyze the concepts of success and failure, identify hurdles, and formulate strategies for overcoming them.
CL03: Demonstrate a positive attitude and self-motivation through an understanding of their impact on personal and interpersonal effectiveness.
CL04: 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 and Diversity Awareness	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 Learning Outcomes: At the end of this course students will be able to

CLO1: Understand the real-world academic/industrial research problems
CLO2: Apply the knowledge gained during various theoretical and practical courses
CLO3: Design different projects with the knowledge of chemistry to solve existing problems in society
CLO4: Understand data interpretation and data analysis
CLO5: Learn to reboot any experimental problems.

Detailed syllabus: Lab-specific research topics.

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