

CURRICULUM OF BS CHEMISTRY

(2026)



RAWALPINDI WOMEN UNIVERSITY

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1. Department Vision:

To promote women's academic and professional growth in chemical sciences through evolving education, analysis, industrial linkages and sustainable practices, enabling them to contribute meaningfully to scientific advancement and societal betterment.

2. Department Mission:

To empower women through excellence in chemical education and impactful research, fostering leadership and innovation in molecular science, sustainable chemistry, and material design to address global challenges in energy, health, and environment.

3. Departmental Objectives:

i Academic Excellence

To provide quality education in basic and advanced chemistry, fostering both theoretical knowledge and psychomotor skills to prepare students for careers in academia, industry, and research.

ii Research and Innovation

To conduct research in various fields of chemistry, encouraging interdisciplinary collaboration and contributions to the advancement of scientific knowledge and technological innovation.

iii Professional Development

To create opportunities for students and faculty to develop professionally, through internships, workshops, seminars, and entrepreneurship that inculcate leadership attributes in them fostering their career in academia, industry, and government.

iv Community Engagement

To collaborate both locally and internationally with industries, government, and community organizations so as to transform lab scale research to real-world solutions.

v Empowerment of Women

To provide an enabling environment to empower women for their personal and professional development which grooms them to contribute effectively in society.

4. Program Objectives

i. Strong Foundation in Chemistry

Equip students with a comprehensive understanding of the fundamental areas of chemistry: organic, inorganic, physical, analytical, and biochemistry

ii. Laboratory Proficiency

Develop proficiency in modern laboratory techniques, instrumentation, and safety practices for chemical experimentation and analysis

iii. Scientific Communication

Cultivate effective communication skills for presenting scientific information clearly in written, oral, and digital formats

iv. Interdisciplinary Competence

Provide exposure to the interdisciplinary nature of chemistry and its applications in fields such as biology, environmental science, medicine, and materials science

v. Preparation for Careers or Further Study

Prepare graduates for employment in chemical industries, education, or government laboratories, and/or for advanced study in graduate or professional schools

5. Admission Criteria for BS (4-Year) Chemistry

As per approved Admission Policy RWU notified vide Notification No. RWU/VC/01/341; dated: 10th Mar, 2023

6. Division and Distribution of Courses for BS (4-Year) Chemistry

Sr. #	Categories	Credit Hours
1	Total Credit Hours	139
2	General Education Courses	32 credit hours
3	Discipline related Courses/Major	81 credit hours
4	Interdisciplinary/Allied Courses	18 credit hours (6 courses)
7	Mandatory Courses	08 credit hours

- Credit Hours Minimum: 139
- Duration Minimum: 4 Years
Maximum: 6 Years
- Semester Duration 16 - 18 Weeks
- Course Load Per Semester 15 - 18 Credit Hours
- Number of Courses per Semester 4 - 6

7. Scheme of Studies for BS (4-Year) Chemistry

Semester	Course Code	Course Title	Credit Hours	Course Type
First	CHM-123	Fundamentals of Chemistry	2	Major
	CHM-123L	Fundamentals of Chemistry (Lab)	1	Major
	MTH-110	Quantitative Reasoning-I	3	General Education
	PHY-103	Applied Physics	2	General Education
	PHY-103L	Applied Physics (Lab)	1	General Education
	UHQ-101/ ETH-103	Understanding of Holy Quran-I/ Ethics-I	1	Mandatory
	ENG-110	Functional English	3	General Education
	CS-107	Applications of Information and Communication Technologies	2	General Education
	CS-107L	Applications of Information and Communication Technologies (Lab)	1	General Education
			Cr.Hr=16	
Second	CHM-124	Principles of Organic Chemistry	2	Major
	CHM-124L	Principles of Organic Chemistry (Lab)	1	Major
	CHM-125	Principles of Inorganic Chemistry	2	Major
	CHM-125L	Principles of Inorganic Chemistry (Lab)	1	Major
	CHM-126	Principles of Physical Chemistry	2	Major
	CHM-126L	Principles of Physical Chemistry (Lab)	1	Major
	STA-112	Quantitative Reasoning-II	3	General Education
	ENG-111	Expository Writing	3	General Education
	PAK-104	Pakistan Studies	2	General Education
	UHQ-102/ ETH-104	Understanding of Holy Quran-II/ Ethics-II	1	Mandatory
			Cr.Hr=18	
Third	CHM-215	Fuel Chemistry	2	Major
	CHM-215L	Fuel Chemistry (Lab)	1	Major

	CHM-216	Principles of Analytical Chemistry	2	Major
	CHM-216L	Principles of Analytical Chemistry (Lab)	1	Major
	CHM-217	Principles of Polymer Chemistry	2	Major
	CHM-217L	Principles of Polymer Chemistry (Lab)	1	Major
	CHM-218	Introduction to Nanochemistry	2	Major
	CHM-218L	Introduction to Nanochemistry (Lab)	1	Major
	PAK-103	Ideology and Constitution of Pakistan	2	General Education
	ISL-101/ ETH-101	Islamic Studies/ Ethics	2	General Education
	BFA-129	Arts and Humanities	2	General Education
			Cr.Hr=18	
Fourth	CHM-219	Forensic Chemistry	2	Major
	CHM-219L	Forensic Chemistry (Lab)	1	Major
	CHM-213	Industrial Chemistry	2	Major
	CHM-213L	Industrial Chemistry (Lab)	1	Major
	CHM-220	Environmental Chemistry	2	Major
	CHM-220L	Environmental Chemistry (Lab)	1	Major
	CHM-221	Pharmaceutical Chemistry	2	Major
	CHM-221L	Pharmaceutical Chemistry (Lab)	1	Major
	SOC-104	Introduction to Social Sciences	2	General Education
	CCE-497	Civic and Community Engagement	2	General Education
	MGT-108	Entrepreneurship	2	General Education
			Cr.Hr=18	
Fifth	CHM-315	Advanced Organic Chemistry	2	Major
	CHM-315L	Advanced Organic Chemistry (Lab)	1	Major
	CHM-316	Advanced Inorganic Chemistry	2	Major
	CHM-316L	Advanced Inorganic Chemistry (Lab)	1	Major
	CHM-317	Advanced Physical Chemistry	3	Major
	CHM-318	Advanced Analytical Chemistry	2	Major

	CHM-318L	Advanced Analytical Chemistry (Lab)	1	Major
	CHM-319	Soil Chemistry	2	Major
	CHM-319L	Soil Chemistry (Lab)	1	Major
	CHM-320	Computational Chemistry	2	Major
	CHM-320L	Computational Chemistry (Lab)	1	Major
			Cr. Hr=18	
Sixth	CHM-321	Agricultural Chemistry	2	Major
	CHM-321L	Agricultural Chemistry (Lab)	1	Major
		Elective – I	3	Major
		Elective – II	3	Major
	RM-402	Scientific Writing and Research Methods	3	Interdisciplinary
	CHM-322	Statistics for Chemists	3	Interdisciplinary
	CHM-323	Principles of Biochemistry	2	Interdisciplinary
	CHM-323L	Principles of Biochemistry (Lab)	1	Interdisciplinary
			Cr.Hr=18	
Seventh	CHM-403	Chemical Safety and Risk Management	3	Major
		Elective – III	3	Major
		Elective – IV	3	Major
		Elective – V	3	Major
	PHY-329	Materials Science	2	Interdisciplinary
	PHY-329L	Materials Science (Lab)	1	Interdisciplinary
	INT-499	Internship	3	Mandatory
			Cr.Hr=18	
Eighth		Elective – VI	3	Major
		Elective – VII	3	Major
	CHM-404	Artificial Intelligence in Chemistry	2	Interdisciplinary
	CHM-404L	Artificial Intelligence in Chemistry (Lab)	1	Interdisciplinary
	CHM-405	Quality Control and Assurance	2	Interdisciplinary

	CHM-405L	Quality Control and Assurance (Lab)	1	Interdisciplinary
	CP-498	Capstone	3	Mandatory
			Cr.Hr=15	
Total Cr.Hrs=139				

Scheme of Studies (2026) For B.Sc Students

B.Sc Degree Annual System (50 Credit Points)

Semester	Course Code	Course Title	Credit Hours	Course Type
Fifth	CHM-315	Advanced Organic Chemistry	2	Major
	CHM-315L	Advanced Organic Chemistry (Lab)	1	Major
	CHM-316	Advanced Inorganic Chemistry	2	Major
	CHM-316L	Advanced Inorganic Chemistry (Lab)	1	Major
	CHM-317	Advanced Physical Chemistry	3	Major
	CHM-318	Advanced Analytical Chemistry	2	Major
	CHM-318L	Advanced Analytical Chemistry (Lab)	1	Major
	CHM-319	Soil Chemistry	2	Major
	CHM-319L	Soil Chemistry (Lab)	1	Major
	CHM-320	Computational Chemistry	2	Major
	CHM-320L	Computational Chemistry (Lab)	1	Major
	CHM-213	Industrial Chemistry	2	Major
	CHM-213L	Industrial Chemistry (Lab)	1	Major
			Cr. Hr = 21	
Sixth	CHM-323	Principles of Biochemistry	2	Interdisciplinary
	CHM-323L	Principles of Biochemistry (Lab)	1	Interdisciplinary
	CHM-321	Agricultural Chemistry	2	Major
	CHM-321L	Agricultural Chemistry (Lab)	1	Major
		Elective – I	3	Major
		Elective – II	3	Major
	RM-402	Scientific Writing and Research Methods	3	Interdisciplinary
	CCE-497	Civic and Community Engagement	2	General Education
	CHM-322	Statistics for Chemists	3	Interdisciplinary
			Cr.Hr = 20	
Summer	CHM-220	Environmental Chemistry	2	Major
	CHM-220L	Environmental Chemistry (Lab)	1	Major
	CHM-221	Pharmaceutical Chemistry	2	Major
	CHM-221L	Pharmaceutical Chemistry (Lab)	1	Major
			Cr.Hr = 06	
Seventh	CHM-403	Chemical Safety and Risk Management	3	Major
		Elective – III	3	Major

		Elective – IV	3	Major
		Elective – V	3	Major
	PHY-329	Materials Science	2	Interdisciplinary
	PHY-329L	Materials Science (Lab)	1	Interdisciplinary
	INT-499	Internship	3	Mandatory
	CHM-218	Introduction to Nanochemistry	2	Major
	CHM-218L	Introduction to Nanochemistry (Lab)	1	Major
			Cr.Hr = 21	
Eighth		Elective – VI	3	Major
		Elective – VII	3	Major
	CHM-404	Artificial Intelligence in Chemistry	2	Interdisciplinary
	CHM-404L	Artificial Intelligence in Chemistry (Lab)	1	Interdisciplinary
	CHM-405	Quality Control and Assurance	2	Interdisciplinary
	CHM-405L	Quality Control and Assurance (Lab)	1	Interdisciplinary
	CP-498	Capstone Project	3	Mandatory
	CHM-215	Fuel Chemistry	2	Major
	CHM-215L	Fuel Chemistry (Lab)	1	Major
	CHM-219	Forensic Chemistry	2	Major
	CHM-219L	Forensic Chemistry (Lab)	1	Major
			Cr.Hr = 21	
	Total Cr.Hrs=50+21+20+06+21+21=139			

Scheme of Studies (2025) For ADP Students

ADP Degree Semester System (65 Credit Points)

Semester	Course Code	Course Title	Credit Hours	Course Type
Fifth	CHM-315	Advanced Organic Chemistry	2	Major
	CHM-315L	Advanced Organic Chemistry (Lab)	1	Major
	CHM-316	Advanced Inorganic Chemistry	2	Major
	CHM-316L	Advanced Inorganic Chemistry (Lab)	1	Major
	CHM-317	Advanced Physical Chemistry	3	Major
	CHM-318	Advanced Analytical Chemistry	2	Major
	CHM-318L	Advanced Analytical Chemistry (Lab)	1	Major
	CHM-319	Soil Chemistry	2	Major
	CHM-319L	Soil Chemistry (Lab)	1	Major
	CHM-320	Computational Chemistry	2	Major
	CHM-320L	Computational Chemistry (Lab)	1	Major
	CHM-213	Industrial Chemistry	2	Major
	CHM-213L	Industrial Chemistry (Lab)	1	Major
			Cr. Hr=21	
Sixth	CHM-323	Principles of Biochemistry	2	Interdisciplinary
	CHM-323L	Principles of Biochemistry (Lab)	1	Interdisciplinary
	CHM-321	Agricultural Chemistry	2	Major
	CHM-321L	Agricultural Chemistry (Lab)	1	Major
		Elective – I	3	Major
		Elective – II	3	Major
	RM-402	Scientific Writing and Research Methods	3	Interdisciplinary
	CCE-497	Civic and Community Engagement	2	General Education
	CHM-322	Statistics for Chemists	3	Interdisciplinary
			Cr.Hr=20	
Seventh	CHM-403	Chemical Safety and Risk Management	3	Major
		Elective – III	3	Major
		Elective – IV	3	Major
		Elective – V	3	Major
	PHY-329	Materials Science	2	Interdisciplinary
	PHY-329L	Materials Science (Lab)	1	Interdisciplinary
	INT-499	Internship	3	Major
			Cr.Hr=18	
Eighth		Elective – VI	3	Major

		Elective – VII	3	Major
	CHM-404	Artificial Intelligence in Chemistry	2	Interdisciplinary
	CHM-404L	Artificial Intelligence in Chemistry (Lab)	1	Interdisciplinary
	CHM-405	Quality Control and Assurance	2	Interdisciplinary
	CHM-405L	Quality Control and Assurance (Lab)	1	Interdisciplinary
	CP-498	Capstone	3	Mandatory
			Cr.Hr=15	
Total Cr.Hrs = 65 + 21 + 20 + 18 + 15 = 139				

8. List of Major Courses

CHM-123	Fundamentals of Chemistry	2	Major
CHM-123L	Fundamentals of Chemistry (Lab)	1	Major
CHM-124	Principles of Organic Chemistry	2	Major
CHM-124L	Principles of Organic Chemistry (Lab)	1	Major
CHM-125	Principles of Inorganic Chemistry	2	Major
CHM-125L	Principles of Inorganic Chemistry (Lab)	1	Major
CHM-126	Principles of Physical Chemistry	2	Major
CHM-126L	Principles of Physical Chemistry (Lab)	1	Major
CHM-215	Fuel Chemistry	2	Major
CHM-215L	Fuel Chemistry (Lab)	1	Major
CHM-216	Principles of Analytical Chemistry	2	Major
CHM-216L	Principles of Analytical Chemistry (Lab)	1	Major
CHM-217	Principles of Polymer Chemistry	2	Major
CHM-217L	Principles of Polymer Chemistry (Lab)	1	Major
CHM-218	Introduction to Nanochemistry	2	Major
CHM-218L	Introduction to Nanochemistry (Lab)	1	Major
CHM-219	Forensic Chemistry	2	Major
CHM-219L	Forensic Chemistry (Lab)	1	Major
CHM-213	Industrial Chemistry	2	Major
CHM-213L	Industrial Chemistry (Lab)	1	Major
CHM-220	Environmental Chemistry	2	Major
CHM-220L	Environmental Chemistry (Lab)	1	Major
CHM-221	Pharmaceutical Chemistry	2	Major
CHM-221L	Pharmaceutical Chemistry (Lab)	1	Major
CHM-315	Advanced Organic Chemistry	2	Major
CHM-315L	Advanced Organic Chemistry (Lab)	1	Major
CHM-316	Advanced Inorganic Chemistry	2	Major
CHM-316L	Advanced Inorganic Chemistry (Lab)	1	Major
CHM-317	Advanced Physical Chemistry	3	Major
CHM-318	Advanced Analytical Chemistry	2	Major
CHM-318L	Advanced Analytical Chemistry (Lab)	1	Major
CHM-319	Soil Chemistry	2	Major
CHM-319L	Soil Chemistry (Lab)	1	Major
CHM-320	Computational Chemistry	2	Major
CHM-320L	Computational Chemistry (Lab)	1	Major
CHM-321	Agricultural Chemistry	2	Major
CHM-321L	Agricultural Chemistry (Lab)	1	Major
CHM-403	Chemical Safety and Risk Management	3	Major

9. Course Outlines for Major Courses:

Fundamentals of Chemistry

BS-Chemistry

Course Code: CHM-123

Credit Hours: 02

Pre-requisite: Nil

Objectives

- To introduce the foundational principles and terminology of chemistry in a simple and accessible manner.
- To develop an understanding of atomic structure, bonding, states of matter, and basic chemical calculations.
- To provide an introductory exposure to organic chemistry concepts and the periodic classification of elements.

Learning Outcomes

- Students will be able to explain basic chemical concepts, perform stoichiometric calculations, and understand the periodic table.
- They will identify types of bonding, describe states of matter, and relate structure to properties of substances.
- Students will recognize simple organic compounds and apply naming rules and bonding principles in organic chemistry

Course outlines

Unit 1. Introduction to Chemistry and Chemical Calculations

Definition and importance of chemistry, matter, mass and weight, atoms and molecules, ions, relative atomic and molecular masses, mole concept, empirical and molecular formulae, stoichiometric calculations, limiting reactants, and percentage yield.

Unit 2. Atomic Structure and the Periodic Table

Historical development of the periodic table, classification of elements by orbital structure, periodic trends and group properties, quantum numbers, electronic configuration, Aufbau principle, Hund's rule, and Pauli exclusion principle.

Unit 3. States of Matter

Properties and behavior of gases (ideal and real gases, kinetic theory, Van der Waals equation), liquids (vapour pressure, surface tension, viscosity, refractive index, dipole moment), and solids (types of solids, crystal lattice, X-ray diffraction, Bragg's law).

Unit 4. Chemical Bonding and Molecular Structure

Types of bonding: ionic, covalent, coordinate covalent and metallic, Lewis structures, hybridization, bond angles, bond energy, inductive effect, resonance, dipole moment, hydrogen bonding, and molecular geometry.

Unit 5. Fundamentals of Organic Chemistry

Introduction to organic compounds, common and IUPAC naming of mono- and bi-functional compounds, basic bonding in organic molecules, delocalized bonding, resonance, hyperconjugation, aromaticity, tautomerism, and inductive effects.

Recommended books/reference material

1. Ahmed, K., & Haq, R. *Basic Concepts of Chemistry*. Ferozsons Publishers, Latest Edition.
2. Choudhary, M.I., Rahman, A.-u., & Shah, M.R. *Fundamentals of Chemistry*. HEJ Research Institute of Chemistry, University of Karachi, Latest Edition.
3. Majid, A., & Haq, A.U. *Chemistry*. Punjab Textbook Board, Lahore, Latest Edition.
4. Tro, N.J. (2020) *Chemistry: A Molecular Approach*. Pearson Education, 5th Edition.

Fundamentals of Chemistry (Lab)

BS-Chemistry

Course Code: CHM-123L

Credit Hours: 01

Pre-requisite: Nil

Objectives

- To develop basic laboratory skills such as accurate measurement, solution preparation, and safe handling of chemicals.
- To understand and apply core chemical concepts like acids and bases, reactions, stoichiometry, and the periodic table.

Learning Outcomes

- Students will be able to identify and correctly use basic laboratory equipment (e.g., beakers, burettes, pipettes, balances, test tubes).
- Students will be able to prepare standard solutions and perform titrations to determine concentrations.
- They will be able to Write balanced chemical equations and relate them to observable phenomena in the lab.
- They will Measure physical properties (like pH, temperature, melting/boiling points) and interpret data.

Course outlines

- Determination of percentage yield of salt
- Measurement of surface tension and viscosity of liquids
- Functional Group Tests in Organic Compounds: Ethanol, Acetone, Acetic Acid, and Benzaldehyde
- Flame Tests for Metal Ions: Sodium (Na^+), Potassium (K^+), Calcium (Ca^{2+}), Copper (Cu^{2+}), and Lithium (Li^+) and other common ions
- Determination of boiling point and its constant for common organic/Inorganic compounds
- Determination of melting point and its constant for common organic/Inorganic compounds

Recommended books/reference material

- Tinoco, I. Sauer, K. Wang, J. Puglisi, J. Harbison, G. Rovnyak, D. (2013) Physical Chemistry: Principles and Applications in Biological Sciences 5th Edition, Pearson.
- Vogel, A. I. Tatchell, A. R. Furnis, B. S. Hannaford, A. J. Smith, P. W. G. (1996) Vogel's Textbook of Practical Organic Chemistry, 5th Edition
- Wilson, J. M. Newcombe, R. J. Denaro, A. R. (2016) Experiments in Physical chemistry, 2nd edition, Elsevier.
- Heaton, C. W. (2018) Experimental Chemistry: A Handbook for the Study of the Science by Simple Experiments, Forgotten Books.

Principles of Organic Chemistry

BS-Chemistry

Course Code: CHM-124

Credit Hours: 2

Pre-requisite: Nil

Objectives

This course aims to develop a foundational understanding of organic chemistry by exploring molecular structure, bonding, functional groups, and reaction mechanisms with applications in pharmaceuticals, polymers, and related fields.

Learning Outcomes

By the end of this course, the students will be able to:

- Explain fundamental principles of organic chemistry, including structure, bonding, and functional groups.
- Understand the reaction mechanisms and synthesis of organic molecules relevant to pharmaceuticals and polymers etc.

Course Outline

Unit 1. Structure and Bonding in Organic Molecules

Atomic orbitals and hybridization (sp , sp^2 , sp^3), covalent bonding and bond polarity, Resonance structures and delocalization of electrons, Functional group classification and identification, Introduction to isomerism: structural and stereoisomers.

Unit 2. Nomenclature of Organic Compounds

Classification of organic compounds, development of systematic nomenclature of organic compounds, nomenclature of hydrocarbons and heteroatom functional groups.

Unit 3. Hydrocarbons and Functional Groups

Alkanes and cycloalkanes: conformation and nomenclature, Alkenes and alkynes: structure, reactions, and stereochemistry, Aromatic compounds: structure of benzene, Huckel's rule, electrophilic aromatic substitution, Alcohols, ethers, amines, aldehydes, ketones, carboxylic acids and derivatives.

Unit 4. Reaction Mechanisms and Types

Introduction to organic reaction mechanisms: nucleophiles and electrophiles, Reaction types: substitution ($SN1$, $SN2$), elimination ($E1$, $E2$), addition, rearrangement, Energy diagrams and transition states.

Unit 5. Synthesis of Organic Molecules

Functional group interconversion, Protecting groups and selectivity, Multistep synthesis: planning and strategy.

Recommended books/reference material

5. Hornby, M., Peach, J. (2023). Foundations of Organic Chemistry. United Kingdom: Oxford University Press.
6. McIntosh, J. M. (2022). Organic Chemistry: Fundamentals and Concepts. Germany: De Gruyter.
7. Ouellette, R. J., Rawn, J. D. (2018). Organic Chemistry: Structure, Mechanism, Synthesis. Netherlands: Academic Press.
8. Vančík, H. (2022). Basic Organic Chemistry for the Life Sciences. Switzerland: Springer International Publishing.

Principles of Organic Chemistry (Lab)

BS-Chemistry

Course Code: CHM-124 L

Credit Hours: 01

Pre-requisite: Nil

Objectives

The objective of this course is to learn about safety, qualitative and quantitative analysis.

Learning Outcomes

By the end of this laboratory course, students will be able to:

- Safely handle and work with organic chemicals and glassware.
- Perform basic organic synthesis and purification techniques.
- Identify functional groups using qualitative tests.
- Analyze purity using chromatographic and melting point techniques.

Course Outline

1. Introduction to Laboratory Safety and Techniques
2. Purification Techniques
3. **Qualitative Analysis of Organic Compounds**
 - Detection of elements (N, S, halogens – Lassaigne's Test)

- Functional group identification tests: Alcohols (Lucas Test, Ceric nitrate), Aldehydes/Ketones (Tollens', 2,4-DNP), Carboxylic acids (NaHCO₃ test), Amines (Hinsberg Test).

4. Simple Organic Syntheses

- Preparation of Acetanilide from aniline (acetylation)
- Synthesis of Aspirin from salicylic acid (esterification)
- Bromination of Acetanilide (Electrophilic aromatic substitution)

5. Chromatography and Purity Analysis

- Thin Layer Chromatography (TLC) – Separation and R_f calculation
- Melting point determination using capillary method
- Optional: Column chromatography demonstration

Recommended books/reference material

1. Fisher, H. L. (2023). Laboratory Manual of Organic Chemistry. (n.p.): Creative Media Partners, LLC.
2. Pavia, D. L., Kriz, G. S., Lampman, G. M., Engel, R. G. (2016). A Microscale Approach to Organic Laboratory Techniques. United States: Cengage Learning.
3. The Organic Chem Lab Survival Manual. (2022). United States: Wiley & Sons.

Principles of Inorganic Chemistry

BS-Chemistry

Credit hours: CHM-125

Credit Hours: 02

Pre-requisite: Nil

Objectives

The objective of this course is to understand the fundamentals of inorganic chemistry and its connection to the real-world processes within industry, materials science, and environmental contexts.

Learning Outcomes

By the end of this course, the students will be able to:

- Describe the fundamental properties, bonding, and reactivity of inorganic compounds.
- Analyze the chemical behavior of elements and their compounds, with relevance to industrial and environmental applications.

- Evaluate the applications of inorganic compounds in materials science, catalysis and environmental management

Course Outline

Unit 1. Foundations of Inorganic Chemistry

Understanding Structure of Atom. Development of periodic table. Classification of elements based on s, p, d, and f orbitals. Group trends and periodic properties in s, p, d and f block elements, i.e., Atomic/ionic radii, Ionization potentials, Electron affinities and electronegativities. Redox Chemistry and Oxidation states.

Unit 2. Acids and Bases

Brief concepts of chemical equilibrium. Acids and bases, Soft and hard acids and bases (SHAB). Concept of relative strength of acids and bases. Significance of pH, pKa, pKb and buffer solutions.

Unit 3. Theories of Chemical Bonding

Introduction and types of chemical bonding; ionic and covalent bonding. Localized bond approach. Theories of chemical bonding, VB theory, Hybridization, Repulsion (VSEPR) model. Prediction of molecular shapes using Valence Shell Electron Pair. Molecular orbital theory (MOT) applied to diatomic molecules. Delocalized approach to bonding, bonding in electron deficient compounds. Hydrogen bonding.

Unit 4. Coordination Compounds and their Chemistry

Introduction, history and background of coordination chemistry. Structure of coordination complexes with coordination number 2-6, chelates and chelate effect. Theories of coordination complexes, crystal field theory (CFT) and Jahn-Teller theorem. Magnetic properties, spectral properties, isomerism and stereochemistry. Solid state structures and Lattice energy.

Unit 5. Industrial and Environmental Applications

Industrial synthesis of ammonia and sulfuric acid. Environmental contaminants such as heavy metals, phosphates and nitrates. Acid Rain. Remediation strategies and green chemistry.

Unit 6. Catalysis and Inorganic Materials

Homogeneous and heterogeneous catalysis (e.g., Ziegler-Natta, transition metal complexes). Inorganic nanomaterials, semiconductors, and biomaterials. Sustainability and circular materials economy.

Recommended books/reference material

1. Brian.W., (2022), Principles of Inorganic Chemistry, (2nd ed.), Wiley publishers
2. House, J. E., & House, K. A. (2015). Descriptive inorganic chemistry. Academic Press.
3. Jordan, R. B. (2024). Principles of Inorganic Chemistry. Springer Nature.

Principles of Inorganic Chemistry (Lab)

BS-Chemistry

Course Code: CHM-125L

Credit Hours: 01

Pre-requisite: Nil

Objectives

Students will acquire knowledge about the key introductory concepts of acid-base and redox titrations. They will learn the synthesis, characterization and purification of simple coordination compounds. They will also practice water purification techniques.

Learning Outcomes

- Students will have a deep understanding of key introductory concepts of acid base titration, redox titration and coordination chemistry. They'll interpret the data to understand the bonding, structure and reactivity of compounds.
- Students will apply knowledge to real world problems in industrial (catalysis etc) and environmental sectors.

Course Outline

- Introduction to Lab ethics and Safety measures of Toxic chemicals
- Acid Base titration
- Preparation and standardization of KMnO_4 and its use for determination of purity of Potassium oxalate solution.
- Preparation of Tetraamminecopper (II) sulphate and Potassium trioxalatochromate (III) and characterization by UV-Vis and/or IR spectroscopy.
- Removal of metal ions from water using precipitation/coagulation methods.

Recommended books/reference material

- Anastas, P. T., & Warner, J. C. (2017). Green chemistry: Theory and practice (2nd ed.). Royal Society of Chemistry.
- VanLoon, G. W., & Duffy, S. J. (2017). Environmental chemistry: A global perspective (4th ed.). Oxford University Press.
- Woollins, J. D. (2016). Inorganic experiments (4th ed.). Wiley.

Principles of Physical Chemistry

BS-Chemistry

Course Code: CHM-126

Credit Hours: 02

Pre-requisite: Nil

Objectives

Student will be able to describe kinetics of Zero, 1st, 2nd, 3rd and fractional order reactions. They will describe the concept relevant to the chemical kinetics i.e. molecularity, order of the reaction, half-life of the reaction etc. They will understand the fundamental laws of thermodynamics and chemical equilibria and Le-Chatelier's Principle in detail.

Learning Outcomes

- Demonstrate a deep understanding of the fundamental principles and theories in physical chemistry, including thermodynamics, kinetics, and quantum mechanics.
- Explain and apply the laws of thermodynamics to describe the behavior of gases, liquids, and solids.
- Analyze thermodynamic processes and understand concepts such as entropy, enthalpy, and Gibbs free energy.
- Understand the principles of chemical kinetics, including reaction mechanisms, rate laws, and factors affecting reaction rates.

Course Outline

Unit 1. Chemical Kinetics

Introduction to Chemical Kinetics. Rate of reaction. Rate law, order and molecularity of the reactions. Zero and first order reactions. Half-lives of reactions. Second and third order reactions. Effect of temperature on the reaction rate. Arrhenius equation Determination of reaction order and its rate constant.

Unit 2. Thermodynamics

Laws of thermodynamics and their applications, Heat capacities and their dependence on temperature, pressure and volume. Thermodynamic functions:

internal energy, enthalpy, entropy and free energy. Reversible and non-reversible processes. Spontaneous and nonspontaneous processes, fugacity and activity.

Unit 3. Chemical Equilibrium

Introduction to Chemical equilibrium. General equilibrium expressions, reaction quotients. Equilibrium reactions in solid, liquid and gas phases. Extent of reactions and equilibrium constants.

Unit 4. Solutions

Van't Hoff equation. Le-Chatelier's principle. Physical properties of liquids: surface tension, viscosity, refractive index etc. and their applications. Ideal and non-ideal solutions. Raoult's law and its applications.

Unit 5. Colligative Properties

Depression of freezing point, osmotic pressure. Lowering of vapor pressure, elevation of boiling point. Vapor pressure of non-ideal solutions and Henry's law. Abnormal Colligative properties. Fractional distillation and concept of azeotropic mixtures.

Recommended Books/Reference Material

1. Atkins, P. W., (2009). "*Physical Chemistry*" 9th ed., W. H. Freeman and Co. New York.
2. Ball, D W., (2003). "*Physical Chemistry*" (1st ed.), Brooks/Cole Co. Inc.
3. Bhatti, H. N., Farooqi, Z. H., (2013) "*Modern Physical Chemistry*" The Carvan Books House, Lahore.
4. Ghulam R. Ch., (2023) "*A Text Book of Physical Chemistry*."
5. Jyotsna. P., Prashant.M.,(2023), *Physical Chemistry*, 1st edition, by AGPH Books, Bhopal India.

Principles of Physical Chemistry (Lab)

BS-Chemistry

Course Code: CHM- 126L

Credit Hours: 01

Objectives

Student will be able to understand the concept, relevant to the surface tension, parachor value, rheochor value and viscosity. They will also acquire the understanding of fundamental laws of thermodynamics by calculating the heat of neutralization and heat of solution.

Learning Outcomes

Theory and Lab course is designed to develop fundamental and conceptual understanding of key concepts in Physical Chemistry which will enable students to grasp advanced topics in Physical Chemistry.

Course Outline

1. Determination of surface tension of different liquids.
2. Determination of percentage composition of unknown sample mixture by Surface tension method.
3. Determination of parachor value of different liquids.
4. Determination of viscosity of different liquids.
5. Determination of percentage composition of unknown sample mixture by Viscosity method.
6. Determination of rheochor values of different liquids.
7. Determination of refractive indices of different liquids.
8. Determination of percentage composition of a sample mixture by refractive index method.
9. Determination of molar refraction of different liquids.
10. Determination of transition temperature of $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$.

Recommended Books/Reference Material

1. Atkins, P. W. (2009). *Physical Chemistry*, (9th ed.) W. H. Freeman and Co., New York.
2. Ball, D W. (2003). *Physical Chemistry*, (1st ed.) Brooks/Cole Co. Inc., USA.
3. Bhatti, H. N., Farooqi, Z. H., (2013). *Modern Physical Chemistry*. The Carvan Books House, Lahore.

Fuel Chemistry

BS-Chemistry

Course Code: CHM-215

Credit Hours: 02

Pre-requisite: Nil

Objectives

This course is designed to provide students with a fundamental understanding of the chemistry of fuels, including conventional and renewable energy sources. It aims to cover the composition, processing, properties, and environmental impact of fuels used in various industrial and energy sectors.

Learning Outcomes

Upon successful completion of this course, students will be able to:

- Understand the classification and chemical nature of solid, liquid, and gaseous fuels.
- Analyze fuels' chemical and physical properties and determine their calorific values.
- Describe the refining, cracking, and reforming processes of petroleum.
- Understand the synthesis, application, and environmental impact of alternative fuels.
- Evaluate clean energy technologies and strategies for sustainable fuel development.

Course Outline

Unit 1. Introduction to Fuel Chemistry

Definition and classification of fuels: solid, liquid, and gas, Characteristics of an ideal fuel. Combustion and calorific value (gross and net), Measurement of calorific value using a bomb calorimeter, Ignition temperature, flame temperature, and explosive limits

Unit 2. Solid and Liquid Fuels

Coal: types, composition, analysis (proximate and ultimate), carbonization, Manufacture of coke: Beehive and Otto-Hoffmann methods, Petroleum: origin, refining (fractional distillation), composition, Cracking (thermal and catalytic), reforming, Octane and cetane numbers, knocking and anti-knocking agents.

Unit 3. Gaseous and Synthetic Fuels

Gaseous Fuels: natural gas, LPG, CNG, biogas, water gas, producer gas, Properties, production, storage, and applications.

Unit 4. Renewable and Alternative Fuels

Biofuels: biodiesel (transesterification), ethanol, algal biofuel, Hydrogen as fuel: production, storage, hydrogen fuel cells.

Unit 5. Environmental Impact and Sustainability

Environmental consequences of fuel combustion, Air pollutants: CO₂, SO_x, NO_x, particulate matter, Greenhouse effect and climate change, Fuel economy and carbon footprint. Clean energy technologies and future perspectives on sustainable fuel chemistry

Recommended books/reference material

1. Piro, M. H. (Ed.). (2020). Advances in Nuclear Fuel Chemistry. Woodhead Publishing.
2. Song, C. (2020). Introduction to chemistry of diesel fuels. In Chemistry of diesel fuels (pp. 1-60). CRC Press.
3. Richards, P., & Barker, J. (2023). Automotive fuels reference book. SAE International.
4. Paxton, B. T., Fugger, C. A., Tomlin, A. S., & Caswell, A. W. (2020). Experimental investigation of fuel chemistry on combustion instabilities in a premixed bluff-body combustor. In AIAA Scitech 2020 Forum (p. 0174).
5. Schobert, H. H. (2013). The chemistry of hydrocarbon fuels. Butterworth-Heinemann.

Fuel Chemistry (Lab)

BS-Chemistry

Course Code: CHM-215L

Credit Hours: 01

Pre-requisite: Nil

Objectives

This lab course is intended to provide hands-on experience in the analysis of conventional and alternative fuels. It aims to develop practical skills in determining fuel properties, understanding fuel behavior, and evaluating fuel performance and environmental effects.

Learning Outcomes

Upon completion of this lab course, students will be able to:

- Analyze various physical and chemical properties of fuels.
- Conduct calorific value determination using a bomb calorimeter.
- Evaluate fuel efficiency and combustion characteristics
- Perform basic experiments for biodiesel and bioethanol preparation.
- Understand and apply safety practices in fuel handling and experimentation.

Course Outline

1. Determination of moisture content in a coal or charcoal sample using oven-drying method.
2. Determination of ash content in coal by heating in a crucible and weighing the inorganic residue.
3. Determination of volatile matter in coal by heating in a covered crucible and calculating weight loss.
4. Calculation of fixed carbon in coal using values from proximate analysis.
5. Determination of calorific value of charcoal using a simple water calorimeter (tin can method).
6. Preparation of ethanol by fermentation of sugar solution using baker's yeast.
7. Purification of fermented ethanol using simple distillation.
8. Preparation of biodiesel from vegetable oil using sodium hydroxide and methanol.
9. Comparison of combustion properties of ethanol, kerosene, and biodiesel using wick lamps.
10. Determination of density of ethanol, kerosene, and diesel using a measuring cylinder and balance.

Principles of Analytical Chemistry

BS Chemistry

Couse Code: CHM-216

Credit Hours: 02

Pre-requisite: Nil

Objectives

Students will acquire knowledge about sampling and their handling and preparation and results calculation and data reporting. In addition, they will learn and develop understanding about the classical techniques of analytical chemistry and quality control and quality assurance.

Learning Outcomes

After completing this program student will be able to learn the following:

- Chemometrics
- Quality Control and Quality Assurance
- Quality Review
- Volumetric Analysis

Course Outline

Unit 1. Chemometrics

Introduction, Sampling, Significant figures, Stoichiometric calculations, Measurement errors, Analysis of variance (ANOVA), Arithmetic mean, Median, Mode, Standard deviation/Relative standard deviation, Confidence limits, Gaussian distribution, least square method, Tests for significance, Outliers.

Unit 2. Quality Control and Quality Assurance

Definitions, Seven tools for quality control, the concept of quality assurance, Quality assurance techniques, Validations based on design qualification (DQ).

Unit 3. Qualification

Installation qualification (IQ), Operational qualification (OQ) and performance qualification PQ).

Unit 4. Quality Review

Calibrations, Monitoring, Quality reviews, Periodical trainings, six sigma concept, Good laboratory practice, ISO 9000.

Unit 5. Volumetric Analysis

Acid-base titrations, Complex metric titrations, Redox titrations, Gravimetric analysis, acid base indicators (theories of indicators).

Recommended Books/Reference Material

1. Christian, G. D. (2006) *Analytical Chemistry*. 6th ed., John-Wiley & Sons, New York.
2. Harris, D. C. (2011) *Quantitative Chemical Analysis*, 8th ed., W. H. Freeman and Company, New York, USA.
3. Kealey, D. and Haines, P. J. (2002) Instant Notes. *Analytical Chemistry*, Bios Scientific Publishers Limited, Oxford, UK.
4. Matthios, Otto, (2007) *CHEMOMETRICS-Statistics and Computed applications in Analytical Chemistry*, 2nd ed., Wiley-VCH, Germany.
5. Miller, J. and Miller, J. (2005) *Statistics and Chemometrics for Analytical Chemistry*, 5thed., Prentice Hall.

6. Mitra A., *Fundamentals of Quality Control and Improvement*, 3rd ed., John-Wiley & Sons. (2008). Skoog, D. A., West, P. M., Holler, F. J., Crouch, S. R. (2013) *Fundamentals of Analytical Chemistry*, 9thed., Brooks Cole Publishing Company.
7. Miller, J. and Miller, J. (2020) *Statistics and Chemometrics for Analytical Chemistry*, 5th. Prentice Hall.

Principles of Analytical Chemistry (Lab)

BS-Chemistry

Course Code: CHM-216L

Credit Hours: 01

Pre requisites: Nil

Objectives

Students will acquire knowledge about sampling and their handling and preparation and results calculation and data reporting. In addition, they will learn and develop understanding about the classical techniques of analytical chemistry and quality control and quality assurance.

Learning Outcomes

After completing this program students will be able to learn the following:

- Complexometry
- Estimation of ions
- Gravimetric analysis
- Volumetric Analysis

Course Outline

1. Calibration of volumetric glassware (pipette, burette and flask).
2. Calibration of electronic equipment (analytical balance, pH meter, conductometer).
3. Determination of hardness of water using EDTA and construction of its calibration curve from its analytical data using spread sheet software.
4. Determination of chloride in tap water sample.
5. Estimation of copper, arsenic, hydrogen peroxide and vitamin C using iodometry along with statistical evaluation of analytical data including linear regression analysis.
6. Gravimetric analysis, determination of barium in barium nitrate.
7. Determination of nickel in a given steel sample.
8. Determination of bicarbonates in a clinical sample using back-titrations.
9. Determination of cation in a mixture by complexometric titration.
10. Studying the effect of common ions on solubility of sparingly soluble salts (e.g. PbSO_4)

Recommended Books/Reference Material

1. Miller, J. and Miller, J. (2005) *Statistics and Chemometrics for Analytical Chemistry*, 5thed., Prentice Hall.
2. Mitra A., *Fundamentals of Quality Control and Improvement*, 3rd ed., John-Wiley & Sons. (2008). Skoog, D. A., West, P. M., Holler, F. J., Crouch, S. R. (2013) *Fundamentals of Analytical Chemistry*, 9thed., Brooks Cole Publishing Company.

Principles of Polymer Chemistry

BS Chemistry

Course Code: CHM-217

Credit Hours: 2

Pre-requisite: nil

Course Objectives

This course aims to provide an in-depth understanding of polymer chemistry, including the principles of polymerization, synthesis methods, reaction mechanisms, and the physical and mechanical properties of polymers. Students will develop both theoretical knowledge and practical skills through laboratory experiments aligned with industrial applications.

Learning Outcomes

By the end of this course, students will be able to:

- Understand the historical background and foundational principles of polymer chemistry.
- Explain and compare various polymerization mechanisms and kinetics.
- Determine molecular weight and distribution of polymers using modern characterization techniques.
- Describe the structural, thermal, and mechanical behavior of amorphous and crystalline polymers.
- Apply concepts of polymer solutions, blends, and processing in real-world applications.
- Perform basic polymer synthesis and characterization in the laboratory.

Course Outline

Unit 1: Introduction to Polymers & Polymerization Mechanisms

History and classification of polymers, Types of polymerization: step-growth vs. chain-growth, Free radical, ionic, and coordination polymerizations, Copolymerization and reactivity ratios, Emulsion and suspension polymerizations, Natural and inorganic polymers

Unit 2: Polymer Molecular Weight and Characterization

Molecular weight: number average, weight average, and polydispersity index, Molecular weight determination techniques: Viscometry, Osmometry, Static and dynamic light scattering

Unit 3: Polymer Structure and Amorphous State

Chain architecture: linear, branched, cross-linked Stereoregularity and tacticity, Chain conformations and configurations, Amorphous polymers: glass transition temperature (T_g), polymer dynamics

Unit 4: Crystalline Polymers and Blends

Crystallization: nucleation, kinetics, and growth, Crystalline structure and morphology (spherulites, lamellae), Characterization: X-ray diffraction, DSC, microscopy, Polymer blends and miscibility.

Unit 5: Polymer Solutions and Advanced Topics

Solubility parameters and thermodynamics of polymer solutions, Polymer swelling, diffusion, and gel formation, Introduction to smart polymers, biodegradable polymers, and nanocomposites, Industrial applications: plastics, fibers, coatings, biomedical uses.

Recommended Books/reference material

1. **Chanda, M., & Roy, S. K. (2008).** *Industrial polymers, specialty polymers, and their applications*. CRC Press. <https://doi.org/10.1201/9781420080599>
2. **Huang, X., & Tanaka, T. (Eds.). (2021).** *Polymer composites for electrical engineering*. Wiley.
3. <https://www.wiley.com/en-us/Polymer+Composites+for+Electrical+Engineering-p-9781119719601>
4. **Matyjaszewski, K., & Möller, M. (Eds.). (2012).** *Polymer science: A comprehensive reference* (Vols. 1–10). Elsevier. <https://www.cmu.edu/maty/publications-and-ip/books-and-book-chapters.html>
5. **Odian, G. (2004).** *Principles of polymerization* (4th ed.). Wiley-Interscience. <https://onlinelibrary.wiley.com/doi/book/10.1002/047147875X>
6. **Subramanian, M. N. (2016).** *Basics of polymer chemistry*. River Publishers. <https://www.routledge.com/Basics-of-Polymer-Chemistry/Subramanian/p/book/9788793519015>

Principles of Polymer Chemistry (Lab)

BS Chemistry

Course Code: CHM-217L

Credit Hours: 01

Pre-requisite: Nil

Objectives

This laboratory course provides practical exposure to the synthesis, processing, and characterization of polymers. Students will explore the behavior of polymer materials and verify theoretical concepts related to polymer chemistry through experiments.

Learning Outcomes

- Students will learn basic techniques for polymer synthesis and processing.
- Students will be able to determine molecular weights and study the thermal and mechanical behavior of polymers.
- Students will interpret experimental data obtained from polymer characterization methods.

Course Outline

1. Synthesis of Nylon 6,6 via interfacial polymerization
2. Free radical polymerization of styrene or MMA
3. Preparation of polylactic acid as a biodegradable polymer
4. Determination of molecular weight of polymers by viscometry
5. Observation of polymer crystallinity using microscopy
6. Thermal analysis of polymers using DSC (demo/data interpretation)
7. Preparation and mechanical testing (e.g., tensile strength) of polymer films
8. Study of swelling behavior in cross-linked hydrogels
9. Preparation and miscibility testing of polymer blends
10. Solubility testing of different polymers in organic solvents

Recommended Books/Reference Material

1. **Chanda, M., & Roy, S. K. (2008).** *Industrial Polymers, Specialty Polymers, and Their Applications.* CRC Press.
<https://doi.org/10.1201/9781420080599>
2. **Huang, X., & Tanaka, T. (Eds.). (2021).** *Polymer Composites for Electrical Engineering.* Wiley.
<https://www.wiley.com/en-us/Polymer+Composites+for+Electrical+Engineering-p-9781119719601>
3. **Matyjaszewski, K., & Möller, M. (Eds.). (2012).** *Polymer Science: A Comprehensive Reference* (Vols. 1–10). Elsevier.
<https://www.cmu.edu/maty/publications-and-ip/books-and-book-chapters.html>

4. **Odian, G. (2004).** *Principles of Polymerization (4th ed.)*. Wiley-Interscience.
<https://onlinelibrary.wiley.com/doi/book/10.1002/047147875X>
5. **Subramanian, M. N. (2016).** *Basics of Polymer Chemistry*. River Publishers.
<https://www.routledge.com/Basics-of-Polymer-Chemistry/Subramanian/p/book/9788793519015>

Introduction to Nanochemistry

BS-Chemistry

Course Code: CHM-218

Credit Hours: 02

Pre requisite: Nil

Objectives

Students should be able to understand: Effects of nano-dimensions of particles and how nanochemistry thereby differs from solid state chemistry. Whether turning to a nanostructured material for a given chemical compound is likely to result in grossly modified chemical or physical properties.

Learning Outcomes

- Apply knowledge of top-down and bottom-up synthesis to create mesoporous materials and composites.
- Demonstrate proficiency in employing various synthesis methods, including anodization and deposition-precipitation, to produce nanomaterials with specific properties.

Course Outline

- | | |
|----------------|--|
| Unit 1. | <u>Size effects in Nanochemistry</u>
Models of reactions of metal atoms in matrices, Properties, Kinetic peculiarities of chemical processes on the surface of nanoparticles, Thermodynamic features of nanoparticles |
| Unit 2. | <u>Synthesis of Nanomaterials</u>
Synthesis of nanoparticles, Mesoporous materials and composites (top down and bottom-up production), Synthesis by anodization, Hydrothermal, Convention heating, Deposition precipitation methods. |
| Unit 3. | <u>Characterization of Nanomaterials</u>
Characterization of nanomaterials by X-ray diffraction (XRD), Scanning electron microscopy (SEM), Transmission electron microscopy (TEM), Brunauer, Emmett and Teller (BET) adsorption method. Thermogravimetric analysis (TGA), Atomic absorption spectroscopy (AAS), Ultravioletvisible spectroscopy (UV-Vis) and fourier transform infrared (FTIR) spectroscopy. |

Unit 4. Applications

Importance of nanotechnology with special reference to environmental pollution, Gas sensors, Solar cells, and Catalysis.

Recommended Books/Reference Material

1. Awan, T. I., Bashir, A., Tehseen, A. (2020). Chemistry of Nanomaterials: Fundamentals and Applications. Netherlands: Elsevier Science.
2. Onishi ,T. (2021) Theoretical Chemistry for Advanced Nanomaterials: Functional Analysis by Computation and Experiment. Singapore: Springer Nature Singapore.
3. Roco, M. C., Mirkin, C. A., Hersam, M. C. (2011). Nanotechnology Research Directions for Societal Needs in 2020: Retrospective and Outlook. Germany: Springer Netherlands.
4. Harrison R.M., Hester R.E., (2007) “Nanotechnology: Consequences for Human Health and the Environment”, The Royal Society of Chemistry, UK.
5. Hosono H., MacKenzie K., Mishima Y., Takezoe H., (2006) “Nanomaterials”, Elsevier Science Ltd.

Introduction to Nanochemistry (Lab)

BS-Chemistry

Course Code: CHM-218L

Credit Hours: 01

Pre requisite: Nil

Objectives

Students should be able to understand: Effects of nano-dimensions of particles and how nanochemistry thereby differs from solid state chemistry. Whether turning to a nanostructured material for a given chemical compound is likely to result in grossly modified chemical or physical properties.

Learning Outcomes

- Apply knowledge of top-down and bottom-up synthesis to create mesoporous materials and composites.
- Demonstrate proficiency in employing various synthesis methods, including anodization and deposition-precipitation, to produce nanomaterial with specific properties.

Course Outline

1. Synthesis of metal nanoparticles by
 - Chemical reduction method
 - Hydrothermal Method
 - Sol-gel Method
2. Synthesis of metal oxide nanoparticles
 - Chemical reduction method
 - Hydrothermal Method
 - Sol-gel Method
3. Characterization Techniques (Demonstration or Data Analysis)
 - Tools:
 - UV-Vis spectroscopy – confirms nanoparticle formation
 - DLS (Dynamic Light Scattering) – size distribution
 - SEM/TEM images – morphology

Surface Area Estimation using Adsorption

- **Concept:** Use dyes or Metal ions to estimate surface area of nanoparticles.

Forensic Chemistry

BS-Chemistry

Course Code: CHM-219

Credit Hours: 02

Pre-requisite: Nil

Objectives

At the end of the course, students will have:

- Basic knowledge of forensic chemistry and its scope.
- Understanding of different types of physical and chemical evidence.
- Familiarity with simple chemical techniques used in crime investigation (such as chromatography and color tests).
- Basic understanding of toxicology, fire chemistry, explosives, and DNA analysis.
- Awareness of the importance of proper evidence handling and ethical standard

Learning Outcomes

After completing this course, students will be able to:

- Understand basic forensic chemistry principles, including types of evidence, simple chemical tests, methods for detecting poisons, drugs, fires, explosives, counterfeit materials, and basics of DNA analysis.
- Apply simple forensic techniques and ethical practices, such as collecting and preserving evidence correctly, demonstrating chemical tests, interpreting simple forensic findings, and maintaining honesty in forensic investigations.

Course Outline

Unit 1. Basics of Forensic Chemistry

What is Forensic Chemistry? Importance of Chemistry in Crime Solving, Types of Evidence (blood, drugs, poisons, fire residues), Rules for Handling and Saving Evidence Properly.

Unit 2. Simple Methods to Analyze Evidence

How to Collect and Preserve Evidence, Basic Chemical Tests (color tests for blood, drugs), Introduction to Paper Chromatography, simple Use of Light (Spectroscopy) to Identify Materials.

Unit 3. Detecting Poisons and Drugs

What are Poisons and Drugs? Common Poisons and How They are detected. Testing Blood and Urine for Drugs, Basic Concept of Toxicity (how much is dangerous).

Unit 4. Chemistry of Fire and Explosives

How Fires Start (Fire Triangle: Fuel, Heat, Oxygen), Identifying Chemicals Left after a Fire, Introduction to Explosives (basic types), Methods for Detecting Explosives

Unit 5. New Uses of Chemistry in Forensics

Basics of DNA Testing for Criminal Investigations, Detecting Fake Medicines and Counterfeit Money, Introduction to Environmental Forensics (pollution crimes), Importance of Honesty and Ethics in Forensic Work.

Recommended books/reference material

1. Eckert, W.G. (1996) Introduction to Forensic Sciences. CRC Press, 2nd Edition.

2. Saferstein, R. (1992) (Editor). Forensic Science Handbook. Prentice Hall, Volumes I & II, and later volumes
3. Saferstein, R. (2014) Forensic Science: From the Crime Scene to the Crime Lab. Pearson, 3rd Edition.
4. White, P. (2010) (Editor). Essentials of Forensic Science. Royal Society of Chemistry.

Forensic Chemistry (Lab)

BS-Chemistry

Course Code: CHM-219L

Credit Hours: 01

Pre-requisite: Nil

Objectives

At the end of the course, students will have:

- Basic knowledge of forensic chemistry and its scope.
- Understanding of different types of physical and chemical evidence.
- Familiarity with simple chemical techniques used in crime investigation (such as chromatography and color tests).
- Basic understanding of toxicology, fire chemistry, explosives, and DNA analysis.
- Awareness of the importance of proper evidence handling and ethical standard

Learning Outcomes

After completing this course, students will be able to:

- Understand basic forensic chemistry principles, including types of evidence, simple chemical tests, methods for detecting poisons, drugs, fires, explosives, counterfeit materials, and basics of DNA analysis.
- Apply simple forensic techniques and ethical practices, such as collecting and preserving evidence correctly, demonstrating chemical tests, interpreting simple forensic findings, and maintaining honesty in forensic investigations.

Course Outlines

1. Visualization and Classification of Latent Fingerprints Using Physical and Chemical Methods

2. Detection of Document Forgery Through Paper Chromatography of Inks
3. Simulation of Blood Typing Using Synthetic Blood and Serological Testing
4. Presumptive Identification of Unknown White Powders Using Chemical and Physical Tests
5. Microscopic Analysis and Comparison of Hair and Textile Fibers as Trace Evidence
6. Simulation of Gunshot Residue (GSR) Detection Using Spot Test Reagents
7. Comparative Analysis of Soil Samples Based on Physical and Chemical Characteristics

Industrial Chemistry

BS-Chemistry

Course Code: CHM-213

Credit Hours: 02

Pre-requisite: NIL

Objectives

Students will acquire understanding about Raw materials, flow sheet diagrams, unit operations and applications of industries, Sulphuric acid, Nitric acid, Hydrochloric acid, Oxalic acid, Formic acid, Caustic soda and Washing soda, Cement industry, Petroleum, Textile, Polymer and Fuel industries.

Learning Outcomes

- Students will have comprehensive knowledge about raw materials.
- Flow sheet diagrams, unit operations and applications of various important industries.

Course Outline

Unit 1.

Introduction of Industrial Chemistry

Orientation of course Industrial Chemistry, Parameter for industrial plant Unit process and unit operation.

Unit 2.

Acids

Sulphuric acid industry, industry of oxalic acid and formic acid, nitric acid industry, industry of hydrochloric acid.

Unit 3.

Soda and Textile Industry

Caustic soda industry. Washing soda industry, textile industry

Unit 4.

Cement, Polymer and Petroleum Industry

Introduction to history and types of cement. Cement industry Industry of petroleum. Polymer industry

Unit 5.

Fuel Industry

Introduction to fuels, Petrochemical.

Recommended Books/Reference Material

1. Achaw, O. W. Boateng, E. D. (2021) Chemical and Process Industries. Springer International Publishing, New York.
2. Dubois, J. L. Kaliaguine, S. (2021) Industrial Green Chemistry. De Gruyter, Germany.
3. Davis, K. H. Berner, F. S. (2022) Handbook of Industrial Chemistry Vol 2 cbs publishers and distributors, India.
4. Benvenuto, M. A. (2023) Industrial Chemistry De Gruyter Textbook.

Industrial Chemistry (Lab)

BS-Chemistry

Course Code: CHM-213L

Credit Hours: 01

Pre-requisite: Nil

Objectives

The objective of this course is to perform experiments related to industrial processes using various methods.

Learning Outcomes

- The lab course will develop a practical understanding of students for identification and quantifications of various kind of Industrial products synthesis and analysis.

Course Outline

- Synthesis of Soap by Saponification
- Making Biodiesel from Vegetable Oil
- Making Perfume Using Essential Oils
- Determination of Acetic Acid Content in Vinegar
- Extraction of Caffeine from Tea Leaves
- Determination of Acetic Acid Content in Vinegar

Recommended books/reference material

1. Achaw, O. W. Boateng, E. D. (2021) Chemical and Process Industries. Springer International Publishing, New York.
2. Dubois, J. L. Kaliaguine, S. (2021) Industrial Green Chemistry. De Gruyter, Germany.
3. Benvenuto, M. A. (2023) Industrial Chemistry, De Gruyter Textbook.
4. Rogers, A. (2023) Laboratory Guide of Industrial Chemistry, Legare Street Press.

5. Ali, M. F. Ali, B. M. Speight, J. G. 2005, Handbook of Industrial Chemistry: Organic Chemicals, 1st Edition, Mc Graw Hill.

Environmental Chemistry

BS-Chemistry

Course Code: CHM-220

Credit Hours: 02

Pre-requisite: Nil

Objectives

The objective of this course is to identify chemical fate and mobility of contaminants and to discuss emission pathways and sources in the emission scenarios that involve the release of chemicals. It will help students to explain the transport, accumulation and transformation processes of organic and inorganic substances in the environment, based on their chemical properties.

Learning Outcomes

- Illustrate chemical processes that affect the toxicity and bioavailability of contaminants.
- Describe chemical aspects of contaminant remediation and pollution prevention (green chemistry).
- Appraise physical, analytical, organic and inorganic chemistry that can be applied to complex environmental systems.
- Independently plan and practically execute an environmental study including sampling, sample handling, analysis and quality control.

Course Outline

Unit 1. Chemistry and Environment

Recap to introductory environmental chemistry, types of chemicals in the environment, biogeochemical cycles of environment

Unit 2. Atmosphere

Chemical composition of atmosphere, classification of air pollutants and their Sources, Major greenhouse gases (CO₂ and H₂O) and their impact, Characteristics of Various Vehicular Pollutants and health impacts.

- Stratospheric Chemistry: The ozone layer and its depletion
- Tropospheric Chemistry: Ground-Level air pollution

- Photochemical smog, acidic deposition, particulates

Unit 3. Remedial Technologies for Atmospheric Pollution

Separation, Sorption, Photocatalytic/Photo electrochemical degradation of pollutants, Clean energy production, CO₂ capture and utilization, Alternative fuels, Eco-friendly cars.

Unit 4. Chemistry of Soil and Treatment Methods

Pollutants, Sources of pollutants, agriculture, mining, urban, industrial and domestic waste treatment, Pesticides and insecticides, organochlorine, Organic farming, integrated pest management, Phyto chemistry.

Unit 5. Analytical Methods

Instrumental methods of environmental chemistry, chemical analysis and analytical methods such as atomic absorption spectrophotometer (AAS), inductively coupled plasma, mass spectrometry (ICP-MS), liquid chromatography (LC), gas chromatography (GC).

Recommended books/reference material

1. Ahluwalia, V. K. (2017). Advanced Environmental Chemistry. The Energy and Resources Institute (TERI).
2. Hanif, M. A. Nadeem, F. Bhatti, I. A. Tauqeer, H. M. (2020) Environmental Chemistry A Comprehensive Approach. Wiley.
3. Manahan, S. E. (2022) Environmental Chemistry, Eleventh Edition, Tylor and Francis.
4. Ogwu, M. C. Izah, S. C. (2025) Sustainable Strategies for Air Pollution Mitigation Springer Cham.

Environmental Chemistry (Lab)

BS-Chemistry

Course Code: CHM-220L

Credit Hours: 01

Pre-requisite: Nil

Objectives

The objective of this course is to identify contaminants in different environmental samples using various experimental methods and enable students to identify and quantify various organic, inorganic pollutants.

Learning Outcomes

- The lab course will develop a practical understanding of students for identification and quantifications of various kind of environmental pollutants

Course Outline

- Quantitative analysis of Nitrate and Phosphate in surface water
- Soil pH and metal Content Mapping of soil samples
- Measuring the Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) of Wastewater
- Natural Indicator Extraction and Use for pH Testing
- Effect of Detergents (other Toxic chemical) on Plant Growth (Toxicity Bioassay)

Recommended books/reference material

1. Murphy, R. A. (2022) Environmental Chemistry in the Lab 1st Edition, Routledge Tylor and Francis
2. Ibanez, J. G. Hernandez-Esparza, M. Doria-Serrano, C. Fregoso-Infante , A. Singh, M. M. (2011) Environmental chemistry; microscale laboratory experiments, Springer New York, NY
3. Manahan, S. E. (2022) Environmental Chemistry, Eleventh Edition, Tylor and Francis.
4. Ogwu, M. C. Izah, S. C. (2025) Sustainable Strategies for Air Pollution Mitigation Springer Cham.

Pharmaceutical Chemistry

BS-Chemistry

Course Code: CHM-221

Credit Hours: 2

Pre-requisite: Nil

Objectives

To introduce students to the basic principles of drug discovery, development, and classification.
To expose students to modern trends such as biopharmaceuticals, nanotechnology, and personalized medicine.

Learning Outcomes

By the end of this course, the students will be able to:

- Explain fundamental concepts in pharmaceutical chemistry, including drug design and synthesis, physico-chemical properties of drugs, and their interactions with biological systems.
- Analyze the principles of drug action, absorption, distribution, metabolism, excretion and toxicity to understand drug efficacy and safety.
- Design, develop and investigate pharmaceutical compounds, emphasizing quality control and assurance.

Course Outline

Unit 1. Introduction to Pharmaceutical Chemistry

Drug discovery and development process. Classification of drugs based on therapeutic use and chemical structure. Overview of dosage forms (tablets, capsules, injections)

Unit 2. Drug Design and Synthesis

Basic principles of drug design and molecular modification, Structure-activity relationships (SAR). Green chemistry approaches.

Unit 3. Pharmacokinetics and Pharmacodynamics

Drug absorption, distribution, and metabolism. Mechanisms of drug action: receptors, enzymes etc.

Unit 4. Quality Control and Assurance

Analytical techniques: UV-Vis, IR, etc, Basics of spectroscopy in drug analysis, Regulatory requirements: FDA, EMA, and WHO guidelines.

Unit 5. Emerging Trends

Biopharmaceuticals and nanotechnology in drug delivery, personalized medicine and pharmacogenomics, Role of artificial intelligence in drug discovery.

Recommended Books/Reference Material

1. Ashutosh Kar (2020). Medicinal Chemistry, New Age International Publishers.
2. David G. Watson (2016). Pharmaceutical Chemistry, Elsevier Health Sciences.
3. G. Patrick (2017). An Introduction to Medicinal Chemistry (6th Ed.), Oxford University Press.

4. Satyajit D. Sarker & Lutfun Nahar (2015). Chemistry for Pharmacy Students, Wiley.
5. Thomas L. Lemke (2019). Foye's Principles of Medicinal Chemistry (8th Ed.), Wolters Kluwer. Valler & Green (2016). Biotechnology and Biopharmaceuticals, Wiley.

Pharmaceutical Chemistry (Lab)

BS-Chemistry

Course Code: CHM-221L

Credit Hours: 1

Pre-requisite: Nil

Objectives

To introduce students to the basic principles of drug discovery, development, and classification.
To expose students to modern trends such as biopharmaceuticals, nanotechnology, and personalized medicine.

Learning Outcomes

By the end of this course, the students will be able to:

- Explain fundamental concepts in pharmaceutical chemistry, including drug design and synthesis, physico-chemical properties of drugs, and their interactions with biological systems.
- Analyze the principles of drug action, absorption, distribution, metabolism, excretion and toxicity to understand drug efficacy and safety.
- Design, develop and investigate pharmaceutical compounds, emphasizing quality control and assurance.

Course Outlines

- Synthesis of Aspirin
- Preparation and purification of acetylsalicylic acid.
- Synthesis and recrystallization of paracetamol.
- Drug Formulation
- Preparation of a simple tablet formulation. Evaluation of tablet hardness and disintegration time.
- Quality Control Testing
- Assay of active pharmaceutical ingredients (APIs) using titration methods.

- Chromatographic Techniques: Separation and identification of drug components using TLC.
- Synthesis of 4-Nitro Aniline and study of its medicinal value.
- Synthesis of Acetanilide and study of its medicinal value.

Recommended Books/Reference Material

1. Ashutosh Kar (2020). Medicinal Chemistry, New Age International Publishers.
2. David G. Watson (2016). Pharmaceutical Chemistry, Elsevier Health Sciences.
3. G. Patrick (2017). An Introduction to Medicinal Chemistry (6th Ed.), Oxford University Press.

Advanced Organic Chemistry

BS-Chemistry

Course Code: CHM-315

Credit Hours: 2

Pre-requisite: Nil

Objectives

The objective of this course is to understand the mechanisms of organic reactions, stereochemical outcomes, and synthetic strategies for designing complex molecules with industrial and pharmaceutical relevance.

Learning Outcomes

- Explain reaction mechanisms, stereochemistry, and the synthesis of organic molecules.
- Apply synthetic methods to design complex organic compounds relevant to pharmaceuticals and polymers.

Course Outline

Unit 1. Reaction Mechanisms in Organic Chemistry

Types of organic reactions: substitution, elimination, addition, rearrangement, Mechanistic pathways: kinetic vs thermodynamic control, Hammond postulate, energy diagrams, Concepts of aromaticity and electrophilic/nucleophilic aromatic substitution.

Unit 2. Stereochemistry and Chiral Molecules

Chirality, enantiomers, diastereomers, and meso compounds, Absolute and relative configuration (R/S and E/Z), Optical activity and resolution of enantiomers, Stereoselective and stereospecific reactions.

Unit 3. Advanced Synthetic Strategies

Chemoselectivity, regioselectivity, and stereoselectivity, Functional group interconversion (FGI) and strategic bond formation, Multi-step synthesis design: case studies.

Unit 4. Named Reactions and Modern Methods

Important named reactions (Aldol, Michael, Diels-Alder, Wittig, Suzuki, Heck, etc.), Use of organometallic reagents (Grignard, organolithium, organocuprates).

Unit 5. Applications in Pharmaceuticals and Polymers

Synthesis of pharmacologically active molecules, Polymer-forming reactions and monomer synthesis, Functional organic materials: dyes, OLEDs, and biomaterials.

Recommended books/reference material

1. Balci, M. (2021). Reaction Mechanisms in Organic Chemistry. Germany: Wiley.
2. Carey, F. A., Sundberg, R. J. (2013). Part B: Reactions and Synthesis. Germany: Springer Berlin Heidelberg.
3. Clayden, J., Greeves, N., Warren, S. (2012). Organic Chemistry. United Kingdom: OUP Oxford.
4. Lewis, D. E. (2016). Advanced Organic Chemistry. United States: Oxford University Press.

Advanced Organic Chemistry (Lab)

BS-Chemistry

Course Code: CHM-315 L

Credit Hours: 01

Pre-requisite: Nil

Objectives

The objective of this course is to provide hands-on training in advanced organic synthesis techniques and reaction mechanisms with emphasis on stereochemistry, purification, and structure elucidation.

Learning Outcomes

By the end of this laboratory course, students will be able to:

- Perform multi-step organic synthesis reactions with precision and safety.
- Analyze stereochemical outcomes of organic reactions.
- Apply green chemistry principles in laboratory practices.
- Use chromatographic and spectroscopic techniques for purification and characterization.

Course Outline

1. Preparation of Acetanilide from Aniline
2. Bromination of Acetanilide (Green Chemistry Approach)
3. Preparation of Benzilic Acid from Benzil
4. Synthesis of Aspirin (Acetylsalicylic Acid)
5. Stereoselective Reduction of Camphor Using Sodium Borohydride
6. Aldol Condensation: Synthesis of Dibenzalacetone
7. Claisen-Schmidt Condensation
8. Diels–Alder Reaction: Cycloaddition of Furan and Maleic Anhydride
9. Extraction and Purification of Caffeine from Tea
10. Chromatography (TLC and Column)
11. Spectral Analysis Practice (UV-Vis, IR, NMR Interpretation Exercises)

Recommended books/reference material

1. Fisher, H. L. (2023). Laboratory Manual of Organic Chemistry. (n.p.): Creative Media Partners, LLC.
2. Liskin, D. V., Chaloner, P. (2015). Advanced Organic Synthesis: A Laboratory Manual. United States: CRC Press.
3. Monson, R. (2012). Advanced Organic Synthesis: Methods and Techniques. United States: Elsevier Science.

4. Pavia, D. L., Kriz, G. S., Lampman, G. M., Engel, R. G. (2016). A Microscale Approach to Organic Laboratory Techniques. United States: Cengage Learning.

Advanced Inorganic Chemistry

BS-Chemistry

Course code: CHM-316

Credit Hours: 02

Pre-requisite: Nil

Objectives

The objective of this course is to acquire knowledge about various types of inorganic materials, their structure, bonding, synthesis, characterization and applications in various fields.

Learning Outcomes

By the end of this course, the students will be able to:

- Describe the bonding, structure, and reactivity of complex inorganic compounds, including transition metals and coordination complexes.
- Analyze advanced inorganic reactions with relevance to catalysis, materials science and bioinorganic applications.
- Evaluate the role of inorganic compounds in industrial processes, environmental chemistry and biological systems.

Course Outline

Unit 1. Transition Metal and Coordination Chemistry

d-block elements, oxidation states. Crystal field and ligand field theories: high-spin vs. low-spin complexes. Jahn–Teller distortions and electronic spectra. Nomenclature, Stereoisomerism (cis/trans, optical), Coordination number, Geometry and Chelation.

Unit 2. Mechanisms in Inorganic Reactions

Substitution reactions: associative/dissociative/interchange. Electron transfer reactions: inner- and outer-sphere mechanisms. Reaction kinetics and factors affecting rate

Unit 3. Inorganic Catalysis

Principles of catalysis: energy profiles and selectivity. Homogeneous catalysis: Wilkinson's catalyst, olefin polymerization. Heterogeneous catalysis: surface interactions.

Unit 4. Inorganic Materials and Solid-State Chemistry

Semiconductors, superconductors, and MOFs (metal-organic frameworks). Nanostructured materials and their inorganic components. Structure–property relationships in materials

Unit 5. Properties of Advanced Materials

Synthesis (e.g., sol-gel, hydrothermal techniques, etc.) and design of inorganic materials, Properties of advanced materials, Inorganic materials characterization. Doping and purification techniques of available inorganic materials

Unit 6. Bioinorganic and Environmental Chemistry

Metals in biological systems: iron, copper, zinc, cobalt. Metalloenzymes and metal-based drugs (cisplatin, MRI agents). Environmental roles: heavy metals, remediation, nutrient cycles.

Recommended books/reference material

- Bhatti, H. N. (2022). Advanced inorganic chemistry (Vol. 1 & 2). Caravan Book House.
- Brian.W., (2022), Principles of Inorganic Chemistry, (2nd ed.), Wiley publishers
- Hosmane, N. S. (2020). Advanced inorganic chemistry: Applications in everyday life. Academic Press.
- Tuli, G. D., Basu, S. K., Prakash, S., & Madan, R. D. (2022). Advanced inorganic chemistry (19th ed., Vol. 1). S. Chand Publishing.

Advanced Inorganic Chemistry (Lab)

BS-Chemistry

Course Code: CHM-316L

Credit Hours: 01

Pre-requisite: Nil

Objectives

After performing Lab, Students will acquire knowledge about various types of inorganic materials, their structure, synthesis, and characterization and applications in various fields.

Learning Outcomes

The lab course is designed to make students comprehend the nature and properties of different materials. After studying this course students will be able to explain the suitability and usefulness of a particular material for a specific purpose.

Course Outline

- Prepare a colored metal–ligand complex such as synthesis of $[\text{Cu}(\text{NH}_3)_4]\text{SO}_4$
- Build models of $[\text{CoCl}_2(\text{NH}_3)_4]^+$ and $[\text{Co}(\text{en})_3]^{3+}$ and identify isomers visually.
- Observe a simple transition metal redox reaction. Mix FeSO_4 and acid in test tube and add KMnO_4 drop by drop—watch purple color fade.
- Observe pH effects on a colored iron complex. Mix FeCl_3 and NaSCN —observe red complex. Add acid/base and note color intensity change.
- Apply simple tests to detect transition metals in water. Add NaOH dropwise to water sample. Note any precipitates (e.g., $\text{Fe}(\text{OH})_3$, $\text{Cu}(\text{OH})_2$). Add NH_3 and observe further color/solubility changes.
- Observe a catalytic reaction using MnO_2 . Add MnO_2 to H_2O_2 —observe rapid bubbling (O_2 release). Discuss role of MnO_2 as a catalyst.

Recommended books/reference material

1. Hosmane, N. S. (2020). Advanced inorganic chemistry: Applications in everyday life. Academic Press. <https://doi.org/10.1016/C2018-0-04451-4>
2. Housecroft, C. E., & Sharpe, A. G. (2018). Inorganic chemistry (5th ed.). Pearson Education.

Advanced Physical Chemistry

BS-Chemistry

Course Code: CHM-317

Credit Hours: 03

Pre-requisite: Nil

Objectives

After studying this course, the students will acquire knowledge and understanding about the theoretical and instrumental as well as application related aspects of conductometric, and electrochemical techniques and surface chemistry. They will also acquire information regarding nuclear binding energy, nuclear instabilities and decay mechanisms as well as the fission and fusion processes.

Learning Outcomes

- Students will gain understanding about conceptual understanding of key concepts in Physical Chemistry especially in field of Nuclear, Surface and electrochemistry.
- Which will help students further in research and applications of Physical Chemistry.

Course Outlines:

Unit 1. Kinetic Theory of Gases

Introduction to Kinetic theory of Gases, Probability density for molecular speeds of gas molecules, Maxwell distribution of molecular speeds, average speeds of gases. Maxwell Boltzmann's law of energy distribution, Pressure of an ideal gas, calculation of molecular speeds, binary collisions, effusion and mean free paths Method for the determination of the Avogadro's number (N_A), Statistical probability and entropy.

Unit 2. Nuclear Chemistry

Atomic nucleus, nuclides, nuclear stability. Modes of decay, nuclear energetics. Nuclear models (shell + liquid drop model), fusion and fission. Nonspontaneous nuclear processes, nuclear reactors, beta decay systematic.

Unit 3. Surface Chemistry

Introduction to surface chemistry, Interfaces, Gibbs surface excess, curved surfaces. Capillary action, adsorption and adsorption isotherms, Freundlich and Langmuir adsorption isotherms, catalysis, colloids, emulsion and their industrial applications.

Unit 4. Conductometry

Ions in solution, measurement of conductance and Kohlrausch's law, mobility of ions and transport number, Conductometric titrations, Debye-Hückel theory and activity coefficient.

Unit 5. Spectroscopy

Electromagnetic radiation, its interaction with matter, nature of different transitions possible in atoms, rotational, vibrational and rotational-vibrational spectra of diatomic and polyatomic molecules.

Recommended Books/Reference Material

1. Alberty, R. A., Bawendi, M. G., and Silbey, R. J., (2005) Physical Chemistry, 4th ed., John-Wiley & Sons.
2. Atkins, P. and Paula, J. D., (2010) Atkin's Physical Chemistry, 9th ed., Oxford University Press.
3. Bhatti, H. N., Farooqi, Z. H., (2013) "Modern Physical Chemistry" The Carvan Books House, Lahore.
4. Ball, D W. (2003) "Physical Chemistry" 1st ed., Brooks/Cole Co. Inc.

5. Bahl, A., Tuli, G.P. (2022), *Essentials of Physical Chemistry* 28th edition, S.Chand Publishers, India.
6. Jyotsna, P., Prashant.M. (2023), *Physical Chemistry*, (1st ed) AGPH Books, Bhopal India.
7. Bahl, A., Tuli, G.P. (2022), *Essentials of Physical Chemistry* 28th edition, S.Chand Publishers, India.
8. Jyotsna, P., Prashant.M. (2023), *Physical Chemistry*, (1st ed) AGPH Books, Bhopal India.

Advanced Analytical Chemistry

BS-Chemistry

Course Code: CHM-318

Credit Hours: 02

Pre-requisite: Nil

Objectives

Students will acquire understanding about the importance of separation techniques, their use in sample separation and its quantitative analysis. They will also learn and develop understanding about spectrophotometer and its applications.

Learning Outcomes

- Students will gain understanding about various analytical techniques used by chemists.
- Students will be able to learn basic principles of separation techniques and spectrophotometric techniques, basic instrumentation and significance of these techniques.

Course Outline

Unit 1. Chromatography

Basics of analytical separations. Principle of chromatography. Classification of chromatographic techniques. Overview of paper chromatography, thin layer chromatography, column and ion exchange chromatography. Gel permeation Chromatography. HPLC and Gas chromatography.

Unit 2. Solvent Extraction

Principle and theory of solvent extraction. Solvent extraction of metals. Multiple batch extraction. Counter current distribution. Solid- phase extraction. Solvent extraction by flow injection method.

Unit 3. Electrophoresis

Principle, types and instrumentation of electrophoresis. Applications of traditional electrophoresis.

Unit 4. Spectrophotometry

Properties of light and its interaction with matter. Relation between frequency, velocity and wave number. Lambert-Beer's law, its applications and limitations. Single beam and double beam spectrophotometers. Lamps and lasers as sources of light.

Unit 5. Flame Emission Spectroscopy

Basic principle of atomic spectroscopy. Use of atomic spectra for detection and determination of elements. Flame as a source of atomization and excitation. Instrumentation involved in FES. FES applications and limitations.

Recommended Books/Reference Material

1. Braithwaite, A., & Smith, J.F. (2012). Chromatographic methods. Springer Science & Business Media, Berlin, Germany.
2. Burgot, G., & Burgot, J.L. (2023). General analytical chemistry: Separation and spectral methods. CRC Press, United States.
3. Fifield F.W., & David K. (2012). Principles and practice of analytical chemistry, (5th ed.) John Wiley and Sons Inc. New Jersey, USA.
4. Gary, D.C. (2004) Analytical chemistry, (6th ed.), John Wiley and Sons Inc. New Jersey, USA.
5. Grinberg, N., & Carr, P.W. (Eds.). (2020). Advances in chromatography, Volume 57 (Vol. 57). CRC Press, United States.
6. Robinson, J.W., Frame, E.M.S., & Frame II, G. M. (2021). Instrumental analytical chemistry: An introduction. CRC Press, United States.
7. Skoog, D.A., & West, D.M. (2014). Fundamentals of analytical chemistry. (9th ed.) Holt Reinchart and Inc, London, UK.
8. Skoog, D. A., West, D. M., Holler, F. J., Crouch, S. R. (2022). Fundamentals of Analytical Chemistry. Brazil: Cengage.
9. Analytical Chemistry: Advancement, Perspectives and Applications. (2021). United Kingdom: Intech Open.

Advanced Analytical Chemistry (Lab)

BS-Chemistry

Course Code: CHM-318L

Credit Hours: 01

Pre-requisite: Nil

Objectives

Students will acquire understanding about the different separation techniques like solvent extractions, thin layer chromatography, paper chromatography, ion exchange chromatography, quantitative determination of different substances by UV –visible and IR spectrophotometer.

Learning Outcomes

- Students will gain understanding about various analytical techniques used by chemists.
- Students will be able to learn basic principles and instrumentation and significance of these techniques.

Course Outline

- Separation of phenol from the given organic mixture by solvent extraction.
- Separation of mixture of cations by paper chromatography.
- Analysis of composition of a mixture of nitro anilines by TLC.
- Separation of sugars by paper chromatography.
- Separation of amino acids by paper/TLC.
- Deionization and softening of water by ion exchange chromatography.
- Determination of λ_{max} of KMnO_4 and KCrO_4 solutions to verify Beer-Lambert's law.
- Determination of analgesic property of aspirin and caffeine by double beam spectrophotometer.
- Quantitative analysis of iron by spectrophotometer.
- Study of IR spectrum of different compounds.

Recommended Books/Reference Material

1. Gary D. Christian, (2004). *Analytical Chemistry*, 6TH Edition, John Wiley and Sons Inc. New Jersey, USA
2. David Kealey, and F. W. Fifield (2012). *Principles and Practice of Analytical Chemistry*, 5th Edition, John Wiley and Sons Inc. New Jersey, USA.
3. Douglas A. Skoog and Donald M. West, (2014). *Fundamentals of Analytical Chemistry*, 9th Edition, Holt Reinchart and Inc, London, UK.
4. E. Heftman, *Chromatography: Fundamentals and Applications of Chromatography and Related Differential Migration Methods*, (2004). Elsevier, Amsterdam, Netherland.
5. A. Braithwaite, (2012). *Chromatographic Methods*, Springer Science & Business Media, Berlin, Germany.

Soil Chemistry

BS-Chemistry

Course Code: CHM-319

Credit Hours: 2

Pre-requisite: Nil

Objective

To provide students with in-depth knowledge of soil composition, nutrient chemistry, and plant-soil-water interactions, emphasizing how these factors affect plant growth and adaptation under various environmental conditions.

Learning Outcomes

- Students will understand the chemical composition and ion exchange processes that govern soil fertility and nutrient availability.
- They will be able to analyze how soil pH, redox potential, and organic matter affect plant nutrient uptake and growth.
- They will also be able evaluate plant responses and adaptations to soil water stress and relate them to soil chemical characteristics.

Course Outline

Unit 1: Soil Composition, Properties and Ion Exchange

Composition and functions of soil, physical and chemical properties of soil, cation and anion exchange capacities of soil, Adsorption and desorption of ions

Unit 2: Soil Chemistry of Nutrients and Environmental Conditions

Chemical forms of essential nutrients in aerated and submerged soils, nutrient availability in relation to redox conditions, soil redox potential and its influence on nutrient forms, soil pH and buffering capacity

Unit 3: Soil Fertility and Soil Organic Matter

Base saturation percentage of soil, Soil organic matter: composition and types, fractionation of organic matter, significance of organic matter in soil chemistry and fertility.

Unit 4: Soil-Plant-Water Relations

Soil-plant-water interactions, movement of water in soil and into roots, root-stem pressure and its relation to plant respiration, mineral uptake mechanisms in plants

Unit 5: Plant Adaptation to Soil Water Stress

Plant adaptations to water-deficient conditions, mechanisms of drought resistance and water use efficiency, effect of soil moisture conditions on nutrient uptake, role of soil chemistry in plant stress physiology.

Recommended books/reference material

1. Anderson, A. (2023). *Introduction to soil science*. Iowa State University.
2. Hafeez, F. Y., & Malik, K. A. (2000). *Manual on biofertilizer technology*. National Institute for Biotechnology and Genetic Engineering (NIBGE).
3. Sparks, D. L., Singh, B., & Siebecker, M. G. (2024). *Environmental soil chemistry* (3rd ed.). Academic Press.
4. Strawn, D. G. (2023). *Soil chemistry* (5th ed.). Wiley.
5. Tan, K. H. (2011). *Principles of soil chemistry* (4th ed.). CRC Press.

Soil Chemistry (Lab)

BS-Chemistry

Course Code: CHM-319L

Credit Hours: 01

Pre-requisite: Nil

Objective

To provide students with in-depth knowledge of soil composition, nutrient chemistry, and plant-soil-water interactions, emphasizing how these factors affect plant growth and adaptation under various environmental conditions.

Learning Outcomes

- Students will understand the chemical composition and ion exchange processes that govern soil fertility and nutrient availability.
- They will be able to analyze how soil pH, redox potential, and organic matter affect plant nutrient uptake and growth.
- They will also be able evaluate plant responses and adaptations to soil water stress and relate them to soil chemical characteristics.

Lab Outline:

1. Soil sampling and sample handling.
2. Determination of soil pH and electrical conductivity (EC)
3. Determination of soil organic matter.
4. Determination of extractable potassium and sodium.
5. Determination of extractable phosphorus.
6. Determination of soil cation exchange capacity (CEC)

Recommended books/reference material

6. Anderson, A. (2023). *Introduction to soil science*. Iowa State University.
7. Hafeez, F. Y., & Malik, K. A. (2000). *Manual on biofertilizer technology*. National Institute for Biotechnology and Genetic Engineering (NIBGE).
8. Sparks, D. L., Singh, B., & Siebecker, M. G. (2024). *Environmental soil chemistry* (3rd ed.). Academic Press.
9. Strawn, D. G. (2023). *Soil chemistry* (5th ed.). Wiley.
10. Tan, K. H. (2011). *Principles of soil chemistry* (4th ed.). CRC Press.

Computational Chemistry

BS-Chemistry

Course Code: CHM-320

Credit Hours: 02

Pre-requisite: Nil

Course Objectives:

By the end of the course, students will:

- Learn the basics of molecular modeling and chemical reaction simulations.
- Understand how to apply computational methods in drug design and materials chemistry.

Learning Outcomes:

After completing this course, students will be able to:

- **Use computational tools** to model molecular structures and simulate chemical reactions.
- **Evaluate simulation results** to understand chemical reactions, drug designs, and material properties.

Course Outline

Unit 1. Introduction to Computational Chemistry

What is Computational Chemistry? Basic Concepts of Molecular Modeling.
Importance of Computational Tools in Chemistry

Unit 2. Modeling Molecular Structures

Basic Techniques for Modeling Molecular Structures, Introduction to Quantum Chemistry and Software Tools (e.g., Gaussian)

Unit 3. Simulating Chemical Reactions

How to Simulate Chemical Reactions, Basics of Potential Energy Surfaces and Reaction Pathways

Unit 4. Applications in Drug Design and Materials Chemistry

Introduction to Drug Design Using Computational Methods, Simulating Material Properties in Chemistry.

Unit 5. Evaluating Computational Results

How to Interpret Simulation Data, Using Computational Chemistry for Experimental Research Planning

Recommended books/reference material

1. Cramer, C. J. (2004) Essentials of Computational Chemistry: Theories and Models. Wiley, 2nd Edition.
2. Hehre, W. J. (2003) A Guide to Molecular Mechanics and Quantum Chemical Calculations. Wavefunction Inc., 2003.
3. Jensen, F. (2017) Introduction to Computational Chemistry. Wiley, 3rd Edition.
4. Leach, A. R. (2001) Molecular Modelling: Principles and Applications. Pearson, 2nd Edition.

Computational Chemistry (Lab)

BS-Chemistry

Course Code: CHM-320L

Credit Hours: 01

Pre-requisite: Nil

Course Objectives:

By the end of the course, students will:

- Learn the basics of molecular modeling and chemical reaction simulations.
- Understand how to apply computational methods in drug design and materials chemistry.

Learning Outcomes:

After completing this course, students will be able to:

- **Use computational tools** to model molecular structures and simulate chemical reactions.
- **Evaluate simulation results** to understand chemical reactions, drug designs, and material properties.

Course Outlines:

1. Geometry Optimization and Energy Minimization of Small Molecules Using Quantum Mechanical Methods
2. Calculation of Molecular Orbitals and Visualization of HOMO-LUMO Using Gaussian or ORCA
3. Prediction of Vibrational Spectra (IR) of Simple Molecules and Comparison with Experimental Data
4. Computational Determination of Reaction Pathways and Activation Energies Using Transition State Theory
- f. Molecular Electrostatic Potential (MEP) Mapping to Identify Reactive Sites in Organic Molecules
5. Conformational Analysis and Potential Energy Surface Scanning of Flexible Molecules
6. Molecular Docking of Small Ligands to Protein Active Sites Using AutoDock or PyRx.

Recommended books/reference material

1. Cramer, C. J. (2004) Essentials of Computational Chemistry: Theories and Models. Wiley, 2nd Edition.
2. Hehre, W. J. (2003) A Guide to Molecular Mechanics and Quantum Chemical Calculations. Wavefunction Inc., 2003.
3. Jensen, F. (2017) Introduction to Computational Chemistry. Wiley, 3rd Edition.
4. Leach, A. R. (2001) Molecular Modelling: Principles and Applications. Pearson, 2nd Edition.

Agricultural Chemistry

BS-Chemistry

Course Code: CHM- 321

Credit Hours: 02

Pre-requisite: Nil

Objective

To provide students with a comprehensive understanding of the chemical principles and applications essential for sustainable agricultural practices

Learning Outcomes

- Students will be able to analyze the chemical properties of soil, water, and fertilizers for optimizing crop productivity.
- They will understand the roles of nutrients, pesticides, and agrochemicals in plant growth and environmental sustainability.
- They will gain insight into modern agricultural technologies such as nanotechnology applications in agriculture.

Course Outline

Unit 1: Introduction to Agricultural Chemistry

Scope and importance of agricultural chemistry, chemistry of irrigation water; composition, salinity, alkalinity, and sodicity, climate change: causes, chemical implications, and impact on agriculture

Unit 2: Soil Chemistry and Fertility

Composition and classification of soils, Soil pH, buffering capacity, and redox potential, cation exchange capacity (CEC) and anion exchange capacity (AEC), soil fertility and nutrient-holding capacity

Unit 3: Plant Nutrition and Fertilizers

Essential plant nutrients: classification, sources, and physiological roles, nutrient deficiency and toxicity symptoms in plants, types of fertilizers: organic, inorganic, and biofertilizers, fertilizer application methods and nutrient use efficiency, environmental concerns: leaching, runoff, and pollution.

Unit 4: Pesticides and Agrochemicals

Classification of pesticides: insecticides, herbicides, fungicides, and others, chemistry and mode of action of major agrochemicals, formulation and application techniques of pesticides, environmental impacts, toxicity, and pesticide residue management.

Unit 5: Applied Agricultural Chemistry

Industrial processes in agriculture: biofuel, sugar, pulp and paper, soap industries, applications of nanotechnology in agriculture.

Recommended books/reference material

1. Havlin, J. L., Tisdale, S. L., Nelson, W. L., & Beaton, J. D. (2023). *Soil fertility and fertilizers: An introduction to nutrient management*. Pearson.
2. Lamb, E. (2022). *Agricultural chemistry: Concepts and applications*. Larsen & Keller Education.
3. Nelson, W. M. (2023). *Sustainable agricultural chemistry in the 21st century: Green chemistry nexus*. CRC Press.
4. Purdue University Extension. (2023). *The complete book of pesticide management*. Purdue University Press.
5. Sela, G. (2023). *Fertilization and irrigation*. Cropaia.
6. Sparks, D. L. (2023). *Environmental soil chemistry* (3rd ed.). Academic Press.
7. Springer. (2023). *One Health implications of agrochemicals and their sustainable alternatives*. Springer Nature. <https://doi.org/10.1007/978-981-99-3439-3>
8. Strawn, D. G., Bohn, H. L., & O'Connor, G. A. (2023). *Soil chemistry* (5th ed.). Wiley.
9. Elsevier. (2023). *Pesticides in the environment: Impact, assessment, and remediation*. Elsevier.

Agricultural Chemistry (Lab)

BS-Chemistry

Course Code: CHM-321L

Credit Hours: 01

Pre-requisite: Nil

Objective

To provide students with a comprehensive understanding of the chemical principles and applications essential for sustainable agricultural practices

Learning Outcomes

- Students will be able to analyze the chemical properties of soil, water, and fertilizers for optimizing crop productivity.
- They will understand the roles of nutrients, pesticides, and agrochemicals in plant growth and environmental sustainability.
- They will gain insight into modern agricultural technologies such as nanotechnology applications in agriculture.

Lab Outline:

1. Formation of soap and detergents.
2. Production of crude brown sugar from sugarcane juice.
3. Extraction of crude oil from oil seeds.
4. Ethanol production from corn.
5. Industrial visit to study the manufacturing process.

Recommended books/reference material

1. Havlin, J. L., Tisdale, S. L., Nelson, W. L., & Beaton, J. D. (2023). *Soil fertility and fertilizers: An introduction to nutrient management*. Pearson.
2. Lamb, E. (2022). *Agricultural chemistry: Concepts and applications*. Larsen & Keller Education.
3. Nelson, W. M. (2023). *Sustainable agricultural chemistry in the 21st century: Green chemistry nexus*. CRC Press.
4. Purdue University Extension. (2023). *The complete book of pesticide management*. Purdue University Press.
5. Sela, G. (2023). *Fertilization and irrigation*. Cropaia.
6. Sparks, D. L. (2023). *Environmental soil chemistry* (3rd ed.). Academic Press.
7. Springer. (2023). *One Health implications of agrochemicals and their sustainable alternatives*. Springer Nature. <https://doi.org/10.1007/978-981-99-3439-3>
8. Strawn, D. G., Bohn, H. L., & O'Connor, G. A. (2023). *Soil chemistry* (5th ed.). Wiley.
9. Elsevier. (2023). *Pesticides in the environment: Impact, assessment, and remediation*. Elsevier.

Chemical Safety and Risk Management

Course Code: CHM-403

Credit Hours: 3

Prerequisite: Nil

Objectives:

The objectives of this course is to study the laboratory management, safety methods and precautions.

Course outcomes:

The students will be able to:

- Comprehend the laboratory organizing, management and safety methods.
- Create willingness to seek knowledge of hazards and of safety procedures and precautions.
- Implement the safety rules in the laboratory effectively.
- Store the equipment, materials and chemicals safely.

Course Outline:

Unit 1. Laboratory Design

Designs of laboratories and other facilities, Storage of laboratory equipment, Storage of materials and chemicals, Management of students

Unit 2. Management of Chemistry Laboratory

Staffing, finance, budgeting, guidelines in preparing lists of requirements, preservation and storage of materials, inspection and maintenance of laboratories and equipment, the chemistry of laboratory.

Unit 3. Laboratory Techniques

Glass working skills, practices in wood working, healthy working environment, metal working, working with electricity, working with chemical reagents and instruments handling.

Unit 4. Laboratory Safety

General laboratory safety and techniques, fire extinguishers, ventilation hoods.

Unit 5. First aid treatment

First aid treatment, chemical hazards, fire hazards.

Recommended Books:

1. Braun, Tibor, BujdosÃ³, Ernő, Schubert, András, Literature of Analytical Chemistry, Edition 1st; 2020.
2. Kenkel, John, Analytical Chemistry Refresher Manual, Edition 1st; 2019.
3. Laboratory Safety Manual, Environmental Health & Safety, University of Washington, 2015.
4. Robert H. Hill and David C. Finster, Laboratory Safety for Chemistry Students, 2nd Edition; 2016, John Wiley & Sons.
5. Zaikov, Gennady E. |Haghi, A. K. Analytical Chemistry from Laboratory to Process Line, Edition 1st; 2021.

10. List of Elective Courses

List of Elective Courses (3 credit Hours each)

Domain	Course Code	Course Title	Course Type
Inorganic chemistry	CHM-412	Pi- acceptor Ligands and polymers	Major
	CHM-413	Inorganic Spectroscopy	Major
	CHM-417	Advanced Coordination Chemistry	Major
	CHM-415	Group Theory	Major
	CHM-407	Chemistry of Transition Metals	Major
	CHM-408	Coordination Chemistry	Major
	CHM-409	Bioinorganic Chemistry	Major
	CHM-410	Inorganic Polymers	Major
	CHM-420	Chemistry of Main Group Elements	Major
	CHM-418	Metal-Based drugs	Major
Organic chemistry	CHM-422	Reactive Intermediates	Major
	CHM-423	Organic Spectroscopy	Major
	CHM-429	Organic Reaction Mechanisms	Major
	CHM-430	Synthetic Organic Chemistry	Major
	CHM-451	Named Organic Reactions	Major
	CHM-452	Heterocyclic Chemistry	Major
	CHM-453	Organic Electronics	Major
	CHM-455	Molecular Rearrangements	Major
	CHM-424	Natural Products	Major
	CHM-428	Advanced Stereochemistry	Major
Physical chemistry	CHM-440	Physical Chemistry of Polymers	Major
	CHM-456	Electrochemistry	Major
	CHM-431	Statistical Thermodynamics	Major
	CHM-437	Surface Chemistry	Major
	CHM-435	Chemical Kinetics	Major
	CHM-457	Molecular Spectroscopy	Major

	CHM-458	Chemical Thermodynamics	Major
	CHM-416	Radio and Nuclear Chemistry	Major
	CHM-459	Colloids & Surfactants	Major
	CHM-436	Radiation and Photochemistry	Major
	CHM-434	Solid State Chemistry	Major
Analytical chemistry	CHM-460	Advanced Chromatography	Major
	CHM-461	Atomic Spectroscopy	Major
	CHM-462	Electro analytical Chemistry	Major
	CHM-445	Hyphenated Techniques	Major
	CHM-463	Sample Preparation Techniques	Major
	CHM-464	Mass Spectrometry and Applications	Major
	CHM-457	Molecular Spectroscopy	Major

11.Course Outlines of Elective Courses

a. Course Outlines of Inorganic Chemistry

Pi-Acceptor Ligands and Polymers

BS-Chemistry

Course Code: CHM-412

Credit Hours: 03

Pre-requisite: Nil

Objectives

Students must have knowledge of chelation/coordination, organometallics and polymer chemistry and its use in various fields.

Learning Outcomes

- Students will acquire understanding about the Chemistry and application of pi acceptor ligands and Applications of inorganic polymers.

Course Outlines:

Unit 1. Pi Acceptor Ligands

Introduction to course contents and π -acceptor ligand. Effective atomic number (EAN) rule. Examples of EAN rule

Unit 2. Chemistry of Metal Carbonyls

Structure elucidation based on spectroscopic evidence. Chemistry of nitrosyls and isocyanides. Applications and uses of metal carbonyls and their derivatives for catalysis and organic synthesis.

Unit 3. Inorganic Polymers

Introduction to homoatomic and heteroatomic inorganic polymers. Introduction of chains and cages of Boron and Sulphur Synthesis. Reactivity and applications of Boron and sulphur

Unit 4. Inorganic Chains and Cages

Assignment 2 chains and cages of Silicon and Nitrogen; their synthesis, reactivity and applications Phosphorous and Sulphur. Chains and cages of Phosphorous; their synthesis, reactivity and applications and Sulphur. Condensed phosphates. Silicates. Borates.

Unit 5. Inorganic Clusters and Cages

Synthesis and reactivity of cages of Silicon, Nitrogen and Phosphorous. Polyionic species: Isoply and heteropoly anions of transition metals, metal clusters.

Recommended Books/Reference Material

1. Marc Visseaux, (2020). *Catalysts for the Controlled Polymerization of Conjugated Dienes*, Mdpi AG.
2. Yanmin Wang, Wei Feng, (2022). *Conductive Polymers and Their Composites*, Springer Nature Singapore.
3. Taotao Ai, Haichang Zhang, Qixin Zhou, (2021). *Design, Synthesis, and Application of Novel π -Conjugated Materials*, Frontiers Media SA.
4. Atkins, P. and Jones, L. (2010). *Chemicals Principles: The Quest for Insight*, (5th ed.), W. H. Freeman.
5. Brady, J. E., and Sense, F. (2009) *Chemistry-The Study of Matter and Its Changes*, (5th ed.), Wiley Plus.
6. Cotton, F. A., Wilkinson, G., Murillo, C. A. and Bochmann, M. (1999). *Advanced Inorganic Chemistry*, (6th ed.), Wiley-Interscience.
7. Crabtree, R. H. (2011). *The Organometallic Chemistry of the Transition Metals*, (5th ed.), John-Wiley and Sons, New Jersey.

Inorganic Spectroscopy

BS-Chemistry

Course code: CHM-413

Credit hours: 3

Pre-requisite: Nil

Objectives

Students will acquire understanding about the importance of spectroscopic techniques, their use in sample qualitative and its quantitative analysis. They will also learn and develop understanding about spectrophotometer and its applications.

Learning Outcomes

By the end of this course, the students will be able to:

- Students will gain understanding about various spectroscopic techniques used by chemists.
- Students will be able to learn basic principles of spectroscopic techniques, basic instrumentation and significance of these techniques.
- Student will be able to do data acquisition and data handling.
- Students will be able to elucidate molecular structures through different spectroscopic methods.

Course Outline

Unit 1. Basic Concept of Spectroscopy

Nature of electromagnetic radiation, Electromagnetic spectrum and regions, Interaction of matter with radiation (absorption, emission, scattering), Energy levels and transitions, Beer–Lambert Law.

Unit 2. Infrared (IR) Spectroscopy

Molecular vibrations: stretching and bending, fundamental, overtone, and combination bands, characteristic and absorption frequency of common functional groups, spectral interpretation.

Unit 3. UV-Visible (UV) Spectroscopy

Electronic transitions: $\sigma \rightarrow \sigma^*$, $\pi \rightarrow \pi^*$, $n \rightarrow \pi^*$, $d \rightarrow d$, charge transfer, chromophore absorption by conjugated system. Woodward Fieser rule, Applications of UV-visible spectrophotometry.

Unit 4. Nuclear Magnetic Resonance (NMR) Spectroscopy

The physical basis of NMR spectroscopy, chemical shift and shielding/deshielding, molecular structure and chemical shift, chemical equivalence and magnetic equivalence, coupling constants.

Unit 5. Mass Spectrometry

Introduction, basic principle, the mass spectrum, fragmentation modes of different molecules.

Recommended books/reference material

1. Banwell, C. N., & McCash, E. M. (2017). *Fundamentals of molecular spectroscopy* (5th ed.). McGraw-Hill Education.
2. De Hoffmann, E., & Stroobant, V. (2016). *Mass spectrometry: Principles and applications* (4th ed.). Wiley.
3. Mohan, J. (2017). *Organic spectroscopy: Principles and applications* (4th ed.). CRC Press.
4. Pavia, D. L., Lampman, G. M., & Kriz, G. S. (2015). *Introduction to spectroscopy* (5th ed.). Cengage Learning.

5. Skoog, D. A., Holler, F. J., & Crouch, S. R. (2017). *Principles of instrumental analysis* (7th ed.). Cengage Learning.

Coordination Chemistry

BS-Chemistry

Course Code: CHM-CHM-408

Credit Hours: 03

Pre-requisite: Nil

Objectives

The objective of this course is to provide an in-depth understanding of the principles of coordination chemistry, including the study of coordination compounds, their bonding, structure, and reactivity. The course will also cover the applications of these compounds in various fields, including biology, catalysis, and industry.

Learning Outcomes

By the end of this course, the students will be able to:

- Understand the theory and structure of coordination compounds.
- Explain the bonding models such as Werner's theory, Crystal Field Theory (CFT), and Molecular Orbital Theory (MOT).
- Recognize various types of isomerism in coordination compounds.
- Evaluate the stability and reactivity of coordination compounds
- Apply knowledge of coordination chemistry to real-world scenarios, including biological and industrial contexts.

Course Outline

Unit 1. Introduction to Coordination Chemistry

Definition of coordination compounds, Ligands: Types and classification (monodentate, bidentate, polydentate), Coordination number and geometry of coordination complexes, Nomenclature of coordination compounds according to IUPAC rules.

Unit 2. Bonding in Coordination Compounds

Werner's theory, Crystal Field Theory (CFT): Octahedral, tetrahedral, and square planar complexes, Molecular Orbital Theory (MOT) for coordination compounds.

Unit 3. Isomerism in Coordination Compounds

Isomerism in transition metal complexes, optical isomerism, geometrical

isomerism, coordination isomerism, ionization and linkage isomerism.

Unit 4. Preparations and Reactions of Coordination Compounds

Substitution reactions in aqueous, non-aqueous and in the absence of solvent, thermal dissociation of complexes, oxidation-reduction reactions, catalysis, substitution reactions without metal ligand bond cleavage.

Unit 5. Applications of Coordination Compounds

Coordination compounds in biological systems, medicine, catalysis and environmental chemistry.

Recommended books/reference material

1. Basolo, F., & Johnson, R. G. (2016). *Coordination Chemistry*. Dover Publications.
2. Cox, P. A. (2017). *The Elements of Coordination Chemistry*. Oxford University Press.
3. Housecroft, C. E., & Sharpe, A. G. (2018). *Inorganic Chemistry* (5th ed.). Pearson Education.
4. Miessler, G. L., Fischer, P. J., & Tarr, D. A. (2016). *Inorganic Chemistry* (5th ed.). Pearson.
5. Weller, M., Overton, T., Rourke, J., & Armstrong, F. (2018). *Inorganic Chemistry* (7th ed.). Oxford University Press.

Group Theory

BS-Chemistry

Course Code: CHM-415

Credit Hours: 03

Pre-requisite: Nil

Objectives

After studying this course, the student will be able to tell: Students can study about magnetism and its applications. Students can study and explain structures of various metal complexes. Students can study about the basic criterion of magnetism. Students can study about the measurements of magnetism in coordination compounds. Students can study about symmetry and group theory.

Learning Outcomes

After completing this program student will be able to learn the following:

- Magnetism and its applications
- Structures of various metal complexes
- Basic criterion of magnetism.
- Measurements of magnetism in coordination compounds
- Symmetry and group theory

Course Outline

Unit 1. Introduction

Introduction to course contents and Theory of magnetism. Diamagnetism, paramagnetism, ferro-, ferri- and antiferromagnetism. Magnetic susceptibility, magnetic moments.

Unit 2. Magnetic Moment

Magnetic moment of lanthanides. Gouy's method. Faraday's methods

Unit 3. Electron Spin Resonance

Electron spin resonance spectroscopy. Effect of temperature on magnetic properties of complexes

Unit 4. Symmetry and Group Theory

Symmetry and group theory. Point groups. Multiplication tables

Unit 5. Group Representation

Group representation. Development of character tables. Introduction to the interpretation of spectra and structure elucidation

Recommended Books/Reference Material.

1. Bogopol'skij, O. V. (2008). *Introduction to Group Theory*, European Mathematical Society.
2. Dresselhaus, M. S., Dresselhaus, G., Jorio, A. (2007). *Group Theory: Application to the Physics of Condensed Matter*, Springer Berlin Heidelberg.
3. Dixon, J. D. (2007). *Problems in Group Theory*, Dover Publications.
4. Mackay, K. M., Mackay, R. A. and Henderson, W. (2002). *Introduction to Modern Inorganic Chemistry*, (6th ed.), CRC Press.

5. Miessler, G. L., Fisher, P. J. and Tar, D, A. (2013). *Inorganic Chemistry*, (5th ed.), Prentice Hall.

Bioinorganic Chemistry

BS-Chemistry

Course Code: CHM –409

Credit Hours: 3

Pre-requisite: Nil

Objectives

To introduce the role and relevance of bioinorganic chemistry in biological systems and to explore the functions of essential metal ions in different biological processes.

Learning Outcomes

By the end of the course, students will be able to:

- Explain the biological roles of important metal and nonmetal elements.
- Describe how metal ions function in enzyme catalysis and in metalloproteins.
- Discuss oxygen carriers, nitrogen fixation, and metal-containing vitamins.
- Understand the use of chelating agents in regulating metal ions in biological systems.

Course Outline

Unit 1. Introduction to Bioinorganic Chemistry

History and development of bioinorganic chemistry, Role and significance of metal ions in biological systems, Overview of essential and trace elements in biology, Introduction to coordination chemistry concepts as applied to biology.

Unit 2. Metals in Biological Systems

Biologically important metals (Na, K, Ca, Mg, Fe, Cu, Zn, Mn, Co, Mo, etc.). Structural and functional roles of metal ions, Storage and transport proteins: Ferritin, transferrin.

Unit 3. Metalloproteins and Metalloenzymes

Introduction to metalloproteins, Structure and function of hemoglobin, myoglobin, and cytochromes. Enzymes with metal centers: carbonic anhydrase, superoxide dismutase, nitrogenase, Role of metal ions in enzyme catalysis.

Unit 4. Oxygen and Nitrogen Metabolism

Oxygen transport and nitrogen fixation. Biological roles of Vitamin B12 and B6.

Unit 5. Non-metals, Chelation and Therapeutic Applications

Importance of non-metals in biological functions, chelating agents in medicine and biology (EDTA, DTPA), Toxicity of metals and detoxification pathways, Metal complexes in medicine: anticancer drugs, imaging agents, and radiopharmaceuticals.

Recommended books/reference material

1. Crichton, R. (2016). Biological Inorganic Chemistry: A New Introduction to Molecular Structure and Function (3rd Ed.), Academic Press
2. Ghosh, A. (Ed.). (2019). Transition Metals in Biological Systems, Springer
3. Kaim, W., & Schwederski, B. (2017). Bioinorganic Chemistry: Inorganic Elements in the Chemistry of Life (2nd Ed.), Wiley
4. Pombeiro, A. J. L. (Ed.). (2018). Bioinorganic Medicinal Chemistry, Wiley-VCH.
5. Robert R. Crichton, Riccardo Bertini (2020). Metals in Cells, Oxford University Press.

Inorganic Polymers

BS-Chemistry

Course code: CHM-410

Credit hours: 3

Pre-requisite: Nil

Objectives

To introduce the fundamentals and classifications of inorganic polymers, including their structures and applications. To develop an understanding of polymer properties and characterization techniques.

Learning Outcomes

By the end of this course, the students will be able to:

- Identify and classify inorganic polymers and explain their synthesis mechanisms.
- Analyze polymer structure, molecular weight, and physical properties.
- Apply basic analytical techniques to evaluate and characterize polymer materials.

Course Outline

Unit 1. Introduction to Polymers

Definition and brief history of polymers, Importance and applications of inorganic polymers. Classification: natural vs. synthetic, organic vs. inorganic, thermoplastics vs. thermosets. Comparison of organic and inorganic polymers.

Unit 2. Types of Polymerization

Introduction to polymerization processes, Addition (chain-growth) vs. condensation (step-growth) polymerization, Examples of inorganic polymers formed by both methods. Industrial relevance of each polymerization type

Unit 3. Polymer Structure and Molecular Weight

Chemical structure of polymers (linear, branched, and cross-linked polymers), Degree of polymerization and chain architecture, Molecular weight concepts: M_n , M_w .

Unit 4. Polymerization Mechanisms

Free radical polymerization: Initiation, propagation, and termination, Ionic polymerization: Cationic and anionic mechanisms, Coordination polymerization, Role of catalysts and inhibitors.

Unit 5. Properties and Characterization of Polymers

Thermal and mechanical properties, and Characterization techniques: Spectroscopy (IR, NMR)

Recommended books/reference material

1. E. Carraher Jr. (2017) – Introduction to Polymer Chemistry (4th Edition), CRC Press.

2. Manas Chanda (2017) – Introduction to Polymer Science and Chemistry: A Problem-Solving Approach (2nd Edition), CRC Press
3. R. Ghosh (2016) – Polymer Science and Technology: Plastics, Rubbers, Blends and Composites, McGraw-Hill Education
4. Stephen L. Rosen (2018) – Fundamental Principles of Polymeric Materials (4th Edition), Wiley.
5. Stuart G. Croll & David W. Thompson (2016) – Essentials of Polymer Science and Engineering, DEStech Publications.

Chemistry of Transition Metals

BS-Chemistry

Course Code: CHM-407

Credit Hours: 3

Pre-requisite: Nil

Objectives

To understand the fundamental properties, electronic structures, and periodic trends of transition metals, explain the bonding, geometry, and magnetic behavior of coordination complexes. explore the stability and applications of metal chelates and transition organometallic compounds.

Learning Outcomes

By the end of this course, the students will be able to:

- Identify and describe key properties of transition metals, including oxidation states, magnetic behavior, and electronic configuration.
- Apply bonding theories (VBT and CFT) to explain structures, colors, and geometries of coordination compounds.
- Analyze the formation and stability of metal chelates and organometallic complexes.
- Evaluate the biological and industrial significance of transition metal compounds, including their roles in catalysis and medicine.

Course Outline

Unit 1. Introduction to Transition Metal Chemistry

General characteristics of transition elements, shapes of d orbitals, electronic configuration, oxidation states and periodic trends; color of transition metal complexes; common coordination numbers and geometries. Comparison of 3d, 4d and 5d series.

Unit 2. Theories of Transition Metal Complex Formation

Valence Bond Theory (VBT); Electrostatic Crystal Field Theory (CFT), Types of magnetic behavior and its qualitative and quantitative discussion with respect to transition metal complexes.

Unit 3. Transition Metal Chelates and their Applications

Types of chelates, Factors affecting the stability of chelates, Applications in of metal chelates in various field. Reactions of transition metal complexes

Unit 4. Organometallic Chemistry of Transition Metals

Metal-carbon bonding (σ and π interactions), Common organometallic compounds (e.g., ferrocene, metal carbonyls).

Unit 5. Biological and Industrial Applications

Transition metals in biological systems (e.g., hemoglobin, chlorophyll), Transition metal complexes in medicine (e.g., cisplatin), metal catalysis in industrial processes, Environmental aspects and toxicology of transition metals.

Recommended Books/Reference Material

1. Basolo, F., & Johnson, R. G. (2016). *Coordination Chemistry*. Dover Publications.
2. Cox, P. A. (2017). *The Elements of Coordination Chemistry*. Oxford University Press.
3. Housecroft, C. E., & Sharpe, A. G. (2018). *Inorganic Chemistry* (5th ed.). Pearson Education.
4. Miessler, G. L., Fischer, P. J., & Tarr, D. A. (2016). *Inorganic Chemistry* (5th ed.). Pearson.
5. Weller, M., Overton, T., Rourke, J., & Armstrong, F. (2018). *Inorganic Chemistry* (7th ed.). Oxford University Press.

Advanced Coordination Chemistry

BS-Chemistry

Course Code: CHM-417

Credit Hours: 03

Pre-requisite: Nil

Objectives

This course aims to introduce the fundamental concepts of coordination chemistry, including the structure, bonding, and nomenclature of coordination compounds. It focuses on metal–ligand bonding theories, isomerism, and the stability and reactivity of coordination complexes. The course also highlights the importance and applications of coordination compounds in biological, medicinal, industrial, and environmental systems.

Learning Outcomes

After completing this course, students will be able to explain basic concepts and nomenclature of coordination compounds, describe metal–ligand bonding using bonding theories, and identify different types of isomerism. They will understand the factors affecting stability and reactivity of coordination complexes and discuss their applications in biological, industrial, and environmental contexts.

Course Outline

Unit 1. Basic Concepts and Classification of Coordination Compounds

Definition and scope of coordination chemistry, coordination compounds and complexes, central metal ions and ligands, classification of ligands (monodentate, bidentate, polydentate), coordination number, oxidation state, and factors affecting coordination number.

Unit 2. Nomenclature and Theories of Metal–Ligand Bonding

Introduction to IUPAC nomenclature, Werner’s coordination theory and its experimental significance. Crystal Field Theory (CFT): crystal field splitting in octahedral and tetrahedral complexes, high-spin and low-spin complexes, factors affecting crystal field splitting. Qualitative introduction to Molecular Orbital Theory for coordination compounds.

Unit 3. Structural and Stereochemical Aspects of Coordination Compounds

Basic geometries of coordination complexes (linear, tetrahedral, square planar, octahedral). Concept and significance of isomerism. Structural isomerism: coordination, ionization, and linkage isomerism. Stereoisomerism: geometrical (cis–trans) and optical isomerism.

Unit 4. Stability, Reactivity, and Reaction Mechanisms of Coordination Compounds

Stability of coordination compounds, factors affecting stability, chelate effect. Basic substitution reactions in coordination complexes (aqueous medium). Introduction to redox reactions and qualitative kinetic and thermodynamic aspects.

Unit 5. Applications of Coordination Compounds

Coordination compounds in biological systems (hemoglobin, chlorophyll, vitamin B₁₂). Applications in medicine, catalysis, and industry. Environmental applications including metal ion sequestration and water treatment.

Recommended books/ Reference material

1. Basolo, F., & Johnson, R. G. (2016). *Coordination Chemistry*. Dover Publications.
2. Cox, P. A. (2017). *The Elements of Coordination Chemistry*. Oxford University Press.
3. Housecroft, C. E., & Sharpe, A. G. (2018). *Inorganic Chemistry* (5th ed.). Pearson Education.
4. Miessler, G. L., Fischer, P. J., & Tarr, D. A. (2016). *Inorganic Chemistry* (5th ed.). Pearson.
5. Weller, M., Overton, T., Rourke, J., & Armstrong, F. (2018). *Inorganic Chemistry* (7th ed.). Oxford University Press.

Metal-Based Drugs

BS-Chemistry

Course Code: CHM-418

Credit Hours: 03

Pre-requisite: Nil

Objectives

- Students should be able to understand the effects of metals in biological systems. Action, metabolism, development along with production of different metal-based drugs.

Learning Outcomes

- Students will gain a comprehensive understanding of metals' role in neurological disorders, drug development processes, drug metabolism, and the pharmaceutical industry.
- These insights are valuable for careers in healthcare, pharmacology, and pharmaceutical research.

Course Outlines

Unit 1. Metals and Neurodegenerative Diseases

Metals in brain, Disorders of copper metabolism: Wilson's and menkes diseases, Aceruloplasminaemia, Creutzfeldt–jakob and other prion diseases, Iron redox metal ions, Oxidative stress and neurodegenerative diseases parkinson's disease, Alzheimer's disease, Huntington's disease, Friedreich's ataxia.

Unit 2. Drugs and their Action

What are drugs and why do we need new ones? Drug discovery and design, Sources of drugs and lead compounds, Drug synthesis, Market forces and 'me-too drugs, Routes of administration, The pharmaceutical phase, Drug action, The pharmacokinetic phase, Absorption, Distribution, Metabolism, Elimination, Bioavailability of a drug, The pharmacodynamic phase.

Unit 3. Drug Metabolism

The stereochemistry of drug metabolism, Biological factors affecting metabolism, Environmental factors affecting metabolism, Species and metabolism, Secondary Pharmacological implications of metabolism, Sites of action, Phase I metabolic reactions, Phase II metabolic routes, Pharmacokinetics of metabolites, Drug metabolism and drug design.

Unit 4. Drug Development and Production

Chemical development, Chemical engineering issues, Chemical plant, Health and safety considerations, Synthesis quality control, Pharmacological actions.

Recommended Books/Reference Material

1. Celine J. Marmion, Etelka Farkas, (2023). Targeted Metallo-Drugs: Design, Development, and Modes of Action, CRC Press.
2. Athar Adil Hashmi, Shahid Ul Islam, Salman Ahmad Khan, (2020). Advances in Metallodrugs: Preparation and Applications in Medicinal Chemistry, Wiley.
3. Crichton, R.R. (2008). Biological Inorganic Chemistry, An Introduction, (1st ed.).
4. Crichton, R.R., Ward, R.J. (2005). Metal Based Neurodegeneration: From Molecular Mechanisms to Therapeutic Strategies, John Wiley and Sons, Chichester.

Chemistry of Main Group Elements

BS-Chemistry

Course Code: CHM-420

Credit Hours: 03

Pre-requisite: Nil

Objectives

This course aims to comprehensively understand the properties, reactions, and applications of main group elements. It emphasizes periodic trends, chemical bonding, structure and reactivity of compounds of s- and p-block elements, and their industrial, biological, and environmental significance.

Learning Outcomes

Upon successful completion of this course, students will be able to:

- Understand periodic trends and the general characteristics of main group elements.
- Describe the structure, bonding, and reactivity of s- and p-block element compounds.
- Explain the role of main group elements in biological and industrial systems.
- Analyze the synthesis and applications of oxides, halides, hydrides, and organometallics of main group elements.
- Evaluate environmental and technological implications of main group element chemistry.

Course Outline

Unit 1. Periodic Classification and General Trends

Periodic classification of elements: s- and p-block, Periodic trends: atomic and ionic radii, Ionization energy, Electronegativity, Electron affinity, Inert pair effect and its implications

Unit 2. Chemistry of Group 1 and Group 2 Elements (s-block)

General properties, reactivity, and compounds of alkali and alkaline earth metals, Hydrides, oxides, hydroxides, halides, and carbonates, Role of s-block elements in biological systems (Na^+ , K^+ , Ca^{2+} , Mg^{2+})

Unit 3. Chemistry of Group 13 and Group 14 Elements

General properties and trends; chemistry of boron and aluminum; Lewis acidity and structure of boranes; allotropes and catenation of carbon and silicon; structure and uses of silicates, zeolites, and industrial aluminum compounds.

Unit 4. Group 15 and Group 16 Elements

Properties, oxidation states, and periodic trends; hydrides, halides, oxides, and oxyacids of nitrogen, phosphorus, oxygen, and sulfur; allotropes of phosphorus and sulfur; biological and industrial importance in fertilizers and pharmaceuticals.

Unit 5. Group 17 and Group 18 Elements

Reactivity trends and properties of halogens and noble gases; hydrogen halides, interhalogens, polyhalides, and halogen oxoacids—preparation, structure, and uses; xenon compounds (XeF_2 , XeF_4 , XeO_3)—structure and bonding; applications of halogenated compounds.

Recommended books/reference material

6. Power, P. P. (2010). Main-group elements as transition metals. *Nature*, 463(7278), 171-177.
7. Rayner-Canham, G. (2020). Periodic Table, The: Past, Present, And Future. World Scientific.
8. Dalal, M. (2017). A Textbook of Inorganic Chemistry–Volume 1. Dalal Institute.
9. Norman, N. C. (2021). Periodicity and the s-and p-Block Elements. Oxford University Press.

10. Winter, A., Newkome, G. R., & Schubert, U. S. (2024). The chemistry of the s- and p-block elements with 2, 2': 6', 2''-terpyridine ligands. *Inorganic Chemistry Frontiers*, 11(2), 342-399.

b. Course Outlines of Organic Chemistry

Reactive Intermediates

BS-Chemistry

Course Code: CHM-422

Credit Hours: 03

Pre-requisite: Nil

Objectives

This course is intended to provide understanding of

- Molecular rearrangements in organic compounds.
- Reactions and mechanisms of free radicals. Introduction and application of reactive intermediates.

Learning Outcomes

This course is intended to provide understanding of: • Molecular rearrangements in organic compounds • Reactions and mechanisms of free radicals.

- Introduction and application of reactive intermediates.

Course Outline

Unit 1. Introduction of Reaction Intermediates

Carbocations, carbanions, free radicals. Carbenes, Structure, generation, stability, reactions, and synthetic applications. Nitrenes generation, stability, reactions, and synthetic applications. Arynes, their generation, stability, reactions, and synthetic applications.

Unit 2. Carbonyl Compounds

Chemistry of Enolates and Enols. Acidity of carbonyl compounds, enolization of carbonyl compounds. α -halogenation of carbonyl compounds.

Unit 3. Condensation Reactions

Aldol-addition and aldol-condensation. Condensation reactions involving ester enolate ions, alkylation of ester enolate ions. Cyclization via aldol-condensation.

Unit 4. Molecular Rearrangements

Types of rearrangements, general mechanisms of nucleophilic, free radical and electrophilic rearrangements. Hydrogen and/or carbon migration to electron-deficient carbon. Rearrangements involving diazomethane. Rearrangement to electron-deficient nitrogen and oxygen, carbon migration to electron-rich carbon.

Unit 5. Aromatic Rearrangements

Mechanism of aromatic rearrangements. Inter-molecular carbon migration from oxygen to carbon. Intra-molecular carbon migration from oxygen to carbon.

Recommended Books/Reference Material

1. Leffler, J. E. (2021). The Reactive Intermediates of Organic Chemistry, Creative Media Partners, LLC.
2. Carroll, F. A. (2023). Perspectives on Structure and Mechanism in Organic Chemistry, Wiley.

Organic Spectroscopy

BS-Chemistry

Course Code: CHM-423

Credit Hours: 03

Pre-requisite: Nil

Objectives

Student will acquire an adequate knowledge about fundamental and instrumental aspect of different spectroscopic techniques and will be able to perform structural elucidation of organic compounds using spectral data.

Learning Outcomes

- Students should have the ability to understand the basics of spectroscopy and its different techniques.
- Students should have the ability to use spectroscopic data for structure elucidation of organic compound.

Course Outlines

Unit 1. UV-Visible Spectroscopy

UV-Visible Spectroscopy Basic Concepts Electronic Transitions. Lambert-Beer's law, factor influencing the λ_{max} values. Woodward rules for calculation of wavelength values.

Unit 2. IR spectroscopy

IR spectroscopy Basic Concepts absorption mechanisms. Functional group determination and factors affecting the absorption frequencies. Structure elucidation of organic compounds through IR spectra.

Unit 3. H-NMR

H-NMR, Basic Concepts, and chemical shifts. Factors affecting chemical shifts. Spin relaxation spin-spin coupling constants.

Unit 4. Mass spectroscopy

Mass spectroscopy Basic concepts, mass spectrometers. Instrumentation and ionization techniques. Different fragmentation patterns and structure elucidation. Combined usage of IR, UV, NMR, and mass spectrometric data for structure elucidation of organic compounds having medium complexity.

Unit 5. Structure Elucidation

Structure elucidation of organic compound through spectroscopy.

Recommended Books/Reference Material

1. Bienz, S., Bigler, L., Fox, T., Meier, H. (2021). Spectroscopic Methods in Organic Chemistry, Georg Thieme Verlag.
2. Pretsch, E., Bühlmann, P., Badertscher, M. (2020). Structure Determination of Organic Compounds: Tables of Spectral Data, Springer Berlin Heidelberg.
3. Fleming, I., Williams, D. (2020). Spectroscopic Methods in Organic Chemistry, Springer International Publishing.
4. Alonso-Amelot, M. E. (2023). The Art of Problem Solving in Organic Chemistry, Wiley.

Synthetic Organic Chemistry

BS-Chemistry

Course Code: CHM-430

Credit Hours: 03

Pre-requisite: Nil

Objectives

Student will acquire knowledge and understanding to design protocols for synthesis of small to medium sized organic compounds and be able to carry out retrosynthetic analysis and propose alternative reactions to synthesize a compound.

Learning Outcomes

- Students will have the ability to understand that how the organic compound can be synthesized.
- Students will have the ability to use the ways to convert one compound into another compound.

Course Outlines

Unit 1. Organic Synthesis

Principles and importance of organic synthesis. Introduction to retrosynthesis and disconnection approach. Synthesis Organic compound; one and two group carbon C-X disconnection.

Unit 2. Donor and Acceptor Synthons

Donner and acceptor synthons synthesis. C-C disconnection and 1,2-,1,3-,1,4-difunctionalized compounds. C-C disconnection and 1,5- and 1,6- difunctionalized compounds

Unit 3. Selective Synthesis and Cyclic Compound Formation

Synthesis of cyclic compound (3-6 membered). Principles of chemoselectivity, regioselectivity, and stereoselectivity in organic synthesis.

Unit 4. Functional Group Protection

Functional group protection (Hydroxyl, amino group, carbonyl, carboxyl, C=C). Solid phase synthesis.

Unit 5. Catalysis

Acid-Base Catalysis, Organocatalysis, Transition Metal Catalysis

Recommended Books/Reference Material

1. Ur Rahman, A. (2020). Advances in Organic Synthesis: Volume 13. Singapore: Bentham Science Publishers.
2. Chris H. Senanayake, (2022). Organic Syntheses, Volume 98. Wiley.
3. Taber, D. F. (2023). Organic Synthesis: State of the Art 2017-2019, Taber Publishing.
4. Stefano Protti, Alessandro Palmieri, (2021). Sustainable Organic Synthesis: Tools and Strategies, Royal Society of Chemistry.

Organic Reaction Mechanisms

BS-Chemistry

Course Code: CHM-429

Credit Hours: 03

Pre-requisite: Nil

Objectives

This course aims to deepen students' understanding of the mechanistic aspects of organic reactions, focusing on the principles that govern reactivity and selectivity. It prepares students for research in organic synthesis and mechanistic investigations, equipping them with tools for rationalizing complex transformations using electronic, stereoelectronic, and kinetic considerations.

Learning Outcomes

- Predict and propose plausible reaction mechanisms based on electronic effects and stereochemical outcomes.
- Analyze reaction pathways using arrow-pushing formalism.
- Evaluate and compare competing mechanisms and understand the factors influencing reaction kinetics and thermodynamics.

Course Outline

Unit 1. Introduction to Organic Reaction Mechanisms

Reaction mechanism fundamentals, types of reactions (addition, elimination, substitution, rearrangement), energy profiles, transition states vs. intermediates, thermodynamic vs. kinetic control.

Unit 2. Nucleophilic Substitution and Elimination Reactions

Advanced SN1, SN2, E1, E2, SNi, and neighboring group participation, stereochemistry; factors affecting reaction pathways; competition between substitution and elimination.

Unit 3. Advanced Rearrangement Mechanisms

Mechanistic pathways of rearrangements: Beckmann, Curtius, Baeyer-Villiger, Stevens, Wittig, and Claisen; orbital symmetry and concertedness.

Unit 4. Pericyclic Reactions

Thermal and photochemical electrocyclic, cycloaddition (e.g., Diels–Alder), and sigmatropic rearrangements; Woodward–Hoffmann rules; FMO theory; Möbius–Hückel approach.

Unit 5. Contemporary Topics in Organic Mechanisms

Mechanistic investigation of green and photoredox organic reactions, multi-component reactions, and cascade processes; applications in total synthesis.

Recommended books/reference material

1. Carey, F. A., Sundberg, R. J. (2013). Part B: Reactions and Synthesis. Germany: Springer Berlin Heidelberg.
2. Clayden, J., Greeves, N., Warren, S. (2012). Organic Chemistry. United Kingdom: OUP Oxford.
3. Elzagheid, M. (2024). Organic Chemistry: 25 Must-Know Classes of Organic Compounds. Germany: De Gruyter.
4. Smith, M. B. (2020). March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure. Wiley.

Advanced Stereochemistry

BS-Chemistry

Course Code: CHM-428

Credit Hours: 03

Pre-requisite: Nil

Objectives

After studying this course, students should be able to understand

- Stereo chemical features of organic molecules.
- Possible pathways to solve the problems and to utilize the chemical products.

Learning Outcomes

- Upon completing this course, students will proficiently recognize and manipulate chirality, differentiate, and correlate stereoisomers, and understand the stereochemistry of alkenes, enabling them to apply these concepts to complex organic molecules and reactions.

Course Outline

Unit 1. Discussion of Chirality

Chirality of chiral carbons, Allenes, Biphenyls, Nomenclature (R/S, E/Z, D/L, d/l), 2-D Representations, Stereochemical terminology for sugars, Amino acids, Identifying stereochemical relationships.

Unit 2. Configuration

Enantiomers, Diastereomers, Epimers, Racemization, Stereochemical correlation. Pseudoasymmetric compounds, Molecules with two chiral centers.

Unit 3. Properties of Stereoisomers

Stereoisomer discrimination, Separation of stereoisomers, Resolution, Racemization, Heterotopic ligands, and faces, Prostereoisomerism, Prochirality, Enantiotopic, Diastereotopic.

Unit 4. Stereochemistry of Alkenes

Conformation of acyclic molecules, configuration, and conformation of cyclic molecules

Recommended Books/Reference Material

1. Mandal, D. K. (2021). Stereochemistry and Organic Reactions: Conformation, Configuration, Stereoelectronic Effects and Asymmetric Synthesis, Elsevier Science.
2. Ahluwalia, V. (2022). Stereochemistry of Organic Compounds, Springer International Publishing.
3. Talapatra, S. K., Talapatra, B. (2023). Basic Concepts in Organic Stereochemistry, Springer International Publishing.
4. Nasipuri, D. (1994). Stereochemistry of Organic Compounds: Principles and Applications, New Age International.
5. Tewari N. Advanced Organic Stereochemistry, Books & Allied Ltd.; 378 pages ISBN: 9788187134732.

Named Organic Reactions

BS-Chemistry

Course Code: CHM- 451

Credit Hours: 3
Pre-requisite: Nil

Objective

To provide an in-depth understanding of key named organic reactions, their mechanisms, and synthetic applications in modern organic chemistry.

Learning Outcomes

- The students will learn the concepts and synthetic applications.
- They will be able to design research schemes and to solve the problems during research.

Course Outline

Unit 1: Substitution, Addition and Elimination Reactions

Mitsunobu reaction; conversion of alcohol into various function such as ether, ester and thiols, **Finkelstein Reaction**; halogen exchange, **Hydroboration-Oxidation**; syn addition of water across a double bond, **Hofmann Elimination**; formation of alkenes from quaternary ammonium salts, **Cope Elimination**; formation of alkenes from amine oxides.

Unit 2. Rearrangement Reactions

Beckmann Rearrangement; conversion of oximes to amides, **Pinacol Rearrangement**; rearrangement of 1,2-diols under acidic conditions, **Wolff Rearrangement**; rearrangement of α -diazoketones to ketenes.

Unit 3. Oxidation, Reduction and Oxidative Cleavage Reactions

Jones Oxidation; oxidation of alcohols using $\text{CrO}_3/\text{H}_2\text{SO}_4$, **Oppenauer Oxidation**; mild oxidation of secondary alcohols, **Baeyer–Villiger Oxidation**; oxidation of ketones to esters, **Clemmensen Reduction**; reduction of carbonyls to alkanes using Zn/Hg , **Wolff–Kishner Reduction**; reduction of carbonyl compounds with hydrazine and base, **Lemieux–Johnson Oxidation**, oxidative cleavage using OsO_4 and NaIO_4

Unit 3. Carbon-Carbon Bond Forming Reactions

Aldol Condensation; formation of β -hydroxy carbonyls, **Claisen Condensation**, ester condensation forming β -keto esters, **Dieckmann Condensation**, intramolecular Claisen condensation, **Mannich Reaction**, formation of β -amino carbonyls

Unit 5. Pericyclic Reactions

Diels–Alder Reaction; [4+2] cycloaddition of a diene and dienophile, **Cope Rearrangement;** [3,3]-sigmatropic rearrangement, **Claisen Rearrangement;** [3,3]-sigmatropic rearrangement of allyl vinyl ethers.

Unit 6. Organometallic Reactions

Grignard Reaction; formation of alcohols from Grignard reagents, **Gilman Reagent Reaction;** organocuprate reactions for alkylation, **Suzuki Coupling;** boronic acid coupling with aryl halides, **Stille Coupling,** coupling involving organotin compounds, **Sonogashira Coupling;** coupling of alkynes with aryl halides.

Recommended books/reference material

1. Carey, F. A., & Sundberg, R. J. (2022). *Advanced organic chemistry: Part B: Reaction and synthesis* (6th ed.). Springer.
2. Clayden, J., Greeves, N., & Warren, S. (2012). *Organic chemistry* (2nd ed.). Oxford University Press.
3. Kurti, L., & Czako, B. (2005). *Strategic applications of named reactions in organic synthesis*. Elsevier Academic Press.
4. Li, J. J. (2023). *Name reactions: A collection of detailed reaction mechanisms* (6th ed.). Springer.
5. March, J., & Smith, M. B. (2020). *March's advanced organic chemistry: Reactions, mechanisms, and structure* (8th ed.). Wiley.
6. Smith, M. B. (2023). *Organic synthesis* (4th ed.). Academic Press.

Heterocyclic Chemistry

BS-Chemistry

Course Code: CHM- 452

Credit Hours: 3

Pre-requisite: Nil

Objective

To provide a comprehensive understanding of the structure, synthesis, reactivity, and applications of heterocyclic compounds in various scientific fields.

Learning Outcomes

- Students will be able to classify and name heterocyclic compounds and explain their structural features and aromaticity.
- They will understand the synthesis and reactivity patterns of heterocycles, including key electrophilic, nucleophilic, and rearrangement reactions.
- Students will gain insight into the biological significance and practical applications of heterocycles in pharmaceuticals, agrochemicals, and materials science.

Course Outlines

Unit 1. Introduction to Heterocyclic Compounds

Introduction, classification and nomenclature of heterocyclic compounds.

Unit 2. Structure, Synthesis and Aromaticity of Heterocycles

Structure, chemical and physical properties, aromaticity and synthesis six- and five membered rings with one heteroatom and six- and five membered ring with two heteroatoms.

Unit 3. Reactions of Heterocyclic Systems

Electrophilic Substitution Reactions; general patterns in five-membered vs. six-membered rings and, nucleophilic substitution reactions; in pyridine and diazines, cycloaddition reactions; [4+2] and [2+1] cycloadditions, oxidation and reduction reactions; oxidation of nitrogen-containing rings and catalytic hydrogenation of heterocycles, rearrangement and ring transformation reactions; Fischer indole synthesis, Bischler-Napieralski reaction, Beckmann rearrangement, acid/base behavior and hydrogen bonding in heterocycles.

Unit 4. Heterocycles in Biochemistry and as a Natural Product

Heterocyclic amino acids, enzyme co-factors; heterocyclic vitamins; Co-enzymes, ribonucleic acid (RNA) and deoxyribonucleic acid (DNA); genetic information; purines and pyrimidines, heterocyclic natural products. Alkaloids, marine heterocycles and other nitrogen-containing natural products including anthocyanins and flavones.

Unit 5. Applications of Heterocycles

Heterocycles in medicinal chemistry, agrochemicals, dyes, and materials.

Recommended books/reference material

1. Acheson, R. M. (2022). *Introduction to the Chemistry of Heterocyclic Compounds* (3rd ed.). Wiley.
2. Carey, F. A., & Sundberg, R. J. (2022). *Advanced organic chemistry: Part B: Reaction and synthesis* (6th ed.). Springer.
3. Clayden, J., Greeves, N., & Warren, S. (2012). *Organic chemistry* (2nd ed.). Oxford University Press.
4. Gilchrist, T. L. (2023). *Heterocyclic Chemistry* (5th ed.). Oxford University Press.
5. Nakamura, I. (2022). *Modern Heterocyclic Chemistry* (2nd ed.). Springer.
6. Rappoport, Z., & Liebman, J. F. (Eds.). (2020). *The Chemistry of Heterocyclic Compounds* (Series). Wiley.

Organic Electronics

BS-Chemistry

Course Code: CHM-453

Credit Hours: 03

Pre-requisite: Nil

Objectives

This course aims to provide students with the knowledge of organic semiconductors and their application in electronic and optoelectronic devices, with a focus on material properties, design, synthesis, and functionality.

Learning Outcomes

- Explain the principles and materials involved in organic electronics.
- Analyze the properties and structure-function relationships of organic semiconductors.
- Evaluate the design and operation of organic electronic devices.

Course Outline

Unit 1. Introduction to Organic Electronics

Definition, scope, and history of organic electronics, Comparison with inorganic electronics, Importance of flexibility, sustainability, and low-cost processing.

Unit 2. Organic Semiconductors and Conducting Polymers

Types of organic semiconductors: small molecules and polymers, Synthesis and properties of conducting polymers (e.g., polyaniline, polythiophene), Charge transport mechanisms in organic materials.

Unit 3. Characterization Techniques

Optical, electrical, and thermal characterization methods, Spectroscopic techniques: UV-Vis, FTIR, NMR, PL, Electrochemical analysis: cyclic voltammetry, impedance spectroscopy.

Unit 4. Organic Electronic Devices

Organic Light Emitting Diodes (OLEDs), Organic Field Effect Transistors (OFETs), Organic Photovoltaics (OPVs) and sensors, Device fabrication and architecture.

Unit 5. Applications and Future Trends

Flexible displays, wearable electronics, e-paper, Biomedical applications and biosensors, Recycling and sustainability in organic electronics, Recent advances and industry case studies.

Recommended books/reference material

1. Forrest, S. R. (2020). Organic Electronics: Foundations to Applications. United Kingdom: Oxford University Press.
2. Klauk, H. Organic Electronics II: More Materials and Applications. (2012). Germany: Wiley.
3. Liu, A. (2018). Photonic MEMS Devices: Design, Fabrication and Control. United States: CRC Press.
4. Oxide Electronics. (2021). United Kingdom: Wiley.
5. Sze, S. M., Li, Y., Ng, K. K. (2021). Physics of Semiconductor Devices. United States: Wiley.

Molecular Rearrangements

BS-Chemistry

Course Code: CHM-455

Credit Hours: 03

Pre-requisite: Nil

Objectives

The objective of this course is to introduce students to fundamental and advanced molecular rearrangement reactions in organic chemistry and to understand their mechanistic pathways, synthetic utility, and applications in drug design and material science.

Learning Outcomes

- Classify and explain various types of molecular rearrangement reactions.
- Predict reaction outcomes based on mechanistic understanding.
- Apply rearrangement strategies in complex molecule synthesis.

Course Outline

Unit 1. Introduction to Molecular Rearrangements

Definition, classification, and general features of rearrangement reactions, Types: 1,2- and 1,3-shifts, sigmatropic rearrangements, Wagner-Meerwein and Pinacol rearrangements.

Unit 2. Anionic and Cationic Rearrangements

Beckmann rearrangement and synthetic applications, Schmidt, Baeyer–Villiger, and Curtius rearrangements, Rearrangements involving carbocations and carbanions.

Unit 3. Pericyclic and Sigmatropic Rearrangements

Cope and Claisen rearrangements, Aromatic sigmatropic shifts, Application of Woodward-Hoffmann rules.

Unit 4. Heteroatom-Involving Rearrangements

Lossen and Hofmann rearrangements, Stevens and Sommelet-Hauser rearrangements, Rearrangements in heterocyclic systems.

Unit 5. Applications in Synthesis and Industry

Strategic use of rearrangements in drug synthesis, Case studies in total synthesis, Green chemistry approaches using rearrangements, Rearrangements in polymer and material chemistry.

Recommended books/reference material

1. Clayden, J., Greeves, N., Warren, S. (2012). Organic Chemistry. United Kingdom: OUP Oxford.
2. Fabirkiewicz, A. M., Stowell, J. C. (2015). Intermediate Organic Chemistry. United Kingdom: Wiley.
3. Harwood, L. M. (2023). Polar Rearrangements. United Kingdom: Oxford University Press.
4. Hent, A., Andraos, J. (2019). Strategies and Solutions to Advanced Organic Reaction Mechanisms: A New Perspective on McKillop's Problems. Netherlands: Elsevier Science.
5. Rojas, C. M. (2015). Molecular Rearrangements in Organic Synthesis. United States: John Wiley & Sons, Incorporated.

Natural Products

BS-Chemistry

Course Code: CHM-424

Credit Hours: 03

Pre-requisite: Nil

Objectives

Students will acquire knowledge about different types of natural products with emphasis on their structure, synthesis, and applications.

Learning Outcomes

By the end of this course, students will be able to:

- Understand the principles of alkaloids, terpenoids, steroids, and flavonoids, including their classification, isolation methods, structural elucidation, synthesis, and biosynthesis.
- Analyze and discuss specific examples of alkaloids (ephedrine, nicotine, atropine, quinine,

Papaverine, morphine), terpenoids (cital, α -terpineol, α -pinene, camphor, α -cadinene), steroids (cholesterol, steroidal hormones), and flavonoids (flavone, flavanol, cyanidin) in relation to their structures, properties, and biosynthetic pathways.

Course Outline

Unit 1. Alkaloids

Introduction, classification, isolation methods, structure elucidation and discussion with reference to structure and synthesis. Biosynthesis of typical alkaloids such as ephedrine, nicotine, atropine, quinine, Papaverine and morphine.

Unit 2. Terpenoids

Introduction, classification, isolation techniques and discussion with reference to structure and synthesis and biosynthesis of typical terpenoids such as citral, α -terpineol, α -pinene, camphor and α -cadinene.

Unit 3. Steroids

Study of cholesterol and steroidal hormones with emphasis on their structure and biosynthesis.

Unit 4. Flavonoids

Introduction and classification of flavonoids, general biosynthetic pathway, synthesis of flavone, flavanol and cyanidin.

Recommended Books/Reference Material

1. Lalith Jayasinghe, Mayuri Napagoda, (2022). Chemistry of Natural Products: Phytochemistry and Pharmacognosy of Medicinal Plants, De Gruyter.
2. Tadhg Begley, Hung-wen Liu, (2020). Comprehensive Natural Products III, Elsevier Science.
3. Atta-ur Rahman, (2023). Studies in Natural Products Chemistry, Elsevier Science.
4. Shahidi, F. And Naczki M. (2004). Phenolics in Food and Nutraceuticals, CRC Press.
5. Sell, C. S. (2003). A Fragrant Introduction to Terpenoid Chemistry, Royal Society of Chemistry, UK.

c. Course Outlines of Physical Chemistry

Physical Chemistry of Polymers

BS-Chemistry

Course Code: CHM-440

Credit Hours: 03

Pre-requisite: nil

Objectives

Students will learn the fundamental principles of polymerization, synthesis methods and reaction mechanisms, thermodynamic and kinetic aspects of the polymerization, and physical and mechanical properties of polymers.

Learning Outcomes

- Students will gain understanding about background of polymer chemistry and the basic principles.

Course Outline

Unit 1. Introduction to Polymers

Step-growth Polymerizations. Polymer chain growth. Kinetics of polymer chain growth. Copolymerization. Emulsion Polymerization. Natural and Inorganic Polymers. Physical Aspects of polymers.

Unit 2. Molecular Weight of Polymers

Distribution, averages, and methods of determination. Viscosity. Osmometry. Light scattering method. Diffusion. Sedimentation. Optical rotation method.

Unit 3. Structure of Polymer Chain

Introduction to chain isomerism, stereochemistry, configurations, and conformations. (not in Hiemenz). Amorphous State of Polymers: In depth examination of polymer conformation, microstructure, and dynamics in the amorphous state. Polymer viscoelasticity: Stress relaxation, mechanical models of polymer behavior, time-temperature superposition, perhaps rheology.

Unit 4. Crystalline State of Polymers

Crystallization and kinetics, crystalline structures, experimental methods. Polymer Solutions and Blends.

Recommended Books/Reference Material

1. Subramanian, M. N. (2022). *Basics of polymer chemistry*. CRC Press.

- Huang, X., & Tanaka, T. (2021). *Polymer Composites for Electrical Engineering*. John Wiley & Sons.
- Malcolm P. S. (2005) “*Polymer Chemistry*” Oxford University Press.
- Ravue, (2000) “*Principles of Polymer Chemistry*” (2nd ed.) Plenum Publishers.

Molecular Spectroscopy

BS-Chemistry

Course Code: CHM-457

Credit Hours: 03

Pre-requisite: Nil

Objectives

- To introduce the fundamental principles of molecular spectroscopy and types of spectra.
- To enable students to interpret basic spectroscopic data for molecular analysis.

Learning Outcomes

- Students will understand how molecules interact with different regions of the electromagnetic spectrum.
- Students will be able to analyze simple IR, UV-Vis, NMR, and mass spectra for structural information.

Course outlines

Unit 1. Introduction to Molecular Spectroscopy

Electromagnetic radiation and spectrum. Energy levels in molecules, Interaction of light with matter (absorption, emission), Basic idea of selection rules.

Unit 2. Rotational Spectroscopy (Microwave Region)

Rigid rotor model for diatomic molecules, Selection rule for pure rotational transitions, Use of spectra to calculate bond lengths

Unit 3. Vibrational Spectroscopy (Infrared Region)

Simple harmonic oscillator model, Fundamental vibrations and overtones. IR activity and selection rules, Simple IR spectral interpretation.

Unit 4. Electronic Spectroscopy (UV-Visible Region)

Electronic transitions in molecules, Franck-Condon principle (qualitative), UV-Vis spectra of simple organic compounds, Applications in determining conjugation and color.

Unit 5. Basic Introduction to NMR and Mass Spectrometry

Nuclear Magnetic Resonance: proton NMR basics, chemical shift, simple splitting,

Mass spectrometry: ionization, molecular ion peak, basic fragmentation patterns.

Recommended books/reference material

1. Atkins, P. W., & de Paula, J. (2014). Physical chemistry (10th ed.). Oxford University Press.
2. Banwell, C. N., & McCash, E. M. (1994). Fundamentals of molecular spectroscopy (4th ed.). McGraw-Hill.
3. McHale, J. L. (2007). Molecular spectroscopy. Pearson Prentice Hall.
4. Pavia, D. L., Lampman, G. M., Kriz, G. S., & Vyvyan, J. A. (2014). *Introduction to spectroscopy* (5th ed.). Brooks/Cole.

Chemical Kinetics

BS-Chemistry

Course Code: CHM-435

Credit Hours: 03

Pre-requisite: Nil

Objectives

Students will acquire knowledge and learning about reaction dynamics and kinetic theories. They will also know about the factors which can influence the rates of reactions under different reaction conditions.

Learning Outcomes

- Students will gain understanding about various kinetic mechanisms and will be able to predict the reaction kinetics.

Course Outline

Unit 1. Derivation of the Rate Equations.

Theory of absolute reaction rate. Reversible reactions, parallel reactions and consecutive reactions. Correlation between physical properties and concentration. Comparison of collision and absolute reaction theories. Advanced theories of unimolecular reactions. Potential energy surfaces.

Unit 2. Thermodynamic Formulation of Reaction Rates.

Calculation of entropy and enthalpy changes. Thermal decomposition of nitrogen pentaoxide. Reactions in solutions. Influence of ionic strength on the reaction rate. Effect of dielectric constant of the medium on the rate of the reaction. Single sphere activated complex model.

Unit 3. Double Sphere Activated Complex Model.

Complex reactions. Chain reactions. Single chain carrier with second order breaking. One chain carrier with first order breaking. Two chain carrier with second order breaking. Experimental techniques for fast reactions.

Recommended Books/Reference Material

1. Frost A. A. and Pearson R. G. (1961) “Kinetic and Mechanism” (2nd ed.) John Wiley and Sons Inc, New York.
2. Laidler K. J. (1987) “Chemical Kinetics” (3rd ed.) Pearson Education Company, New York.
3. Singh, M. (2021) Chemical Kinetics. INSC International Publisher (IIP).
4. Arnaut, L. (2021). Chemical Kinetics: From Molecular Structure to Chemical Reactivity. Netherlands: Elsevier Science.

Surface Chemistry

BS-Chemistry

Course Code: CHM-437

Credit Hours: 03

Pre-requisite: Nil

Objectives

Explore the properties and preparation methods of colloidal solutions, emphasizing the role of surfactants and nanomaterials in industrial catalysts. Examine the applications of emulsions and nanoscale chemistry, emphasizing their significance in various industries.

Learning Outcomes

- Demonstrate an understanding of catalyst preparation techniques and the characteristics of industrial catalysts used in colloidal solutions.
- Apply knowledge of surfactants and nanomaterials to analyze their applications in diverse fields, showcasing an awareness of their impact on industrial processes.

Course Outline

Unit 1. Colloidal Solutions

Catalyst preparation methods, industrial catalysts, emulsion, surfactant, nanoscale chemistry, nanomaterials and their applications.

Unit 2. Dimensional Control in Nanostructures

Macromolecular surface films, charged films and Langmuir-Blodgett layers, characterization methods and applications.

Unit 3. Solid Surfaces

Surface structures, clean surface structures, gas solid interface, thermodynamics of adsorption.

Unit 4. Heterogeneous Catalysis

Kinetic and mechanisms of catalyzed reactions, adsorption at liquid surfaces, chemisorption, physisorption and dynamics, enzymatic catalysis, organized molecular assemblies.

Unit 5. Experimental Probes for Surface and Adsorbent

Scanning probe techniques, low energy electron diffraction (LEED), electron spectroscopy, and other surface analysis techniques.

Recommended Books/Reference Material

1. Rasheed M. N. Colloids: Types, Preparation and Applications. (2021). United Kingdom: IntechOpen.
2. Pashley, R. M., Karaman, M. E. (2021). Applied Colloid and Surface Chemistry. United Kingdom: Wiley.
3. Birdi, K. S. (2020). Surface and Colloid Chemistry: Principles and Applications. United Kingdom: CRC Press.
4. Klabunde, K. J., (2003) "Nanoscale Materials in Chemistry," John-Wiley & Sons, Inc.
5. Kolunsiki, K. W., (2012) "Surface Science: Foundations of Catalysis and Nanoscience", (3rd ed.) John-Wiley & Sons, Ltd.

Electrochemistry

BS-Chemistry

Course Code: CHM-456

Credit Hours: 03

Pre-requisite: Nil

Objectives

- To provide students with a foundational understanding of electrochemical principles, redox reactions, and electrochemical cell systems.
- The course aims to link theoretical knowledge with practical applications such as pH measurement, corrosion control, and fuel cell technology.

Learning outcomes

- By the end of the course, students will be able to explain and apply core electrochemical concepts, calculate cell potentials, and analyze redox behavior.
- They will also understand the role of electrochemistry in real-world applications including industrial electrolysis, corrosion prevention, and sustainable energy.

Course Outlines

Unit 1. Basic Concepts in Electrochemistry

Introduction to oxidation and reduction reactions, Electrochemical cells: Galvanic vs Electrolytic, Electrode potential and standard electrode potentials, Electrochemical series and its significance, Thermodynamics of redox reactions (ΔG , E°_{cell} , and equilibrium constant)

Unit 2. Nernst Equation and Electrochemical Measurements

Nernst equation and applications to half-cells and full cells, Liquid junction potential and the role of salt bridge, Measurement of pH: glass electrode and other methods, Determination of pKa using electrochemical techniques, Potentiometry: working principles and uses.

Unit 3. Electrodes and Electrolytic Cells

Reference electrodes: SHE, Calomel, Ag/AgCl, Indicator electrodes: metal and membrane electrodes, Construction and working of electrolytic cells, Applications of electrolysis (brief industrial examples).

Unit 4. Corrosion and Its Electrochemical Prevention

Electrochemical theory of corrosion, Types of corrosion (dry, wet, pitting), Factors affecting corrosion, Methods of corrosion prevention: coatings, cathodic protection, inhibitors.

Unit 5. Fuel Cells and Hydrogen Economy

Introduction to fuel cells: principle and classification, Working of hydrogen-oxygen fuel cells, Efficiency and advantages over conventional energy systems, Hydrogen economy: production, storage, and role in clean energy.

Solid State Chemistry

BS-Chemistry

Course Code: CHM-434

Credit Hours: 03

Pre-requisite: Nil

Objectives

Students will acquire understanding about the forces and the structures of solids.

Learning Outcomes

- Students will gain understanding of how intermolecular forces control the symmetry and geometry of solids.

Course Outline

Unit 1. Introduction to Solid State Chemistry

Importance and applications. Classification of solids: crystalline vs. amorphous. Review of bonding in solids (ionic, covalent, metallic, van der Waals)

Unit 2. Crystal Structures and X-ray Diffraction

Unit cells, lattices, and symmetry, Bravais lattices and crystal system. Common crystal structures: NaCl, perovskites. Packing efficiency and coordination numbers. Bragg's law. Powder X-ray diffraction. Indexing diffraction patterns. Determination of lattice parameter.

Unit 3. Symmetry of Condensed Systems

Properties of solids (electrical, mechanical and optical). Lattice defects, doping for defects. Electron-gas model, heat capacity paradox, electrical conductivity. Band theory of metallic state.

Unit 4. Conductor Semiconductors and Insulators.

Controlled valency and hopping phenomena, p & n-type conductivity, p, n-junctions. Solid-state reactions. Developments in superconductivity.

Recommended Books/Reference Material

1. West, A. R. (2022). *Solid state chemistry and its applications*. John Wiley & Sons.
2. Bhatia, S., (2020). *Zeolite catalysts: principles and applications*. CRC press.
3. Rudin (1990) “*The Element of Polymer Science and Engineering*” Academic Press.
4. West A. R. (1989) “*Solid State Chemistry*”, J. Wiley, New York.

Radiation and Photochemistry

BS-Chemistry

Course Code: CHM-436

Credit Hours: 03

Pre-requisite: Nil

Objectives

- Students will learn about the mechanisms of radiation induced chemical changes in molecules, radiation dosimeter and applications of the radiation chemistry.
- They will also learn about radioactive decays, and how radioisotopes are produced and applied in Mössbauer spectroscopy.
- Students will be able to understand the principles of fluorescence, phosphorescence and other photochemical processes, and their applications.

Learning Outcomes

- Apply advanced kinetic approaches to understand the intricacies of radioactive and nonradioactive processes in photochemical reactions, including flash photolysis.

Course Outline

Unit 1. Radiation Chemistry

Development and advancement in radiation chemistry. Radiation dosimeter. Fricke dosimeter, dosimetry in pulse radiolysis.

Unit 2. Energy States in Radiation Chemistry

Excited states, production formation through excited states. Fragmentation, predissociation, photochemical decay. Evidence for the existence of excited state and its types. Ions and electrons, radiolysis of gases.

Unit 3. Photophysical Processes

Radiative vs. non-radiative decay, Fluorescence and phosphorescence, internal conversion and intersystem crossing, Fluorescence quenching (static and dynamic).

Unit 4. Photochemical Reactions

Photodissociation and photoionization, Norrish Type I and II reactions. Cis-trans isomerization. Photosensitization and energy transfer mechanisms (Förster and Dexter mechanisms)

Unit 5. Advance Approach to Kinetics of Photochemical Reactions

Applied photochemistry. Atmospheric photochemistry. Photosynthesis, photochemistry of polymers, photomedicines. Techniques in photochemistry, introduction, light source. Incandescent filament lamps, discharge lamps, lasers, synchrotron reaction.

Recommended Books/Reference Material

1. Blatchley, E. R., Blatchley, E. R. (2022). Photochemical Reactors: Theory, Methods, and Applications of Ultraviolet Radiation. United Kingdom: Wiley.
2. Sharon, M., Sharon, M. (2021). *Nuclear Chemistry*. Germany: Springer International Publishing.
3. Calvert J. G. and Pitts J.N., (1966) “*Photochemistry*” John Wiley, New York.
4. Wayne and Richard P. (1988) “*Photochemistry*” Macmillan.
5. Hughes G. (1973) “*Radiation Chemistry*” Oxford Series, UK.
6. Spinks J. W. T. and Woods R. J. (1976) “*An introduction to Radiation Chemistry*” Wiley Inter Sci. Pub, USA.
7. O'Donnell J. H. and Sangster D. F. (1970) “*Principle of Radiation Chemistry*” Edward Arnold Pub, UK.

Colloids and Surfactants

BS-Chemistry

Course Code: CHM-459

Credit Hours: 03

Pre-requisite: Nil

Objectives

- To introduce students to the basic principles and behavior of colloids and surfactants.
- The course emphasizes their types, properties, and practical applications in daily life and industry.

Learning Outcomes

- Students will be able to classify colloids and surfactants, explain their mechanisms, and analyze their roles in various applications.
- They will gain foundational knowledge useful in fields like pharmaceuticals, food science, and materials engineering.

Course Outlines

Unit 1. Introduction to Colloids

Definition and types of colloids (sol, gel, foam, emulsion, aerosol). Classification based on the phase of dispersed system. Tyndall effect, Brownian motion, and colloidal size range. Real-life examples: Milk, fog, paints, toothpaste.

Unit 2. Colloidal Properties and Stability

Surface area and adsorption in colloids. Surface and interfacial tension. Electrical properties: Zeta potential, double layer. Stability of colloids: Coagulation and peptization.

Unit 3. Introduction to Surfactants

What are surfactants? Structure (hydrophobic & hydrophilic parts). Classification: Anionic, cationic, nonionic, zwitterionic. Micelle formation and Critical Micelle Concentration (CMC). Examples: Soap, detergents, shampoo.

Unit 4. Surfactant Action and Applications

Mechanism of cleaning action. Emulsification and solubilization. Role of surfactants in pharmaceuticals, food, and cosmetics. Environmental impact and biodegradable surfactants.

Unit 5. Industrial and Biological Applications

Use of colloids in medicine (drug delivery, nanocolloids). Surfactants in textile and petroleum industries. Colloidal systems in wastewater treatment. Introduction to nanocolloids and smart surfactants.

Recommended books/reference material

1. Holmberg, K. (Ed.). (2002). *Handbook of applied surface and colloid chemistry* (Vols. 1–2). John Wiley & Sons.
2. Hunter, R. J. (2001). *Foundations of colloid science* (2nd ed.). Oxford University Press.
3. Myers, D. (2020). *Surfactant science and technology* (4th ed.). Wiley.
4. Rosen, M. J., & Kunjappu, J. T. (2012). *Surfactants and interfacial phenomena* (4th ed.). Wiley.
5. Shaw, D. J. (1992). *Introduction to colloid and surface chemistry* (4th ed.). Butterworth-Heinemann.
6. Tadros, T. F. (2011). *Colloids in cosmetics and personal care* (1st ed.). Wiley-VCH.

Radio and Nuclear Chemistry

BS-Chemistry

Course Code: CHM-416

Credit Hours: 03

Pre-requisite: Nil

Objectives

After studying this course, the student will be able to explain in detail

- the structure of nucleus. Describe the phenomenon of radioactivity and types of radioactive rays.
- Describe the applications of radioactivity in various aspects of life. Understand the kinetics of nuclear reactions. Explain artificial radioactivity and its applications. Fathom concepts like nuclear binding energy and binding modes.

Learning Outcomes

- This course is designed to develop fundamental and conceptual understanding of key concepts in Nuclear Chemistry

- It will enable students to be able to get in touch with the latest advances in the field of nuclear energy and contribute towards sound research in Pakistan in this field.

Course Outline

Unit 1. Fundamentals Aspects of Radioactivity and Nuclear Chemistry

Fundamentals aspects of Radioactivity and Nuclear Chemistry. Applied aspects of Radioactivity and Nuclear Chemistry. Types and characteristics of nuclear radiations.

Unit 2. Structure of Nucleus

Structure of Nucleus. Half-life of nuclear decay. Nuclear binding energy and binding modes.

Unit 3. Nuclear Reactions

Stability of nucleoids. Nuclear reactions

Unit 4. Artificial Radioactivity

Artificial radioactivity. Fission reactions and their applications. Fusion reactions and their applications.

Unit 5. Radioisotopes

Acceleration of charged particles. Radioisotopes and their application.

Recommended Books/Reference Material

1. Sharon, M., Sharon, M. (2021). Nuclear Chemistry, Springer International Publishing.
2. Kratz, J. (2022). Nuclear and Radiochemistry: Fundamentals and Applications, Wiley.
3. Loveland W., Morrissey D.J. and Seaborg J.T. (2006). Modern Nuclear Chemistry, John Wiley and Sons, Inc.
4. Prakash S. (2000). Advanced Inorganic Chemistry, S. Chand Limited

Chemical Thermodynamics

BS-Chemistry

Course Code: CHM-458

Credit Hours: 03

Pre-requisite: Nil

Objectives

The students will acquire knowledge:

- To understand the fundamental principles and laws of thermodynamics and chemical equilibrium.
- To investigate physical properties of ideal/non-ideal binary solutions.
- About the rates of reaction and perform related equations.

Course Outlines:

Unit 1. Introduction to Thermodynamics

Definition and scope of thermodynamics. Systems and surroundings: open, closed, isolated systems. Types of processes: isothermal, adiabatic, isobaric, isochoric. State and path functions, extensive and intensive properties.

Unit 2. Laws of Thermodynamics

First, second and third law of thermodynamics. Derivation and their applications.

Unit 3. Thermodynamic Functions and Relations

Helmholtz free energy (A) and Gibbs free energy (G). Criteria for spontaneity and equilibrium. Maxwell relations. Thermodynamic equations of state. Fundamental equations and exact differentials.

Unit 4. Chemical Equilibrium

Equilibrium constants and Gibbs free energy. Standard Gibbs free energy changes. Relationship between K_p , K_c , and ΔG° . Temperature dependence of equilibrium constants (van't Hoff equation). Le Chatelier's principle.

Unit 5. Applications of Thermodynamics

Thermodynamic cycles: refrigeration, engines. Thermodynamics of biochemical systems. Industrial chemical thermodynamics (e.g., ammonia synthesis).

Recommended Books/reference material

1. DeVoe, H. (2001). *Thermodynamics and chemistry* (p. 431). Upper Saddle River, NJ: Prentice Hall.

2. Halder, G. (2014). *Introduction to chemical engineering thermodynamics*. PHI Learning Pvt. Ltd.
3. Gaskell, D. R., & Laughlin, D. E. (2024). *Introduction to the Thermodynamics of Materials*. CRC press.
4. Borgnakke, C., & Sonntag, R. E. (2020). *Fundamentals of thermodynamics*. John Wiley & Sons.

Statistical Thermodynamics

BS-Chemistry

Course Code: CHM-431

Credit Hours: 03

Pre-requisite: Nil

Objectives

The students will acquire knowledge:

- Understand the molecular basis of thermodynamics by relating macroscopic thermodynamic properties to microscopic molecular behavior using statistical methods.
- Explain the fundamental postulates of statistical mechanics, including microstates, macrostates, ensembles, and probability distributions.
- Derive thermodynamic quantities such as internal energy, entropy, Helmholtz free energy, and heat capacity from molecular partition functions.

Course Outline:

Unit I: Fundamentals of Statistical Thermodynamics

1. Introduction & Review

- Scope of statistical thermodynamics
- Relation between classical thermodynamics and molecular approach
- Probability theory & statistical methods (review)

2. Concept of Ensembles

- Microcanonical, canonical, and grand canonical ensembles
- Postulates of statistical mechanics

Unit 2: Partition Functions

Molecular Partition Functions

- Translational, rotational, vibrational, and electronic contributions
- Factorization of partition functions

Thermodynamic Properties from Partition Functions

- Internal energy, entropy, Helmholtz free energy, heat capacities
- Connection between molecular properties and macroscopic observables

Unit 3: Applications

Ideal Gases & Real Systems

- Statistical basis of ideal gas law
- Non-ideal gases and virial expansion

Equilibrium

- Equilibrium constants from statistical mechanics
- Application to chemical reactions

Unit 4: Quantum Statistics

Quantum Distributions

- Maxwell–Boltzmann, Bose–Einstein, and Fermi–Dirac statistics
- Applications to photons (Planck’s law) and electrons (Fermi energy)

Solids & Heat Capacity

- Einstein and Debye models of solids
- Application to specific heats

Recommended books/reference material

1. McQuarrie, D. A. (2000). *Statistical mechanics*. University Science Books.
2. McQuarrie, D. A., & Simon, J. D. (1997). *Physical chemistry: A molecular approach*. University Science Books.
3. Hill, T. L. (1986). *An introduction to statistical thermodynamics*. Dover Publications.
4. Levine, I. N. (2009). *Physical chemistry* (6th ed.). McGraw-Hill Education.
5. Atkins, P., de Paula, J., & Keeler, J. (2018). *Atkins’ physical chemistry* (11th ed.). Oxford University Press.
6. Pathria, R. K., & Beale, P. D. (2011). *Statistical mechanics* (3rd ed.). Elsevier.

d. Course Outlines of Analytical Chemistry

Advanced Chromatography

BS-Chemistry

Course Code: CHM-460

Credit Hours: 03

Pre-requisite: Nil

Objectives

The primary objective of this course is to equip students with a comprehensive understanding of advanced chromatographic techniques, their principles, instrumentation, and practical applications across various scientific disciplines.

Learning Outcomes

- Identify and configure the components of advanced chromatographic instruments
- Optimize parameters such as flow rates, temperature, column selection, and detector settings for enhanced performance.
- Perform qualitative and quantitative analysis of environmental pollutants, pharmaceuticals, biological samples, and industrial chemicals.

Course Outline

Unit 1. Gas Chromatography

Instrumentation and Operational Principles, Capillary vs. Packed Columns, Detectors (FID, ECD, TCD, MS), Carrier Gases and Flow Rate Optimization, Sample Preparation and Injection Techniques, Interpretation, Applications in Environmental, Pharmaceutical, and Forensic Analysis.

Unit 2. High Performance Liquid Chromatography

Principles of Liquid Chromatography, Instrumentation Overview: Solvent reservoir, pump, injector, column, detector, and data acquisition, Interpretation, Column, Stationary phase, Mobile Phase, Elution strategies.

Unit 3. Specialized Liquid Chromatographic Techniques

Ultra-Performance Liquid Chromatography (UPLC), Fast protein liquid chromatography (FPLC), Affinity chromatography.

Unit 4. Thin-Layer Chromatography (TLC)

Basic Principles of TLC, High-Performance Thin-Layer Chromatography (HPTLC), Detection and Quantification Methods, Advanced visualization Techniques

Unit 5. Super Critical Fluid Chromatography

Principles and Instrumentation, Mobile Phases and Modifiers, Detectors and Data Analysis, Applications in Pharmaceuticals and Environmental Analysis

Recommended books/reference material

1. Waters, T. (2024). Process Gas Chromatography: Advanced Design and Troubleshooting. John Wiley & Sons.
2. Akash, M. S. H., & Rehman, K. (2025). Comprehensive Insights into Gas Chromatography. In Essentials of Pharmaceutical Analysis. Springer, Singapore.
3. Debnath, S., Das, M., Mondal, S., Sarkar, B. K., & Babu, G. (2025). Advances in chromatography: Contemporary techniques and applications. Essential Chem, 2(1), 1-27.
4. Kowalska, T., & Sajewicz, M. (2022). Thin-layer chromatography (TLC) in the screening of botanicals—its versatile potential and selected applications. Molecules, 27(19), 6607.
5. Roy, D., & Farooq, M. (2024). Supercritical Fluid Chromatography: A Workhorse in Drug Discovery.
6. Monesh Babu, J. D. (2025). Applications of Supercritical Fluid Chromatography. Cuestiones de Fisioterapia, 54(3), 2956-2963.

Atomic Spectroscopy

BS-Chemistry

Course Code:CHM-461

Credit Hours: 03

Pre-requisite: Nil

Objectives

This course provides an in-depth understanding of atomic spectroscopy techniques, focusing on their principles, instrumentation, applications, and method development.

Learning Outcomes

- Explain the principles of atomic absorption and emission
- Describe the mechanisms of atomic excitation, ionization, and emission of radiation.
- Configure and calibrate instruments for optimal performance in qualitative and quantitative analysis.

Course Outline

- Unit 1. Fundamentals of Atomic Spectroscopy**
Basic principle of Atomic Spectroscopy, Atomic structure and electron transitions. Energy levels, Emission spectra, and absorption spectra, Quantitative aspects of atomic spectroscopy, Spectral line broadening mechanisms.
- Unit 2. Flame Emission**
Basic principle of Flame Emission spectroscopy, Use of atomic spectra for detection and determination of elements, Flame as a source of atomization and excitation, Instrumentation involved in FES, Applications and limitations.
- Unit 3. Atomic Absorption Spectroscopy**
Basic Principle of AAS, Flameless AA spectroscopy including graphite furnace and hydride generation.
- Unit 4. Arc/Spark Spectroscopy**
Fundamental Principles of Arc/Spark AES, Atomic excitation, emission of photons, and spectral lines, Mechanisms of electrical discharge: Arc vs. Spark. Energy transfer and ionization processes. Types of electrical discharges: DC Arc, AC Arc, and Spark discharges.
- Unit 5. Inductively Coupled Plasma**
ICP theory, instrumentation, Sample introduction system, excitation sources, ICP torch, Detector.

Recommended books/reference material

1. Thomas, R. (2023). Practical Guide to ICP-MS and Other Atomic Spectroscopy Techniques: A Tutorial for Beginners. CRC Press.
2. Welz, B., & Vale, M. G. R. (2019). Atomic absorption spectrometry and related techniques. In Ewing's Analytical Instrumentation Handbook, Fourth Edition (pp. 71-116). CRC Press.
3. Bruno, T. J., Robinson, J. W., Frame, E. M. S., & Frame, G. M. (2023). Atomic Emission Spectroscopy. In Undergraduate Instrumental Analysis (pp. 421-488). CRC Press.
4. Evans, E. H., Pisonero, J., Smith, C. M., & Taylor, R. N. (2021). Atomic spectrometry update: review of advances in atomic spectrometry and related techniques. Journal of Analytical Atomic Spectrometry, 36(5), 868-891.

5. Dean, J. R. (2019). Practical inductively coupled plasma spectrometry. John Wiley & Sons.

Electro Analytical Chemistry

BS-Chemistry

Course Code: CHM-462

Credit Hours: 03

Pre-requisite: Nil

Objectives

This course provides a comprehensive exploration of electroanalytical chemistry, focusing on the principles, instrumentation, and applications of modern electrochemical methods.

Learning Outcomes

- Students will be able to understand about different techniques relating to electrochemical methods
- Electrochemical cells and various types of electrodes and their working.

Course Outline

Unit 1. Fundamentals of Electroanalytical chemistry

Development and scope of electro analytical techniques, Fundamental concepts: oxidation, reduction, electrochemical cells. Standard electrode potentials and electrochemical series.

Unit 2. Instrumentation and Electrode Types

Polarography and applications of polarography in analytical chemistry, amperometric techniques and instrumentation, voltametric techniques, instrumentation, linear potential sweep (DC) voltammeter, potential methods, phase-sensitive alternating current voltammeter, stripping voltammeter.

Unit 3. Qualitative and Quantitative Aspects of Voltammeter

Analogue instrumentation, overcoming solution resistance with stability and grace in potentiostatic circuits, conductivity and conductometry, electrochemical cells.

Unit 4. Carbon and Film Electrodes

Microelectrodes, chemically modified electrodes, mercury electrodes, solvent and supporting electrolytes. Electrochemical studies at reduced temperature, electro analytical techniques for molten salts.

Unit 5. Potentiometry

Measurement of electrode potentials and cell voltage, Reference electrodes: Standard Hydrogen Electrode (SHE), Calomel, and Ag/AgCl.

Recommended books/reference material

1. Simoska, O., & Minteer, S. D. (2022). Techniques in electroanalytical chemistry (Vol. 28). American Chemical Society.

2. Smutok, O., & Katz, E. (2024). Electroanalytical instrumentation—how it all started: history of electrochemical instrumentation. *Journal of Solid-State Electrochemistry*, 28(3), 683-710.
3. Vani, K. D., Dorai, S. T., & Chandrashekhara, S. (2025). Review on Voltammetry. In *Advancements in Voltammetry for Biosensing Applications* (pp. 1-16). Singapore: Springer Nature Singapore.
4. Mahajan, P. G., Yadav, A., Tiwari, P., & Chandrashekhara, S. (2025). Brief Overview of Voltammetry for Biosensing Applications. *Advancements in Voltammetry for Biosensing Applications*, 45-62.
5. Zia, A. W. (Ed.). (2025). *Applications of Diamond-like Carbon Coatings*. John Wiley & Sons.
6. Manjunatha, J. G. (Ed.). (2025). *Handbook of Carbon Sensors: Understanding and Applications*. CRC Press.
7. Ritgen, U. (2025). Potentiometry. In *Analytical Chemistry II* (pp. 93-111). Berlin, Heidelberg: Springer Berlin Heidelberg.

Hyphenated Techniques

BS-Chemistry

Course Code: CHM-445

Credit Hours: 03

Pre-requisite: Nil

Objectives

Explore and understand hyphenated techniques such as GC-MS, LC-MS, MS-MS, LC-FTIR, and ICP MS in analytical chemistry. Apply theoretical principles from key textbooks by Christian, Skoog et al., and Willard et al., to enhance proficiency in analytical techniques.

Learning Outcomes

- Demonstrate practical knowledge of Gas Chromatography-Mass Spectrometry (GC-MS) and Liquid Chromatography-Mass Spectrometry (LC-MS) applications.
- Integrate insights from foundational texts, enabling a comprehensive understanding of hyphenated techniques in instrumental analysis.

Course Outline

Unit 1. Gas Chromatography-Mass Spectrometry (GC-MS)

Principles of GC-MS Coupling, Optimization of GC-MS Parameters, Comprehensive Two-Dimensional GC-MS for enhanced resolution, Data analysis and reporting: Qualitative and quantitative analysis, peak integration, and spectral matching.

Unit 2. Liquid Chromatography-Mass Spectrometry (LC-MS)

Overview of Liquid Chromatography and Mass Spectrometry, Evolution and significance of LC-MS in analytical chemistry, Mechanism of ionization in LC-MS, Separation and detection process, Understanding chromatographic peaks and mass spectra.

Unit 3. Liquid Chromatography -FTIR

Overview of Liquid Chromatography (LC) and Fourier Transform Infrared Spectroscopy (FTIR), Interfaces and Coupling Mechanisms, Strategies for solvent removal (post-column evaporation, membrane interfaces, Flow cells vs. light-pipe interfaces for IR detection, Challenges in LC-FTIR coupling: Solvent absorption, signal attenuation.

Unit 4. Inductively Coupled Plasma-Mass Spectrometry

Instrumentation, Sample Introduction Systems: Nebulizers: Concentric, Cross-flow, and Babington nebulizers, Spray chambers: Scott-type, Cyclonic, and double-pass chambers, Flow injection and laser ablation techniques, detection and signal processing in ICP-MS.

Unit 5. Capillary Electrophoresis- Mass Spectrometry

Overview of Capillary Electrophoresis (CE) and Mass Spectrometry (MS), Evolution and significance of CE-MS as a hyphenated technique, separation methodology in CE-MS.

Recommended books/reference material

1. Miller, J. M. (2021). Chromatography: concepts and contrasts. John Wiley & Sons.
2. Poole, C. (Ed.). (2023). Instrumental thin-layer chromatography. Elsevier.
3. Rouessac, F., & Rouessac, A. (2022). Chemical analysis: modern instrumentation methods and techniques. John Wiley & Sons.

Sample Preparation Techniques

BS-Chemistry

Course Code: CHM-463

Credit Hours: 03

Pre-requisite: Nil

Objectives

Describe the principles and purposes of sample preparation in different analytical techniques. Select appropriate sample preparation methods for specific analytical goals and sample types.

Learning Outcomes

- To understand the fundamental principles and importance of sample preparation in analytical chemistry.

- To learn various techniques for isolating, concentrating, and purifying analytes from complex matrices.

Course Outline

- Unit 1. Fundamentals of Sample Preparation**
Purpose and significance of sample preparation in analytical chemistry, Types of samples: biological, environmental, food, pharmaceutical
- Unit 2. Sampling**
Sampling theory, Solid, liquid and gas sampling, preparing test sample, selecting test portion, dissolution of inorganic and organic samples.
- Unit 3. Sample Isolation methods**
Liquid-liquid extraction, solid phase extraction, membrane based isolation, precipitation techniques.
- Unit 4. Preservation of Samples**
Volatilization and choice of proper containers, Absorption of gases from the atmosphere, chemical changes, Preservation of unstable solids.
- Unit 5. Preparation of Samples for Metal Analysis**
Wet digestion methods, dry ashing, sample preparation for water samples.

Recommended books/reference material

1. Neng, N. (2019) Modern sample preparation approaches for separation science, MDPI, Molecules.
2. Pawliszyn, J. Lord, H.L. (2011) Handbook of Sample preparation, John Wiley & Sons.
3. Mitra, S. (2003) Sample preparation techniques in analytical chemistry, John Wiley & Sons.

Mass Spectrometry and Applications

BS-Chemistry

Course Code: CHM-464

Credit Hours: 03

Pre-requisite: Nil

Objectives

The primary objective of this course is to provide students with a comprehensive understanding of the principles, instrumentation, and practical applications of mass spectrometry for the identification, structural elucidation, and quantification of chemical and biological compounds.

Learning Outcomes

- Understand how mass spectrometry works and how it is used to study different substances.
- Learn to identify unknown compounds using mass spectra.
- Gain basic skills to apply mass spectrometry in research, medicine, and industry.

Course Outline

Unit 1. Introduction to Mass Spectrometry

Introduction, basic principle, the mass spectrum, determination of molecular formula through molecular weight and formula, exact mass and molecular formula, index of hydrogen deficiency, different fragmentation modes.

Unit 2. Instrumentation and Techniques

Mass analyzers including TOF, quadrupole, and ion trap, Ion sources like EI, ESI and MALDI, Detectors and Data Acquisition

Unit 3. Interpretation of Mass Spectra

Understanding m/z values, Isotopic patterns, Fragmentation and Structural Analysis

Unit 4. Applications in Chemistry and Biology

Drug analysis and metabolite identification, Proteomics and biomolecule analysis, Environmental and forensic applications

Unit 5. Advanced Methods and Hyphenated Techniques

Tandem MS (MS/MS) and high-resolution MS, LC–MS, GC–MS, and other coupled methods, Quantitative mass spectrometry

Recommended books/reference material

1. Pandey, A. (2025). Mass Spectrometry: Techniques and applications. Educohack Press.
2. Johnson, P., & Downs, M. L. (2025). Mass spectrometry for analysis of food allergens. In Handbook of Food Allergen Detection and Control (pp. 415-435). Woodhead Publishing.
3. Hossain, M. (2020). The mass spectrometer and its components. In Selected Reaction Monitoring Mass Spectrometry (SRM-MS) in Proteomics: A Comprehensive View (pp. 17-52). Cham: Springer International Publishing.
4. Kuril, A. K. (2024). Exploring the versatility of mass spectrometry: Applications across diverse scientific disciplines. European Journal of Mass Spectrometry, 30(5-6), 209-220.
5. Patidar, A., & Kamble, P. (2025). A Comprehensive Review on Liquid Chromatography-Mass Spectrometry (LC-MS): A Hyphenated Technique. Asian Journal of Pharmaceutical Research and Development, 13(1), 95-103.
6. Jones, O., & Jones, O. (2020). Hyphenation. Two-Dimensional Liquid Chromatography: Principles and Practical Applications, 49-59.

12. List of General Education Courses:

S.N.	Course	Credits	Category
1.	Applied Physics	2	General Education
	Applied Physics (Lab)	1	General Education
2.	Quantitative Reasoning I	3	General Education
3.	Functional English	3	General Education
4.	Applications of Information and Communication Technologies	2	General Education
	Applications of Information and Communication Technologies (Lab)	1	General Education
5.	Social Sciences	2	General Education
	Introduction to Social Sciences		
6.	Quantitative Reasoning II	3	General Education
7.	Expository Writing	3	General Education
8.	Arts & Humanities	2	General Education
9.	Islamic Studies /Ethics	2	General Education
10.	Ideology and Constitution of Pakistan	2	General Education
11.	Civic and Community Engagement	2	General Education
12.	Entrepreneurship	2	General Education
13.	Pakistan Studies	2	General Education

13. Course outlines of General Education Courses

Quantitative Reasoning-I

Course Code: MTH-110

Pre-requisite: N.A

Credit Hours: 03

Objectives:

Quantitative Reasoning-I is an introductory-level undergraduate course that focuses on the fundamentals related to the quantitative concepts and analysis. The course is designed to familiarize students with the basic concepts of mathematics to develop students' abilities to analyze and interpret quantitative information. Through a combination of theoretical concepts and practical exercises, this course will also enable students cultivate their quantitative literacy and problem-solving skills while effectively expanding their academic horizon and breadth of knowledge of their specific major / field of study.

Learning Outcomes:

By the end of this course,

- The students shall have fundamental numerical literacy to enable them work with numbers, understand their meaning and present data accurately.
- Understanding of fundamental mathematical concepts. Basic ability to interpret data presented in various formats including but not limited to tables, graphs, charts, and equations etc.

Course Outline:

Unit-1. Numerical Literacy

Number system and basic arithmetic operations. Units and their conversions, dimensions, area, perimeter and volume. Rates, ratios, proportions and percentages. Types and sources of data; Measurement scales. Tabular and graphical presentation of data. Quantitative reasoning exercises using number knowledge.

Unit-2. Fundamental Mathematical Concepts

Basics of geometry (lines, angles, circles, polygons etc. Relations, functions, and their graphs. Exponents, factoring and simplifying algebraic expressions. Algebraic and graphical solutions of linear and quadratic equations and inequalities. Quantitative reasoning exercises using fundamental mathematical concepts.

Unit-3. Mathematical Modeling and Analyses

Introduction to deterministic models. Use of linear functions for modeling in real-world situations. Modeling with the system of linear equations and their solutions. Elementary introduction to derivatives in mathematical modeling. Linear and exponential growth and decay models. Quantitative reasoning exercises using mathematical modeling.

Unit-4. Introduction to Logic

Introduction and importance of logic. Inductive, deductive and abductive approaches of reasoning. Propositions, arguments (valid, invalid), logical connectives.

Unit-5. Truth Tables and Logical Reasoning Concepts

Truth tables and propositional equivalences. Logical fallacies. Venn Diagrams. Predicates and quantifiers. Quantitative reasoning exercises using logical reasoning concepts and techniques.

Recommended Books/Reference Books

1. Bennett, J., & Briggs, W.L and Badalamenti. A. (2019). *Using and understanding mathematics: A quantitative reasoning approach*. Pearson.
2. Mesquita, E.B., and Fowler, A. (2021). *Thinking Clearly with Data: A Guide to Quantitative Reasoning and Analysis*. Princeton University Press.
3. Rosen, K. H. (2007). *Discrete mathematics and its applications*. The McGraw Hill Companies.
4. Schröder, B. (2010). *Fundamentals of Mathematics*. Wiley.
5. Zaslow, E. (2020). *Quantitative Reasoning: Thinking in Numbers*. Cambridge University Press.

Functional English

Course Code: ENG-110

Credit Hours: 03

Pre-requisite: N.A

Objectives:

This course is designed to equip students with essential language skills for effective communication in diverse real-world scenarios. It focuses on developing proficiency in English language usage: word choices, grammar and sentence structure. In addition, the course will enable students to grasp nuanced messages and tailor their communication effectively through application of comprehension and communication aspects including professional writing, public speaking, and

everyday conversation. Ensuring that students are equipped in both academic and professional spheres. An integral part of the course is fostering a deeper understanding of the impact of language on diverse audiences. Students will learn to communicate inclusively and display a strong commitment to cultural awareness in their language use. Additionally, the course will enable them to navigate the globalized world with ease and efficacy, making a positive impact on their functional interactions.

Learning Outcomes:

- Apply enhanced English communication skills through effective use of word choices, grammar and sentence structure
- Comprehend a variety of literary non-literary written and spoken texts in English.
- Effectively express information, ideas and opinions in written and spoken English.
- Recognize inter-cultural variations in the use of English language and to effectively adapt their communication style and content based on diverse cultural and social contexts.

Course Outline:

Unit-1. Introduction

Ice breaking Activities. Types and modes of Communication. Intrapersonal, Intrapersonal and group Communication.

Unit-2. Rules for Structure of Sentences

Types of sentences on the basis of function (Declarative, Interrogative, Imperative, Exclamatory and structure (simple, compound, complex). Synthesis of sentences. Punctuation and Spellings. Vocabulary, lexical and functional categories.

Unit-3. Concept of Time and Tense (present, past, future).

Discussion: General topics and everyday conversation. Concept of Voice: active and passive voice. Functional use of Voice in different situations.

Unit-4. Direct and Indirect Reporting.

Discussion regarding description of things persons, places, pictures, events etc. Salutation & Greeting, Introduction, asking and answering questions.

Unit-5. Practicing Everyday Conversation

Request and Permission, Agreement and Disagreement. Apologizing, Expressing likes and Dislikes, expressing opinion. Expressing approval, Disapproval.

Unit-6. Articulating Expression

Expressing appreciation, regret, and indifference. Expressing certainty, uncertainty, and obligation. Expressing suggestion, warning, Expressing possibility, impossibility & logical conclusion.

Unit-7. Art of Inviting

Accepting, declining invitation. Expressing & inquiring about preferences. Stating intentions and Making Plans. Giving directions. Instructing people how to do things.

Unit-8. Discussing Past and Present

Future prospects, talking about the past.

Recommended Books/ Reference Material

1. Azar, B. S. (2003). *Fundamentals of English grammar*. Longman.
2. Beebe, S. A., Beebe, S. J., & Ivy, D. K. (2010). *Communication: Principles for a lifetime* (p. 483). Boston, MA: Allyn & Bacon.
3. Eastwood, J. (1994). *Oxford guide to English grammar*. Oxford University Press.
4. Floyd, K., & Cardon, P. (2023). *Business and Professional Communication*. McGraw-Hill US Higher Ed USE.)
5. Kortmann, B. (2020). *English linguistics: essentials*. Springer Nature.
6. Langan, J. (2001). *College writing skills with readings*. New York.
7. Murphy, R. (2003). *English grammar in use*. Cambridge: Cambridge University Press.
8. Sharma, Gajendra Dutt (2023) *A Comprehensive Resource Book of Functional English*, OEP, New Delhi.
9. Thomson, A. J., & Martinet, A. V. (2015). *A practical English grammar*. New York: Oxford University Press.
10. Wren, P. C., & Martin, H. (2000). *English grammar and Composition*. New Delhi: S Chand & Company Ltd.

Introduction to Social Sciences

Course Code: SOC-104

Credit Hours: 02

Pre-requisite: Nil

Objectives:

Introduction to Social Sciences offers a comprehensive overview of the various disciplines within social sciences, exploring their origins, scope, methodologies, applications, and interconnectedness. Students will be introduced to anthropology, sociology, psychology, political science, economics, geography, and history, with an emphasis on their relevance to contemporary Pakistani society. The course encourages critical thinking, interdisciplinary understanding, and the application of social sciences in real-world contexts.

Learning Outcomes

Upon completion of this course, students will be able to:

- Understand the origins and development of social sciences as distinct fields of study.
- Recognize the scope, methodologies, and principles of various social science disciplines.
- Analyze social phenomena from interdisciplinary perspectives.
- Apply social science concepts to understand and address issues relevant to Pakistani society.
- Engage in critical discussions, research, and ethical considerations within social sciences.

Course Outlines**Unit 1. Introduction to Social Science**

Definition and Importance of Social Sciences. Historical Development and Interconnectedness

Unit 2. Anthropology

Scope, Methods, and Key Concepts. Cultural and Biological Anthropology

Unit 3. Sociology

Origin and Scope of Sociology. Key Concepts. Sociological Imagination

Unit 4. Psychology

Introduction to Psychology and its Branches Human Behavior and Mental Processes

Unit 5. Political Science

Understanding Political Systems and Governance. Politics and International Relations

Unit 6. Social Sciences in Pakistani Society

Application of Social Sciences in Pakistani Context. Social Issues, Policies, and Cultural Insights

Unit 7. Research Methods in Social Sciences

Quantitative and Qualitative Research. Research Ethics

Unit 8. Interdisciplinary Approaches and Future Trends

Integration of Social Science Disciplines. Emerging Trends and Future Challenges

Recommended Books/Reference Material

1. Colander, D., & Hunt, E. (2022). *Social science: An introduction to the study of society*. Routledge.
2. Gerring, J. (2011). *Social science methodology: A unified framework*. Cambridge University Press.
3. Habermas, J. (2015). *On the logic of the social sciences*. John Wiley & Sons.
4. Sharpe, D. K. (2009). *The evolution of the social sciences*. Lexington Books.
5. Williams, M. (2012). *Science and social science: An introduction*. Routledge.

Applied Physics

Course Code: PHY-103

Credit Hours: 02

Prerequisites: Nil

Objectives

The main objective of the course is to provide basic information about Mechanics, Electricity, Magnetism, Electromagnetism, Waves and oscillations, optics, and Electronics to the technology students. The course gives the students a sound knowledge of Physics with its applications to problems of practical nature

Learning Outcomes

- Apply fundamental principles of mechanics, relativity, and vector analysis to solve problems involving motion, force, and planetary dynamics.
- Analyze electric and magnetic fields in physical systems, including the behavior of capacitors, inductors, and DC circuits.
- Explain the working principles and applications of semiconductor devices such as diodes, transistors, and LEDs based on their electronic structure.

Course Outline

Unit 1. Physics Fundamentals

Basic concept of units, vectors and scalars, measurements and uncertainties, Addition of vectors by graphical and component method. Multiplication of vectors, vectors in three dimensions,

Unit 2. Newton's Laws and Relativity

Newton's laws of motion and their applications, Work and Kinetic Energy, Gravitation, Circular motion, projectile motion, orbits of planets, linear and angular momenta, basic concepts of general and special theory of relativity.

Unit 3. Electricity

Conductors and Insulators, Electrostatic Force, Capacitors and Dielectrics, Capacitance, Energy store in capacitor (Capacitor as memory device), DC Circuits, Measuring V, I, R, RC Circuits.

Unit 4. Magnetism

Magnetic Fields, Magnetic Force, Magnetic Field, Magnetic Field Energy, inductors and inductance, energy stored in inductor (inductor as memory device) magnetic materials.

Unit 5. Semiconductors

Semi-Conductors Energy levels in a semi-conductor, Hole concept, Intrinsic and Extrinsic regions, PNP, NPN junction Transistor, LEDs.

Recommended Books/Reference Material

1. Beiser A. & Hademenos G. J. (2012). *Applied physics*. McGraw Hill.
2. Giambattista A. Richardson B. M. C. & Richardson R. C. (2020). *Physics*. McGraw-Hill Education.
3. Halliday, D., Resnick, R., & Walker, J. (2021). *Fundamentals of physics*, Extended (12th ed.). Wiley.
4. Hecht E. (2021). *College physics*. McGraw Hill Education.
5. Serway, R. A., & Jewett, J. W. (2018). *Physics for scientists and engineers* (10th ed.). Cengage Learning.

Applied Physics (Lab)

Course Code: PHY-103L

Credit Hours: 01

Prerequisites: Nil

Objectives

The course objectives are to enable students to comprehend and apply fundamental principles of measurement, elasticity, electrical circuits, and logic gates. They should develop the ability to conduct experiments, analyze data, and manipulate instruments for various measurement and electrical applications, fostering a solid foundation in experimental physics and electronics.

Learning Outcomes

- Demonstrate a solid understanding of fundamental principles in applied physics, including mechanics, thermodynamics, and electromagnetism.
- Apply mathematical and computational techniques to analyze and solve real-world problems in various branches of applied physics.

- Develop practical skills in laboratory experiments, data acquisition, and analysis, enhancing the ability to apply theoretical concepts to hands-on situations.
- Communicate effectively, both orally and in writing, about complex physics concepts, experimental results, and their applications in practical scenarios.

List of Experiments

1. Study and understand the working principle of Vernier caliper and Screw Gauge.
2. Study Hooke's Law using the mass-spring system, determining the stiffness (k -value) of the spring.
3. Investigate the relationship between the length of a pendulum and its period of oscillation.
4. Determine the internal resistance of a galvanometer using the half deflection method.
5. Experiment with various resistors and voltage sources to verify Ohm's law ($V = IR$) by measuring voltage, current, and resistance in a circuit.
6. Convert a galvanometer into a voltmeter.
7. Convert a galvanometer into an ammeter.
8. Study the series and parallel configurations of capacitors and resistors and verify binary truth tables using logic gates.

Recommended Books/Reference Material

1. Giambattista A. Richardson B. M. C. & Richardson R. C. (2020). *Physics*. McGraw-Hill Education.
2. Halliday, D., Resnick, R., & Walker, J. (2021). *Fundamentals of physics*, Extended (12th ed.). Wiley.
3. Hecht E. (2021). *College physics*. McGraw Hill Education.
4. Loyd, D. H. (2008). *Physics laboratory manual*. Thomson Higher Education.
5. Smith, W. F. (2020). *Experimental physics: principles and practice for the laboratory*. Taylor and Francis.
6. Wilson, J. D., & Hernández-Hall, C. A. (2014). *Physics laboratory experiments*. Cengage Learning.

Pakistan Studies

Course Code: PAK-104

Credit Hours: 02

Pre-requisite: Nil

Objectives

This course is designed to provide students with a comprehensive exploration of Pakistan's identity, spanning geographical, historical, and cultural dimensions. It delves into the diverse landscapes, ancient civilizations, and rich cultural heritage that define Pakistan. Moreover, it examines the socio-cultural and political transformations in Pakistan over

time including democratic transitions and military interventions. The aim of this course is to inculcate in students a nuanced understanding of Pakistan's past, present, and potential future trajectories, enabling them to critically evaluate the complex dynamics shaping the nation's development.

Learning Outcomes

After studying this course, the student will be able to:

- Have enhanced knowledge of the geographical, historical, and political aspects of Pakistan.
- Understand the society and culture of Pakistan.
- Understand and explain the socio-economic developments in Pakistan.
- Explore contemporary issues and challenges faced by Pakistan and their implications for the future.

Course Outline

Unit 1. Introduction to Pakistan

Geographical location and significance. Historical background: Ancient civilizations in the region. Factors leading to the creation of Pakistan.

Unit 2 Political History of Pakistan

Formative phase. Military interventions and democratic transitions.

Unit 3. Geography of Pakistan

Physiography: Mountains, plains, plateaus, deserts, valleys and coastal areas. River systems: Indus River and its tributaries. Climatic regions of Pakistan.

Unit 4. Society and Culture of Pakistan

Socio-cultural diversity. Languages and literature of Pakistan

Unit 5. Economic Development of Pakistan

Agriculture and industrial sectors of Pakistan. Economic challenges of Pakistan.

Unit 6. Contemporary Issues

Foreign relations of Pakistan. Security challenges: terrorism, extremism, and regional conflicts. Environmental problems and sustainable development (SDGs). Media and social change.

Recommended Books/ Reference Material

1. "Jinnah of Pakistan" by Stanley Wolpert
2. "The Sole Spokesman: Jinnah, the Muslim League, and the Demand for Pakistan" by Ayesha Jalal
3. "The struggle for Pakistan" by Ishtiaq Husain Qureshi
4. "Pakistan, the Formative Phase, 1857-1948" by Khalid B. Sayeed
5. "Pakistan Studies: A Book of Readings" by Sikandar Hayat
6. "Constitutional and Political History of Pakistan" by Hamid Khan
7. "Trek to Pakistan" by Ahmad Saeed and Kh. Mansur Sarwar
8. "Pakistan: A Modern History" by Ian Talbot
9. "Politics in Pakistan: The Nature and Direction of Change" by Khalid B. Sayeed
10. "Physical Geography of Pakistan" by Umar Jahangir
11. "A Geography of Pakistan: Environment, People, and Economy" by Fazle Karim Khan
12. "Pakistan's Foreign Policy: An Historical Analysis" by S. M. Burke
13. "Separatism in East Pakistan" by Rizwan Ullah Kokab
14. "Being Pakistani: Society, Culture and the Arts" by Raza Rumi
15. "Pakistan's Cultural Heritage: Socio-Economic and Technological Aspects" edited by Abdul Jabbar Khan

16. "Language and Politics in Pakistan" by Tariq Rahman
17. "Sociology" by Horton and Hunt
18. "Pakistan in the Twentieth Century: A Political History" by Lawrence Ziring
19. "Economic Development of Pakistan" by Ishrat Husain
20. "Issues in Pakistan's Economy" by S. Zaidi

Application of Information and Communication Technologies

Course Code: CS-107

Credit Hours: 02

Pre-requisite: N.A

Objectives:

This course provides a very broad range of topics and prepares the students for various DOMAINS in computing that they will face in upcoming semesters. This course is very comprehensive as it provides every student a set of productivity tools that they will be able to use for the rest of their lives. It provides knowledge and skills for use of computing and communication technologies to solve real life problems. This is an introductory course about Information and Communication Technologies that includes ICT terminologies, hardware and software components, the internet and World Wide Web, and ICT based applications.

Learning Outcomes:

- **Define** various types and components of computer including input/output devices, memory, storage media.
- **Describe** different types of software from operating systems to system utilities and productivity apps.
- **Describe** the basic concepts of computer networks, database management and computer security from a user point of view, components of a computer including input/output devices, memory, storage media.

Course Outline:

Unit-1. Technology

Types of Computers, Mobile & Game Devices, Data and Information, The Web, Web Searching, Online Social Networks, Internet Communications. Digital Security and Privacy, Viruses and Other Malware, Privacy, Health Concerns, Environmental Issues, Programs and Apps, Operating Systems, Applications, Installing and Running Programs, Developing Programs and Apps,

Communications and Networks, Wired and Wireless Communications, Networks, Technology Uses, Government, Finance, Retail, Entertainment, Health Care, Science, Travel, Publishing, Manufacturing, Technology Users.

Unit-2. Online Web

The Internet, Websites and Media, The Internet, Evolution of the Internet, connecting to the Internet, Internet Service Providers, How Data Travels the Internet, IP & MAC Addresses and Domain Names, The World Wide Web, Navigating the Web, Web Addresses, Web Apps and Mobile Apps. Types of Websites, Digital Media on the Web, Graphics, Audio, Video, Plug-Ins, Other Internet Services, Email, Email Lists, Internet Messaging, Chat Rooms, Online Discussions, VoIP, FTP, Netiquette.

Unit-3. Evaluating Computers and Mobile Devices

Mobile Computers and Desktops, Laptops, Tab and Other Mobile Computers, Handheld Computers, Desktops and All-in-Ones, Servers, Terminals, Point-of-Sale Terminals, Wearable Devices, Game Devices, Embedded Computers, Inside the Case, The Motherboard, Processors, The Control Unit, The Arithmetic Logic Unit, Machine Cycle, Registers, The System Clock, Personal Computer and Mobile Device Processors, Processor Cooling, The Internet of Things, Cloud Computing, Cloud Computing Services. Memory, Bytes and Addressable Memory, Types of Memory, RAM, Cache, ROM, Flash Memory, CMOS, Memory Access Times, Adapters, Adapter Cards, USB Adapters, Buses, Bus Width, Types of Buses, Power Supply and Batteries, Data Representation & Number System.

Unit-4. Programs and Apps

Role of the Operating System, Obtaining Software, Installing Software, Categories of Programs and Apps, Multimedia and Interest Applications, Communications Applications, File, Disk, and System Management Tools.

Unit-5. Digital Security Ethics, and Privacy: Threats, Issues, and Defenses

Digital Security Risks, Cybercrime, Internet and Network Attacks Malware, Botnets, Encryption, Digital Signatures and Certificates, Hardware Theft, Vandalism, and Failure, Backing Up — The Ultimate Safeguard, Wireless Security, Ethics and Society, information Accuracy, Intellectual Property Rights, Codes of Conduct, Cookies, Phishing, Spyware and Adware, Social Engineering, Privacy Laws, Employee Monitoring, Content Filtering, What is data base and data base management system, Evolution of database management, Data Concepts and Characteristics, Data Organization. Operating Systems, Operating System Functions, Starting Computers and Mobile Devices, Shutting Down Computers and Mobile Devices, providing a User Interface, Managing Programs, Managing Memory.

Recommended Books/Reference Material:

1. Campbell, J. T., Freund, S. M., Frydenberg, M., Last, M. Z., & Pratt, P. J. (2016). Shelly Cashman Series Discovering Computers & Microsoft Office 365 & Office 2016: A Fundamental Combined Approach. Cengage Learning.
2. Hafez, K., Skinner, A., & Grüne, A. (2022). Foundations of Global Communication: A Conceptual Handbook. Routledge.
3. Hawkrigde, D. (2022). New information technology in education. Taylor & Francis.
4. Pearlson, K. E., Saunders, C. S., & Galletta, D. F. (2016). Managing and using information systems: A strategic approach. John Wiley & Sons.
5. Pearlson, K. E., Saunders, C. S., & Galletta, D. F. (2024). Managing and using information systems: A strategic approach. John Wiley & Sons.

Application of Information and Communication Technologies (Lab)

Course Code: CS-107L

Credit Hours: 1

Pre-requisite: N.A

Objectives:

This course provides a very broad range of topics and prepares the students for various DOMAINS in computing that they will face in upcoming semesters. This course is very comprehensive as it provides every student a set of productivity tools that they will be able to use for the rest of their lives. It provides knowledge and skills for use of computing and communication technologies to solve real life problems. This is an introductory course about Information and Communication Technologies that includes ICT terminologies, hardware and software components, the internet and World Wide Web, and ICT based applications.

Learning Outcomes:

- **Define** various types and components of computer including input/output devices, memory, storage media.
- **Describe** different types of software from operating systems to system utilities and productivity apps.
- **Describe** the basic concepts of computer networks, database management and computer security from a user point of view, components of a computer including input/output devices, memory, storage media.

Course Outline:

Unit-1. Technology

Introduction to the lab equipment and SOPs of the labs. Introduction to computer hardware and system information. Introduction to the Web, Web Searching, Online Social Networks, Internet Communications. Digital Security and Privacy, Viruses and Other Malware, Privacy.

Unit-2. Online Web

IP & MAC Addresses and Domain Names, The World Wide Web, Navigating the Web, Web Addresses, Web Apps and Mobile Apps. Types of Websites, Digital Media on the Web, Graphics, Audio, Video, Plug-Ins, Other Internet Services, Email, Email Lists, Internet Messaging, Chat Rooms, Online Discussions, VoIP, FTP, Netiquette.

Unit-3. Evaluating Computers and Mobile Devices

Inside world: The Motherboard, Processors, The Control Unit, The Arithmetic Logic Unit, Machine Cycle, Registers, The System Clock, Personal Computer and Mobile Device Processors, Processor Cooling, The Internet of Things, Cloud Computing, Cloud Computing Services. Memory, Bytes and Addressable Memory, Types of Memory, RAM, Cache, ROM, Flash Memory, CMOS, Memory Access Times, Adapters, Adapter Cards, USB Adapters, Buses, Bus Width, Types of Buses, Power Supply and Batteries, Data Representation & Number System.

Unit-4. Programs and Apps

File, Disk, and System Management Tools. MS office

Unit-5. Digital Security Ethics, and Privacy: Threats, Issues, and Defenses

Digital Security Risks, Cybercrime, Internet and Network Attacks Malware, Botnets, Encryption, Digital Signatures and Certificates, Hardware Theft, Vandalism, and Failure. Backing Up — The Ultimate Safeguard, Wireless Security, Ethics and Society, information Accuracy, Intellectual Property Rights, Codes of Conduct, Cookies, Phishing, Spyware and Adware, Social Engineering, Privacy Laws, Employee Monitoring, Content Filtering. What is data base and data base management system, Evolution of database management, Data Concepts and Characteristics, Data Organization. Operating Systems, Operating System Functions, Starting Computers and Mobile Devices, Shutting Down Computers and Mobile Devices, providing a User Interface, Managing Programs, Managing Memory.

Recommended Books/Reference Material

1. Campbell, J. T., Freund, S. M., Frydenberg, M., Last, M. Z., & Pratt, P. J. (2016). Shelly Cashman Series Discovering Computers & Microsoft Office 365 & Office 2016: A Fundamental Combined Approach. Cengage Learning.

2. Hafez, K., Skinner, A., & Grüne, A. (2022). Foundations of Global Communication: A Conceptual Handbook. Routledge.
3. Hawkrigde, D. (2022). New information technology in education. Taylor & Francis.
4. Pearlson, K. E., Saunders, C. S., & Galletta, D. F. (2016). Managing and using information systems: A strategic approach. John Wiley & Sons.
5. Pearlson, K. E., Saunders, C. S., & Galletta, D. F. (2024). Managing and using information systems: A strategic approach. John Wiley & Sons.

Quantitative Reasoning-II

Course Code: STA-112

Credit Hours: 03

Pre-requisite: N.A

Objectives:

The main purpose of the course is to enable students to understand the significance of statistics in the real world, particularly in the field of other sciences. The course focuses on the methods of collection presentation and analysis of data using measures of central tendency and measures of dispersion. The course also focuses on basic principles of probability and distributions, regression and correlation analysis, estimation and testing of hypothesis. It will prepare students to apply the quantitative reasoning skills in solving quantitative problems which they will experience in their practical lives.

Learning Outcomes:

- Student will understand the basic statistical concepts and have basic ability to interpret data presented in various formats including but not limited to tables, graphs, charts and equation etc.
- Understand basic quantitative modeling and analyses.
- Ability to critically evaluate quantitative information to make evidence based decision through appropriate statistical tools.

Course Outline:

Unit-1. Introduction of Statistic and Data Condensation

Types and sources of data. Measurement scales. Population and sample. Tabular and graphical presentation of data. Quantitative reasoning exercises using fundamental statistical concepts.

Unit-2. Measure of Central Tendency and Dispersion

Measure of central tendency. Measure of dispersion. Data interpretation. Quantitative reasoning exercises using statistical concepts.

Unit-3. Probability and Probability Distributions

Basic probability theory. Rules of counting (multiplicative, permutation, combinations). Introduction to random variables and their probability distributions. Quantitative reasoning exercises using probability theories and distribution concepts.

Unit-4. Regression and Correlation Analysis

Introduction to probabilistic models. Bivariate analysis. Scatter plots. Simple linear regression model. Correlation analysis. Quantitative reasoning exercises using statistical modelling.

Unit-5. Estimation and Testing of Hypothesis

Basics of estimation and confidence interval. Testing of Hypothesis (z-test; t-test). Statistical inference in decision making. Quantitative reasoning exercises using estimation and Statistical inference concepts and techniques.

Recommended Books/Reference Material

1. Chaudhry S.M., & Kamal. S. (2018). *Introduction to statistical theory part I*. Lahore, Pakistan: Ilmi Kitab Khana.
2. Chaudhry S.M., & Kamal. S. (2018). *Introduction to statistical theory part II*. Lahore, Pakistan: Ilmi Kitab Khana.
3. Hogg, R., McKean, J., & Craig, A. (2021). *Introduction to mathematical statistics*, (8th ed.). Boston: Pearson Education.
4. Mendenhall, W., Beaver, R. J., & Beaver, B. M. (2012). *Introduction to probability and statistics*. Cengage Learning.
5. Mood, A.M., Graybill, F.A., & Boes, D.C. (1974). *introduction to the theory of statistics*, (3rd ed.). New York: McGraw Hill.
6. Moore, D. S., McCabe, G.P., & Craig, B. A. (2021). *Introduction to the practice of statistics*, (10th ed.). New York: WH Freeman.
7. Walpole, R. E. (2002). *Introduction to statistics*, (7th ed.). New York: Macmillan publishing company.
8. Walpole, R.E., Myers, R.H., & Myers, S.L. (1998). *probability and statistics for engineers and scientist*, (6th ed.). New York: Prentice Hall.

Expository Writing

Course Code: ENG-111

Credit Hours: 03

Pre-requisite: N.A

Objectives:

Expository Writing is a sequential undergraduate course aimed at refining writing skills in various contexts. Building upon the foundation building pre-requisite course, Functional English, this course will enhance students' basic skills of producing clear, concise and coherent written texts in English. The course will also enable students to dissect intricate ideas, to amalgamate information and to express their views and opinions through well-organized essays. The students will further be able to refine their analytical skills to substantiate their viewpoints using credible sources while adhering to established ethical writing norms. Additionally, the course will highlight the significance of critical thinking enabling students to produce original and engaging written texts.

Learning Outcomes:

- Understand the essentials of the writing process integrating pre-working, drafting, editing and proofreading to produce well-structured essays.
- Uphold ethical practices to maintain originality in expository writing.

Course Outline:

Unit-1. Introduction to Expository Writing

Understanding expository writing (definition, types, purpose and applications). Characteristics of effective expository writing (clarity, coherence and organization). Introduction to paragraph writing.

Unit-2. The Writing Process

Pre-writing techniques (brainstorming, free-writing, mind-mapping, listing, questioning and outlining etc.). Drafting (three stage process of drafting techniques). Revising and editing (ensuring correct grammar, Clarity, coherence, conciseness etc.). Proofreading (fine-tuning of the draft). Peer review and feedback (providing and receiving critique).

Unit-3. Essay Organization and Structure

Introduction and hook (engaging readers and introducing the topic). Thesis statement (crafting a clear and focused central idea). Body Paragraphs (topic sentences, supporting evidence and transitional devices). Conclusion (types of concluding paragraphs and leaving an impact). Ensuring cohesion and coherence (creating seamless connections between paragraphs).

Unit-4. Types of Expository Writing

Description, Illustration, Classification. Cause and effect (exploring causal relationships and outcomes). Process analysis (explaining step-by-step procedures). Comparative analysis (analyzing similarities and differences)

Unit-5. Writing for Specific Purposes and Audiences

Different types of purposes (to inform, to analyze, to persuade, to entertain etc.). Writing for academic audiences (formality, objectivity, and academic conventions). Writing for public audiences (engaging, informative and persuasive language). Different tones and styles for specific purposes and audiences.

Unit-6. Ethical Considerations

Ensuring original writing (finding credible sources, evaluating information etc.). Proper citation and referencing (APA, MLA, or other citation styles), Integrating quotes and evidences (quoting, paraphrasing, and summarizing), Avoiding plagiarism (ethical considerations and best practices)

Recommended Books/ Reference Material

1. Axelrod, R. B., & Cooper, C. R. (2010). *The St. Martin's guide to writing*. Macmillan.
2. Faigley, L., Selzer, J., Enoch, J., & Wible, S. (2009). *Good reasons with contemporary arguments*. Pearson Longman.
3. Floyd, K., & Cardon, P. (2023). *Business and Professional Communication*. McGraw-Hill US Higher Ed USE.
4. Graff, G., Birkenstein, C., & Maxwell, C. (2014). *They say, I say: The moves that matter in academic writing* (p. 245). Gildan Media Corp Book Publisher.
5. Johnson-Sheehan, R., Paine, C., & Paine, C. (2010). *Writing today*. Pearson Education India.
6. Keizer, E. (2015). *A functional discourse grammar for English*. Oxford University Press.
7. Rosenwasser, D., & Stephen, J. (2011). *Writing analytically*. Cengage Learning Press.
8. Straaijer, R. (2018). Modern English usage from Britain to America: Bryan Garner follows Henry Fowler from A Dictionary of Modern American English Usage to Garner's Modern English Usage. *English Today*, 34(4), 39-47.
9. Wachal, R. S. (2000). The Elements of Style, by William Strunk, Jr., and EB White; and A Dictionary of Modern American Usage, by Bryan A. Garner. *American speech*, 75(2), 199-207.
10. Williams, J. M., & Bizup, J. (2022). *Lessons in clarity and grace*. Pearson.

Arts and Humanities

Course Code: BFA-129

Credit Hours: 02

Pre-requisite: Nil

Objectives

Students will recognize the varying historical, social, political, and economic conditions that shape human action. They will identify how individuals relate to or diverge from particular social norms through the creation of artistic and expressive forms. Students will examine “texts” in any language or structure, and/or art forms in one or more media. They will account for how different worldviews and challenges are expressed in the arts and humanities as a product of interaction among diverse groups.

Learning Outcomes

- Students will gain knowledge in the Arts and Humanities • Students will engage in complex analysis and reasoning.
- Students will demonstrate media and information literacy.
- Students will communicate effectively.

Course Outlines

Unit 1. Criticism, Appreciation and History

What is criticism? What is appreciation? What is History? Comparison between the three. Defining art by different forms of arts: Visual, Performing, Minor, Applied, Plastic Arts, Tiles, Cave art, Music, Dance, Architecture, Painting, Sculpture, Minor arts, literature, etc. Stressing on visual arts. Assignment: Mini sculptures, designing tiles, jewelry making, mosaic.

Unit 2. Appreciation, Meaning of Humanities, Background of Arts

Subject, Function, Medium, Organization, Style and Judgment. Subject: What is it about? Function: what is it for? Medium, very essential: what is it made of? Organization: how is it put together? Style: what is the personality, the individuality of the work? Judgment: how effective is it? Experience, authority, sincerity, humanity. Subject: subject in music, art and nature, art and history, way of presenting the subjects, explanation of the subject, symbol, the irrational, sources of the subject (nature, mythology/religion, history and genre).

Unit 3. Function / Medium

Artist and his medium, techniques, judgment in relation to medium. Organization Plans: (typical, symmetrical, pyramidal, vertical, radical, compound plans), examples from visual arts. Centre of interest: organization of the visual arts, the elements of visual arts.

Unit 4. Art and Culture

Art and Beauty. Art and Religion. Art and Nature. Art and History. Art as an Idea.

Unit 5. Style/ Judgment

Definition, a few characteristics of style, two approaches to study styles, historical style, realism / judgment. Judgment: Sincerity and Sentimentality The problem of judgment. Scope: how much the artist is trying to do? What has he attempted? Levels of meanings. Truth. Magnitude: growth in judgment. Assignment: Working with elements of art.

Recommended Books/Reference Material

1. Davies. (2018) Definitions of Art. Cornell University Press, New York.
2. Edwards. (2023). Ancient Civilizations of History - Trivia Adventures. United States.
3. Nguyen. (2023). The Art of Creating:How to Create Art that Transforms Yourself and the World. One Satori Publishing, United States.
4. Sporre, D. (2015). Perceiving the Arts: An Introduction to Humanities. New Jersey, Prentice Hall.

Islamic Studies

Course Code: ISL-101

Credit Hours: 02

Pre-Requisites: N.A

Objectives:

Students will be able to demonstrate enhanced knowledge of Islamic Fundamentals, beliefs, practices, historical development, spiritual values and Ethical Principles. Describe Basic sources of Islamic Law and their application in daily life. Also, Identify and discuss contemporary issues being faced by the Muslim world Including Social Challenges, Gender Role and Interfaith dialogue.

Learning Outcomes:

- Evaluate and discuss their understanding about the beliefs, history and Ethical values of Islam.
- Be able to apply and relate the Articles of faith in their life according to present world.
- Be able to analyze the importance of Quran and Sunnah in their life and also to refute many relating misconceptions
- Engage in Discussions and write about Contemporary issues specifically related to Women.

Course Outline:

Unit-1. Introduction to Islam

Definition of Islam and its core Beliefs (Tawheed, Akhirat and Risalat), Pillars of Islam and their significance (Tawheed, Prayers, Fasting, Zakat & Hajj), The Holy Quran (Introduction, Revelation & Compilation), Sunnah & Hadith (Introduction, Revelation & Compilation)

Unit-2. Seerah of the Holy Prophet pbuh

Life of Prophet pbuh in Makkah, Life of Holy Prophet pbuh in Medina, Diverse roles of Holy Prophet pbuh (individual, leader, peacemaker, educator etc)

Unit-3. Islamic History and Civilization

World before Islam, The Rashidun Caliphate and its expansion, Contributions of Muslim Scientists and Philosophers.

Unit-4. Islamic Jurisprudence

Fundamental sources of Islamic Jurisprudence, Major Schools of Islamic Jurisprudence, Significance & principle of Ijtihad

Unit-5. Family & Society in Islam

Status and Rights of Women in Islam, Marriage, Family & Gender roles in Muslim Society, Family values and Structure in Muslim Society

Unit-6. Islam & Modern world

Relevance of Islam in Modern World. (Islamophobia, Interfaith dialogue & Multiculturalism), Islamic viewpoint towards socio-cultural and technological changes.

Recommended Books/Reference Material

1. Ahmed, Dr. A. (1996). *Women & Social Justice: An Islamic Paradigm*, The Islamic Foundation UK

2. Ahmed, K. (1971) *Islami Nazria e Hayat*, Karachi University press.
3. Ahmed, K. (1980). *Islam, Its meaning & message*, The Islamic Foundation UK.
4. Al-Mubarikpuri, M. S. (2002), *Al Raheeq ul Makhtoom (The Sealed Nector)*, Dar ul Salam.
5. Al-Suhaym, Dr. M.B., A. (2006) *Islam, Its foundation & concepts*, Darussalam
6. An Introduction to Islamic Theology by John Renard.
7. Bokhari, A.S, Zafar, M.D., Prof. Shakir, A.S. (2021). *A textbook of Islamic Education*, Akram Printing Press, Lahore.
8. Hussain, M. *The Five Pillars of Islam: A Framework for Islamic Values and Character building*, Kube Publishing, The Islamic Foundation UK
9. Maududi, Abul A. (2008). *Islamic Civilization Foundations, Beliefs & Principles*, Kube Publishing, Islamic Foundation UK
10. Maududi, Abul. A. (2007). *Towards understanding Islam*, The Islamic foundation UK
11. Phillip, Dr. A. A., B. (2018) *Islamic Studies*, International Islamic Publishing House.
12. Prof. Dr. Chaudary, M.N., Prof. Malik, M.A (2022). *Tafheem e Islamiyat*, Qureshi Brothers Publishers, Lahore.

Ethics

Course Code: ETH-101

Course Title: Ethics

Credit Hours: 2

Pre-Requisite: N.A

Objectives:

Upon successful completion of the course, students will be able to know the basics of Ethics & Morality and develop Ethical approach, Identify the concept of Ethics in Different Religions & Relate the ethical values with their lives business ethics, journalism ethics etc.

Learning Outcomes:

- Students will be able to demonstrate their understanding about the meaning of Ethics and Morality.
- Analyze the Similarities and Differences between ethical teachings of various religions.

- Develop sense of belongingness to the ethical values as a student, being member of the society etc

Course Outline:

Unit-1. Meaning and Scope of Ethics

Meaning and Definition of Ethics and Morality, Difference between Ethics and Morality, Relation of Ethics with: Religion, Science, Law.

Unit-2. Historical development of Morality

Instinctive Moral Life, Customary Morality, Reflective Morality.

Unit-3. Moral Theories, Moral Ethics and Society

Hedonism (Mill), Intuitionism (Butler), Kant's Moral Theory, Freedom and Responsibility, Tolerance, Justice, Punishment.

Unit-4. Moral Teaching of Major Religions

Judaism, Christianity, Islam, Islam and Minorities.

Unit-5. Professional Ethics

Medical Ethics, Ethics of Student, Ethics of Teacher, Business Ethics.

Recommended Books/ Reference Material

1. R. Shafer-Landau. (2020). *The Fundamentals of Ethics*, 5th Edition.
2. S. Blackburn. (2021). *Ethics: A Very Short Introduction (Very Short Introductions)* 2nd Edition.
3. S. Liautaud, L. Sweetingham. (2022). *The Power of Ethics: How to Make Good Choices in a Complicated World*.
4. S. M. Cahn, P. Markie. (2019). *Ethics: History, Theory, and Contemporary Issues*, 7th Edition.

Ideology and Constitution of Pakistan

Course Code: PAK-103

Credit Hours: 02

Pre-requisite: N.A

Objectives:

This course is designed to provide students with a fundamental exploration of the ideology and the constitution of Pakistan. The course focuses on the underlying principles, beliefs, and aspirations that have been instrumental in shaping the creation and development of Pakistan as a sovereign state. Moreover, the course will enable students to understand the core provisions of the Constitution of the Islamic Republic of Pakistan concerning the fundamental rights and responsibilities of Pakistan citizens to enable them function in a socially responsible manner.

Learning Outcomes:

- Demonstrate enhanced knowledge of the basis of the ideology of Pakistan with special reference to the contributions of the founding fathers of Pakistan.
- Demonstrate fundamental knowledge about the Constitution of Pakistan 1973 and its evolution with special reference to state structure.
- Explain about the guiding principles on rights and responsibilities of Pakistani citizens are enshrined in the Constitution of Pakistan 1973.

Course Outline:

Unit-1. Introduction to the Ideology of Pakistan:

Definition and significance of ideology. Historical context of the creation of Pakistan (with emphasis on socio-political. Religious and cultural dynamics of British India between 1857 till 1947). Contributions of founding fathers of Pakistan in the freedom movement including but not limited to Allama Muhammad Iqbal, Muhammad Ali Jinnah etc. Contributions of women and students in the freedom movement or separate homeland.

Unit-2. Two-Nation Theory:

Evolution of the Two-Nation Theory (Urdu-Hindi controversy. Partition of Bengal. Simla Deputation 1906, Allama Iqbal Presidential Address 1930, Congress Ministries 1937 Lahore Resolution 1940). Role of communalism and religious differences.

Unit-3. Introduction to the Constitution of Pakistan:

Definition and importance of a constitution. Ideological factors that shaped the Constitution(s) of Pakistan. Overview of constitutional developments in Pakistan.

Unit-4. Constitution and State Structure

Structure of government (executive, legislature, and judiciary). Distribution of powers between federal and provincial governments. Eighteenth Amendment and its impact of federalism.

Unit-5. Fundamental Rights, Principles of Policy and Responsibilities

Overview of fundamental rights guaranteed to citizens by the Constitution of Pakistan 1973 (Articles R-28). Overview of Principles of Policy (Articles 29-40). Responsibilities of the Pakistani citizen.

Unit-6 Constitutional Amendments:

Procedures for amending the Constitution. Notable constitutional amendments and their implications

Recommended Books/Reference Material

1. Ahmed, A. S. (1997). *Jinnah, Pakistan and Islamic Identity: The Search for Saladin*. Routledge.
2. Aziz, K. K. (2002). *The Making of Pakistan: A Study of Nationalism*. Sang-e-Meel Publishers.
3. Choudhury, G. W. (1969). *Constitution-Making in Pakistan: The Dynamics of Political*. Columbia: University of British.
4. Cohen, S. P. (2004). *The Idea of Pakistan*. Washington: Brookings Institution Press.
5. Hussain, M. (2020). *The Parliament of Pakistan*. London:Oxford University press.
6. Iqbal, J. (2005). *Ideology of Pakistan*. Sang-e-Meel.
7. Jalal, A. (2014). *The Struggle for Pakistan: A Muslim Homeland and Global Politics*. Belknap Press: An Imprint of Harvard University Press.
8. Khan, H. (2020). *Constitutional and Political Development of Pakistan*. London: Oxford University Press.
9. Mahmood, S. (2003). *Pakistan: Political Roots and Development*. Sterling: University of Michigan.
10. Mujahid, S. u. (2001). *Ideology of Pakistan*. Progressive Publishers.
11. Qureshi, I. H. (1965). *The Struggle for Pakistan*. Karachi: University of Karachi Press.
12. Sayeed, K. B. (1960). *Pakistan: The Formative Phase*. London: Oxford University Press
13. Talbot, I. (2015). *Pakistan: A New History*. London: Oxford University Press.
14. *The Constitution of Pakistan 1973*. Original text. Retrieved from website: National Assembly: https://na.gov.pk/uploads/documents/1333523681_951.pdf
15. Ziring, L. (2000). *Pakistan in the Twentieth Century: A Political History*. London: Oxford University Press

Civic and Community Engagement

Course Code: CCE-497

Credit Hours: 02

Pre-requisite: Nil

Objectives:

This course is designed to provide students with fundamental knowledge about civics, citizenship and community engagement. In this course the students will learn about the essential of civil society, government, civic responsibilities, inclusivity and effective ways to participate in shaping the society which will help them apply the theoretical knowledge to the real-world situation to make a positive impact on their communities.

Learning Outcomes:

By the end of this course, student will be able to:

- Demonstrate fundamental understanding of civics, government, citizenship and civil society.
- Understand the concept of community and recognize the significance of community engagement for individuals and groups.
- Recognize the importance of diversity and inclusivity for societal harmony and peaceful co-existence.

Course Outline:

Unit-1. Civics and Citizenship

Concepts of civics, citizenship, and civic engagement. Foundations of modern society and citizenship. Types of citizenship: active, participatory, digital etc.

Unit-2. State, Government and Civil Society

Structure and function of government in Pakistan. The relationship between democracy and civil society. Right to vote and importance of political participation and representation.

Unit-3. Rights and Responsibilities

Overview of fundamental rights and liberties of citizens under constitution of Pakistan 1973. Civic responsibilities and duties. Ethical consideration in civic engagement (accountability, non-violence, peaceful dialogue, civility etc.).

Unit-4. Community Engagement

Concept, nature and characteristics of community. Community development and social cohesion. Approaches to effective community engagement. Case studies of successful community driven initiatives.

Unit-5. Advocacy and Activism

Public discourse and public opinion. Role of advocacy in addressing social issues. Social action movements.

Unit-6. Digital Citizenship and Technology

The use of digital platform for civic engagement. Cyber ethics and responsible use of social media. Digital divides and disparities (access, usage, socio-economic, geographic etc.) and their impact on citizenship.

Unit-7. Diversity, Inclusion and Social Justice

Understanding diversity in society (ethnic, cultural, economic, political etc.). Youth, women and minorities engagement in social development. Addressing social inequalities and injustices in Pakistan. Promoting inclusive citizenship and equal rights for social harmony and peaceful co-existence.

Suggested Practical Activities (Optional)

Apart of the overall learning requirements, the course may have one or a combination of the following practical activities

1. **Community Storytelling:** Students can collect and share stories from community members. This could be done through oral histories, interviews or multimedia presentations that captured the lived experiences and perspectives of diverse individuals.
2. **Community Event Planning:** Student can organize a community event or workshop that addresses a specific issue or foster community interaction. This could be a health fair, environmental cleanup, cultural festival or educational workshop
3. **Service Learning:** Student can collaborate with a local nonprofit organization or community group. They can actively contribute by volunteering their time, and skills to address a particular community need, such as tutoring, mentoring or supporting vulnerable population.
4. **Cultural Exchange Activities:** Student can organize a cultural exchange event that celebrates the diversity within the community. This could include food tastings, performances and presentations that promote cross cultural understanding.

Recommended Books/Reference Material

1. Džankić, J., & VINK, M. P. (2022). Citizenship & migration.
2. Kymlicka, W. and Norman, W. (2010). *Citizenship in Diverse Societies*. University Press, United Kingdom.
3. Mackert, J., & Turner, B. S. (2017). The Transformation of Citizenship, Volume 2. Boundaries of Inclusion and Exclusion.
4. Mattson, K. (2017). *Digital Citizenship in Action: Empowering Students to Engage in Online Communities*. : International Society for Technology in Education, United Kingdom.
5. McGraw-Hill Education, (2009). *Civics Today: Citizenship, Economics, & You*, Student Edition. United States.
6. Weinstock, D. (2017). Citizenship and Cultural Diversity. The Oxford Handbook of Citizenship.

7. Youniss, J. and Levine, J. (2009). *Engaging Young People in Civic Life*. Vanderbilt University Press, Ukraine.

Entrepreneurship

Course Code: MGT-108

Credit Hours: 02

Pre-requisite: Nil

Objectives

This course is basically designed to enhance entrepreneurial attitude among students by imparting confidence in them, by having them hands on experience of small entrepreneurial activity. This will contribute towards economic development of Pakistan, as these students will soon be in the market and will be contributing in the economy in a better way through entrepreneurial activities.

Learning Outcomes

After studying this course, the student will be able to:

- Better understand themselves and their suitability to be an entrepreneur.
- Better understand the marketing and sales concepts and strategies, engaging customers, building the brand, and driving revenues.

Course Outlines

Unit 1. The Challenge of Entrepreneurship

The World of the Entrepreneur. What is an Entrepreneur? The Benefits of Entrepreneurship. The Potential Drawbacks of Entrepreneurship. The Power of “Small” Business. Putting Failure into Perspective. The Ten Deadly Mistakes of Entrepreneurship. How to Avoid the Pitfalls. Creativity, Innovation, and Entrepreneurship. Creativity – Essential to Survival. Creative Thinking. Barriers to Creativity. The Creative Process. Techniques for Improving the Creative Process.

Unit 2. Designing a Competitive Business Model and Building a Solid

Strategic Plan

Building a Competitive Advantage. The Strategic Management Process. Formulate strategic options and select the appropriate strategies. The Balanced Scorecard

Unit 3. Conducting a Feasibility Analysis, Forms of Business Ownership and Franchising

Conducting a Feasibility Analysis. Why Develop a Business Plan? The Elements of a Business Plan. The Sole Proprietorship. Other Forms of Ownership. Types of Franchises. The Benefits of Buying a Franchise.

The Drawbacks of Buying a Franchise. Franchising and the Law. The Right Way to Buy a Franchise. Trends Shaping Franchising

Unit 4. Building a Powerful Marketing Plan

Building a Guerrilla Marketing Plan. Pinpointing the Target Market. Determining Customer Needs and Wants through Market Research. Plotting a Guerrilla Marketing Strategy: How to Build a Competitive Edge

Unit 5. Creating a Successful Financial Plan

Basic Financial Statements. Projected Financial Statements. Ratio Analysis. Interpreting Business Ratios. Breakeven Analysis

Unit 6. Sources of Financing: Debt and Equity Phase Discussion

Planning for Capital Needs. Sources of Equity Financing. Corporate Venture Capital. Sources of Debt Capital. Federally Sponsored Programs. Small Business Administration (SBA)

Unit 7. Choosing the Right Location and Layout

Location: A Source of Competitive Advantage. Location Criteria for Retailers and Service Businesses. Location Options for Retail and Service Businesses. The Location Decision for Manufacturers. Layout and Design Considerations. Layout: Maximizing Revenues, Increasing Efficiency, or Reducing Cost

Recommended Books/ Reference Material

1. "Essentials of entrepreneurship and small business management" by Scarborough, Norman M & Jefferey R.Cornwall.
2. "Entrepreneurship: A Real-World Approach" by Rhonda Abrams.

14. List of Interdisciplinary Courses:

Name of Courses	Credit Hours
Scientific Writing and Research methods	3
Statistics for Chemists	3
Material Science	2
Material Science (Lab)	1
Artificial Intelligence in Chemistry	2
Artificial Intelligence in Chemistry (Lab)	1
Quality Control and Assurance	2
Quality Control and Assurance (Lab)	1
Principle of Biochemistry	2
Principle of Biochemistry (Lab)	1

15. Course Outlines of Interdisciplinary Courses:

Scientific Writing and Research methods

BS-Chemistry

Course Code: RM-402

Credit Hours: 3

Pre-requisite: Nil

Objectives

The students should be able to understand: What is research and why it is carried out, what methodologies need to be adopted, how to write the thesis and research paper, research proposal and get funds.

Learning Outcomes

- Students will be able to learn about fundamentals of writing research synopsis, thesis, report.
- They will be able to write and submit research proposals and research articles to publish.

Course Outline

Unit 1. Orientation of Course

Research and its classification, research processes.

Unit 2. Research Processes

Tools of data collection, ethics of research, research variables, synopsis.

Unit 3. Research Projects/ Proposal

Thesis write up, article write up, types of research articles

Unit 4. Statistical Analysis in Chemistry

Impact factor, plagiarism, citation, reference format, precision, accuracy, validation, statistical analysis, tools of data collection

Unit 5. Scientific Poster

Use of MS office/excel and end note, chemistry software

Recommended Books/Reference Material

1. C. R. Kothari (2004). "Research methodology; methods and techniques" New Age Publisher.
2. Marczyk, G., DeMatteo, D., Festinger, D., (2005). "Essentials of research design and methodology" John Willey and Sons.
3. Robinson, MS., Stoller, FL., Jones, JK. Robinson, MSC. (2008). "Write like a Chemist" Oxford University Press, NY.
4. Valiela, I. (2008). "Doing Science" Design, analysis and communication of scientific research. Oxford University Press, NY.

Quality Control and Assurance

BS-Chemistry

Course Code: CHM-405

Credit Hours: 2

Pre-requisite: Nil

Objectives

The objective of this course is to study about quality control, regulation and management of good manufacturing practices of products at industrial level

Learning Outcomes

By the end of this course, the students will be able to:

- Describe principles of quality control and assurance in chemical manufacturing and laboratory testing.
- Understand the requirements of good manufacturing practices (GMP) and quality management systems to ensure product safety, efficacy, and regulatory compliance.
- Explain the importance of quality control in maintaining industrial standards and consumer safety.

Course Outline

Unit 1. Introduction and Importance of Quality control

Introduction to manufacturing, Basics of operations and productivity; Overview of quality and quality control systems; Comparison between quality control and quality assurance; Seven tools for quality control.

Unit 2. Quality Management

Introduction to industrial management; Basic functions of management; Installation qualification (IQ), Operational qualification (OQ) and performance qualification PQ) total productive maintenance; Managing quality improvement teams and projects.

Unit 3. International Industrial Standards

Calibrations, Monitoring, Quality reviews, Periodical trainings, six sigma concept, Good laboratory practice, The ISO 9000 standard for quality management systems; Sector specific standards; ISO 9001 requirements; ISO 17025, ISO 14000 series standards.

Unit 4. Quality Assurance and Quality Control in the Analytical Chemistry

Reference Materials, Inter-laboratory Comparisons, Method Validation (Characterization of Validation Parameters: Selectivity, Linearity, Limit of Detection and Limit of Quantitation, Range, Sensitivity, Precision, Accuracy, Measurement Errors, Robustness and Ruggedness, Uncertainty).

Unit 5. Statistical analysis/tools for quality control and quality assurance

Significant Figures, Standard Deviation, Mean, median, average, Control Charts, Confidence Limit, Tests of Significance, Rejection of Result, Correlation Coefficient and Coefficient of Determination, Use of Spreadsheets in Analytical Chemistry, Use of Spreadsheets for Plotting Calibration Curves, Slope, Intercept and Coefficient of Determination, Statistics Software Packages.

Recommended books/reference material

1. Kumar, A. 2015. Industrial Management: An Introduction, Alpha Science Intl. Ltd. Oxford, UK

2. Miller, J. and Miller, J. (2020) Statistics and Chemometrics for Analytical Chemistry, 5th. Prentice Hall.
3. Christian, G. D., Dasgupta, P. K., & Schug, K. A. (2013). Analytical chemistry. John Wiley & Sons.
4. V. Barwick (Ed), Eurachem/CITAC Guide: Guide to Quality in Analytical Chemistry: An Aid to Accreditation (3rd ed. 2016). ISBN 978-0-948926-32-7.

Quality Control and Assurance (Lab)

BS-Chemistry

Course Code: CHM-405L

Credit Hours: 1

Pre-requisite: Nil

Objectives

The objective of this course is to study about quality control, regulation and management of good manufacturing practices of products at industrial level

Learning Outcomes

By the end of this course, the students will be able to:

- Describe principles of quality control and assurance in chemical manufacturing and laboratory testing.
- Understand the requirements of good manufacturing practices (GMP) and quality management systems to ensure product safety, efficacy, and regulatory compliance.
- Explain the importance of quality control in maintaining industrial standards and consumer safety.

Course Outlines:

1. Calibration of volumetric glassware (pipette, burette and flask).
2. Calibration of electronic equipment (analytical balance, pH meter, conductometer).
3. Calibrations of primary and secondary standard solutions (standardization of secondary base and acid.)
4. Determination of hardness of water using EDTA and construction of its calibration curve from its analytical data using spread sheet software.

5. Estimation of copper, arsenic, hydrogen peroxide and vitamin C using iodometry along with statistical evaluation of analytical data including linear regression analysis.
6. Gravimetric analysis, determination of barium in barium nitrate.
7. Determination of nickel in a given steel sample.
8. Determination of bicarbonates in a clinical sample using back-titrations.
9. Determination of cation in a mixture by complexometric titration.
10. Studying the effect of common ions on solubility of sparingly soluble salts (e.g. PbSO_4)

Recommended books/reference material

1. Skoog, D. A., West, P. M., Holler, F. J., Crouch, S. R. (2018) Fundamentals of Analytical Chemistry, 9th ed., Brooks Cole Publishing Company.

Material Science

Course Code: PHY-329

Credit Hours: 02

Prerequisites: Nil

Objectives

This course is designed to introduce students to the physical structure and behavior of materials. It focuses on the relationship between chemical bonding, microstructure, and the macroscopic properties of materials including metals, ceramics, and polymers. Students will also explore key techniques for material characterization and evaluate material selection strategies in industrial and technological applications.

Learning Outcomes

- Explain the relationship between chemical structure, properties, and applications of different materials, including metals, ceramics, and polymers
- Characterize materials using techniques such as X-ray diffraction and electron microscopy
- Evaluate the selection and design of materials for specific industrial and technological applications

Course Outline

Unit 1. Structure of Materials

Atomic bonding in solids, crystal structures of metals and ceramics, amorphous and semi-crystalline structures in polymers, unit cells and lattice types, coordination number, atomic packing factor

Unit 2. Imperfections and Diffusion

Point, line, and planar defects, dislocations and their motion, diffusion mechanisms in solids, Fick's laws of diffusion, temperature dependence of diffusion, relevance to chemical synthesis and material processing

Unit 3. Mechanical Properties

Stress-strain relationships, elastic and plastic deformation, tensile and hardness testing, fracture, fatigue, creep, strengthening mechanisms in metals and polymers

Unit 4. Thermal, Electrical and Optical Properties

Thermal expansion, heat capacity, thermal conductivity, electrical conductivity of metals and semiconductors, dielectric behavior of ceramics and polymers, introduction to optical properties such as transparency and color in solids

Unit 5. Characterization and Material Selection

X-ray diffraction (XRD) basics and applications, scanning electron microscopy (SEM), energy-dispersive X-ray spectroscopy (EDX), thermal analysis techniques (TGA/DSC), criteria for selecting materials for chemical reactors, biomedical devices, and consumer products.

Recommended Books/Reference Material

1. Callister, W. D., & Rethwisch, D. G. (2021). *Materials Science and Engineering: An Introduction* (10th ed). Wiley
2. Shackelford, J. F. (2020). *Introduction to Materials Science for Engineers* (9th ed). Pearson
3. Smith, W. F., & Hashemi, J. (2022). *Foundations of Materials Science and Engineering* (6th ed). McGraw-Hill
4. Cullity, B. D., & Stock, S. R. (2020). *Elements of X-Ray Diffraction* (3rd ed). Pearson
5. Van Vlack, L. H. (2001). *Elements of Materials Science and Engineering* (6th ed). Addison-Wesley

Material Science (Lab)

Course Code: PHY-329L

Credit Hours: 02

Prerequisites: Nil

Objectives

This lab course introduces students to the experimental methods used in the physical characterization of materials. It focuses on basic mechanical, thermal, and structural analysis techniques that are essential for understanding the behavior and selection of materials in chemistry-related applications.

Learning Outcomes

- Perform basic tests to evaluate physical properties of materials
- Use laboratory tools to characterize structural features of metals, ceramics, and polymers
- Interpret experimental results and relate them to material structure and function

List of Experiments

1. Identification of crystal structures using model kits and unit cell geometry
2. Tensile strength measurement of polymer or metal samples
3. Microstructure observation of metal or ceramic samples using optical microscopy
4. Measurement of hardness using Vickers or Brinell method
5. Grain size estimation using metallographic techniques
6. Thermal expansion analysis using dilatometer or comparative method
7. Introduction to X-ray diffraction: pattern recognition and lattice spacing calculation
8. Surface morphology analysis using sample SEM images (demo or virtual lab)
9. Electrical conductivity measurement of metal wires and semiconductors
10. Differential scanning calorimetry (DSC) or thermogravimetric analysis (TGA) of a polymer sample

Recommended Books/Reference Material

1. Suryanarayana, A. K. (1995). *Experimental Techniques in Materials and Mechanics*. CRC Press
2. Cullity, B. D., & Stock, S. R. (2014). *Elements of X-Ray Diffraction* (3rd ed). Pearson
3. Arora, C. L. (2001). *B.Sc. Practical Physics*. S. Chand & Company
4. Taylor, J. R. (1997). *An Introduction to Error Analysis* (2nd ed). University Science Books
5. Shackelford, J. F. (2020). *Introduction to Materials Science for Engineers* (9th ed). Pearson

Artificial Intelligence in Chemistry

BS-Chemistry

Course Code: CHM-404

Credit Hours: 02

Pre-requisite: Nil

Objectives

The objective of this course is to equip students with foundational knowledge of artificial intelligence and its applications in analyzing, modeling, and predicting chemical behavior and processes

Learning Outcomes

- Explain the basic concepts of artificial intelligence (AI) and its applications in chemistry.
- Analyze chemical datasets using AI techniques such as machine learning, pattern recognition, and predictive modeling.
- Apply AI tools and software to solve problems in molecular modeling, reaction optimization, drug discovery, and property prediction.

Course Outline

Unit 1. Introduction to Artificial Intelligence and Machine Learning

Definition and scope of AI and machine learning (ML), Types of ML: Supervised, unsupervised, reinforcement learning, Basic AI/ML workflow: data collection, preprocessing, training, validation, Overview of tools: Python, scikit-learn, TensorFlow, RDKit.

Unit 2. AI in Molecular Modeling and Simulations

Molecular descriptors and fingerprints (SMILES, InChI), Use of AI in predicting molecular structures and energies, Neural networks for quantum chemistry predictions (e.g., ANI, SchNet), Case studies: AI-driven potential energy surface modeling.

Unit 3. AI in Drug Discovery and Chemoinformatics

AI for ligand-based and structure-based drug design, Virtual screening using AIQSAR modeling with ML techniques, Deep learning applications in protein-ligand interactions.

Unit 4. AI for Chemical Reaction Prediction and Optimization

Reaction classification and mechanism prediction using AI, Retrosynthesis planning with neural networks, Optimization of reaction conditions using Bayesian optimization, Tools: IBM RXN for Chemistry, ASKCOS.

Unit 5. AI in Materials and Property Prediction

Predictive modeling for physical and chemical properties, AI in materials informatics and catalyst design, High-throughput screening and AI integration

Data sources: PubChem, Materials Project, ChemSpider

Recommended books/reference material

1. Géron, A. *Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow* (2nd ed.). O'Reilly Media, 2019.
2. Butler, K. T., Davies, D. W., Cartwright, H., Isayev, O., & Walsh, A. 2018. Machine learning for molecular and materials science. *Nature*, 559(7715), 547–555. <https://doi.org/10.1038/s41586-018-0337-2>
3. von Lilienfeld, O. A., Müller, K.-R., & Tkatchenko, A. Exploring chemical compound space with quantum-based machine learning. *Nature Reviews Chemistry*, 4, 347–358. <https://doi.org/10.1038/s41570-020-0189-9>, (2020)
4. Gasteiger, J., & Engel, T. (Eds.). *Chemoinformatics: A Textbook*. Wiley-VCH, 2003.
5. Schneider, G. Automating drug discovery. *Nature Reviews Drug Discovery*, 17, 97–113. <https://doi.org/10.1038/nrd.2017.232>, 2018.
6. Ramsundar, B., Eastman, P., Walters, P., & Pande, V. *Deep Learning for the Life Sciences*. O'Reilly Media, 2019.

Artificial Intelligence in Chemistry (Lab)

BS-Chemistry

Course Code: CHM- 404L

Credit Hours: 01

Pre-requisite: Nil

Objectives

To use a supervised machine learning model (linear regression) to predict a molecular property (e.g., boiling point) based on molecular descriptors

Learning Outcomes

By the end of the laboratory component, students will be able to:

- Use basic AI tools and libraries (e.g., RDKit, scikit-learn, TensorFlow, IBM RXN) to handle and analyze chemical data.

- Build and train ML models (e.g., regression, random forest, neural networks) to predict molecular properties and chemical reactivity.
- Compute molecular descriptors and fingerprints, and perform chemical similarity searches.
- Apply AI platforms and software (e.g., IBM RXN, DeepChem) to solve practical problems such as retrosynthesis and virtual screening.
- Visualize, interpret, and validate the outcomes of AI models in the context of chemical research and decision-making.

Course Outline

Experiment 1

Predicting Molecular Properties Using Linear Regression: Use a publicly available dataset (e.g., from PubChem or UCI ML Repository) with chemical compounds and boiling points. i.e. Calculate molecular descriptors using **RDKit**, Split data into training and test sets, Build and train a **linear regression model** using scikit-learn, Evaluate model performance (R^2 , MAE).

Experiment 2

Molecular Fingerprint-Based Similarity Search: Load a small set of molecules (e.g., 20–50 compounds) using **SMILES** strings: Compute **Morgan fingerprints** using RDKit, Calculate **Tanimoto similarity** between a query molecule and dataset., Visualize similarity scores and identify the top 5 most similar compounds.

Experiment 3

QSAR Modeling with Random Forest: Use a dataset with biological activity (e.g., IC_{50} values): Compute molecular descriptors using RDKit., Train a Random Forest Regressor using scikit-learn., Evaluate the model with cross-validation., Interpret feature importance.

Experiment 4

Retrosynthesis Prediction Using IBM RXN: Access the free IBM RXN for Chemistry platform, Input a target compound using SMILES or structure editor, Analyze the retrosynthetic steps proposed by the model, Compare AI-suggested route with textbook/classical synthesis methods

Recommended books/reference material

1. Schwaller, P., Laino, T., Gaudin, T., Bolgar, P., Hunter, C. A., Bekas, C., & Lee, A. A. Molecular transformer: A model for uncertainty-calibrated chemical reaction prediction. ACS Central Science, 5(9), 1572–1583, 2019.
2. IBM Research. (n.d.). IBM RXN for Chemistry. <https://rxn.res.ibm.com/>
3. Segler, M. H. S., Preuss, M., & Waller, M. P, Planning chemical syntheses with deep neural networks and symbolic AI. Nature, 555(7698), 604–610, 2018.

Statistics for Chemists

Course Code: CHM-322

Credit Hours: 3

Prerequisite: Nil

Objectives:

The purpose of this study is conduct a literature survey and identify research problems.

Learning Outcomes:

Students should be able to understand:

- Conduct a literature survey and identify research problems.
- Handle data and calculate various statistical parameters which may make the data meaningful.
- Comprehend error, its types and distribution.

Course Outline:

Unit 1.

Introduction to Research Methodology

Concept of Research: Definition and scope of research, use of digital resources for literature survey, designing research problems and objectives, Research Ethics: Importance of ethics in research, ethical considerations in data collection, analysis, and reporting.

Unit 2. Errors in Research

Concept of Error: Definition and types of errors in research, sources and implications of errors in data, Distribution and Propagation of Error: Theory behind error distribution, methods to quantify and propagate errors in experimental data.

Unit 3. Statistical Methods in Research

Introduction to Statistical Methods: Role of statistics in research, basic concepts such as population, sample, and variability, Application of Statistical Methods: Use of statistical methods for data analysis and interpretation, techniques for determining and eliminating errors in data.

Unit 4. Spreadsheets for Statistical Analysis

Introduction to Spreadsheets: Overview of spreadsheet software (e.g., Excel), benefits of using spreadsheets for statistical analysis, Statistical Analysis Techniques: Handling outliers in data, concepts and applications of regression analysis, calculating correlation coefficients.

Unit 5. Advanced Topics in Research Methodology

Modern Tools for Research: Advanced digital resources for literature survey, techniques for efficient data collection and management, Emerging Issues in Research Ethics: Current trends and challenges in research ethics, ethical considerations in digital research and big data analytics.

Recommended Books/reference material

1. Agresti, A., & Finlay, B. (2009). *Statistical Methods for the Social Sciences* (4th ed.). Pearson Education.
2. Babbie, E. R. (2016). *The Practice of Social Research* (14th ed.). Cengage Learning.
3. Field, A. (2013). *Discovering Statistics Using IBM SPSS Statistics* (4th ed.). SAGE Publications Ltd.
4. Montgomery, D. C., Runger, G. C., & Hubele, N. F. (2015). *Engineering Statistics* (5th ed.). Wiley.

5. Peck, R., Olsen, C., & Devore, J. L. (2015). *Introduction to Statistics and Data Analysis* (5th ed.). Cengage Learning.

Principles of Biochemistry

BS-Chemistry

Course Code: CHM-324

Credit Hours: 02

Pre-requisite: Nil

Objectives

Student will be able to learn the fundamental concepts of Biochemistry, Acid-Base and Electrolyte Chemistry, Chemistry of Carbohydrates, lipids and proteins, Chemistry of Nucleic Acids.

Learning Outcomes

Student should have knowledge about

- Fundamental concepts of Biochemistry
- Acid-Base and Electrolyte Chemistry
- Chemistry of Carbohydrates, lipids and proteins
- Chemistry of Nucleic Acids

Course Outline

Unit 1. Carbohydrates

Brief introduction, to the scope and history of Biochemistry, Molecular logic of the living organism. Cell structures and their functions. Origin and nature of biomolecules. Definition and classification, Chemistry, physical and chemical properties of various classes of carbohydrates, Biological functions of starch and glycogen. Biological functions of cellulose and cell wall polysaccharides, acid muco polysaccharides and proteoglycans.

Unit 2. Lipids

Definition and classification of lipids, Chemistry and biological importance of fatty acids. Biological importance waxes, glycerides, phospholipids, sphingolipids, glycolipids, sterols and prostaglandins, Significance of lipids in biological membranes and transport mechanism.

Unit 3. Proteins and Aminoacids

Chemistry and Classification of Amino acids. Physical and chemical properties of amino acids, Biological significance of amino acids, peptides. Proteins; their classification, properties and biological significance, Primary, secondary tertiary and quaternary structure of proteins. Denaturation of proteins. Enzymes. (Introduction, properties, kinetics).

Unit 4. Nucleic Acid

Chemical composition of nucleic acids. Structure and biological significance of nucleic acids, Chemical synthesis of Oligonucleotides. Nucleic acids hydrolysis, Isolation and separation of Nucleic acids.

Unit 5. pH and Homeostasis

Intracellular and extracellular electrolytes, body fluids as electrolyte solutions pH, Henderson-Hasselbalch equation and buffers. Amino acids, peptides and proteins, buffer capacity. Buffers of body fluids, hemoglobin as an acid-base system. Renal control of acidbase, balance, acid-base disorders: acidosis, alkalosis. Hemoglobin and homeostasis, variation of Na⁺, K⁺, Cl⁻ in acid-base disturbances.

Recommended Books/Reference Material

1. Lehninger, A. L, (2001) "Principles of Biochemistry", Worth Publisher, New York.
2. Voet, D. and Voet J. G., "Biochemistry", John Wiley & Sons, New York, (2000).
3. Murray, R. K., Mayes P. A., Granner, D. K. and Rodwell, V. W., Harper's Biochemistry", Appleton & Lange (2000).

Principles of Biochemistry (Lab)

BS-Chemistry

Course Code: CHM-324L

Credit Hours: 01

Pre requisites: Nil

Objectives

Student will be able to learn the fundamental concepts of Biochemistry, Acid-Base and Electrolyte Chemistry, Chemistry of Carbohydrates, lipids and proteins, Chemistry of Nucleic Acids.

Learning Outcomes

Student should have knowledge about

- Fundamental concepts of Biochemistry
- Acid-Base and Electrolyte Chemistry
- Chemistry of Carbohydrates, lipids and proteins
- Chemistry of Nucleic Acids

Course Outline

1. Qualitative and quantitative analysis of carbohydrates,
2. Qualitative and quantitative analysis of lipids
3. Qualitative and quantitative analysis of proteins
4. Determination of pH 5. Preparation of buffers.
6. Enzyme catalysis
7. Progress curve for enzyme catalyzed reactions
8. To study the effect of different factors on the rate of enzyme catalyzed reactions.

Recommended Books/Reference Material

1. Murray, R. K., Mayes P. A., Granner, D. K. and Rodwell, V. W. (2000). Harper's Biochemistry", Appleton & Lange.
2. Ochs, R. S., (2021) Biochemistry. CRC Press, United States.
3. Lorch, M., (2021) Biochemistry: A Very Short Introduction. Oxford University Pres

16. List of Mandatory Courses:

S.N.	Course	Credits	Category
1	Understanding of Holy Quran-I/Ethics-I	1	Mandatory
2	Understanding of Holy Quran-II/Ethics-II	1	Mandatory

17. Course outlines of Mandatory Courses:

Understanding of Quran/ Fehm e Quran

Course Title: Understanding of Quran - I

Course Code:

Credit Hours: 1

Pre-Requisites: Nil

Course Objectives:

This course will enable the students to understand the Holy Quran by learning Arabic in a simple and easy way. Through relating their basic Urdu vocabulary with Quran, and without engaging them in complex Arabic Grammar, Sarf or Balagha. Students will gradually build the skills to read and understand Quranic verses directly—without needing translation. The course focuses on making Arabic accessible for everyone, even those with no prior background.

Learning Outcomes:

This course will enable the students to:

1. Develop the ability to understand basic words of the Quran, phrases and sentences that do not contain verbs (unit 1 to 5 of Muallim ul Quran Book) and then sentences having present tense (first half of unit 6 of Muallim ul Quran Book).
2. Acquire a strong foundation for understanding long verses of the Quran with clarity.
3. Comprehend Quranic vocabulary, particles (operative & non operative particles), compounds (Adjective & Possessive compound), pronouns (singular & plural) and types of plurals through hundreds of Quranic sentences.
4. Recognize and understand different styles of Quranic sentences, including nominal sentence, emphatic sentence, double emphatic sentence, negative sentence, interrogative sentence, oath –based sentences.
5. Strengthen understanding of fundamental Quranic linguistic styles, expressions and idioms.
6. Understand at least 30 to 40 % of each page of the Holy Quran.

Course Outline:

Unit 1: Simple Quranic Words

Muallim ul Quran: Book 1: Unit: Lesson 1-19

Unit 2: Words that comes before (The simple Quranic words)

Muallim ul Quran: Book 1: Unit#2: Lesson 1-13

Unit 3: Quranic words in terms of their relationship and characteristics

Muallim ul Quran: Book 1: Unit#3: Lesson 1-10

Unit 4: Singular Pronouns

Muallim ul Quran: Book 2: Unit#4: Lesson 1-17

Unit 5: Singular pronouns & Demonstrative Pronouns

Muallim ul Quran: Book 2: Unit#5: Lesson 1-23

Unit 6: Present Tense

Muallim ul Quran: Book 3: Unit#6: Lesson 1-5

Reference Books:

1- بشير، دكتور. عبيد الرحمن - معلم القرآن - اسلام آباد: دار العلم، ۲۰۲۴. جلد ۱، ۲ & ۳

Ethics (in lieu of Understanding of Quran)

Course Title: Ethics-I

Course Code:

Credit hours: 1

Pre-Requisites: Nil

Objectives

Upon successful completion of the course, students will be able to know the basics of ethics, & know how to develop an ethical approach. Also, analyze the importance of ethical and ethical values for a human being. And identify the Semitic & Non-Semitic Religions. Moreover, develop the concept of Ethics in Semitic & Non-Semitic religions. Also, analyze the similarities and differences between ethical teachings of various religions.

Learning Outcomes:

- Students will be able to demonstrate their understanding about the concept of ethics & ethical approach.
- Analyze the difference between the concept of Ethics in Semitic and Non-Semitic religions.

Course Outline:

Unit 1: Introduction and Importance of Ethics & Basic Ethical Principles

Definition of Ethics, Importance of Ethics, Beneficence, Non-maleficence, Autonomy, Justice as basic ethical behaviors.

Unit 2: Theories of Moral Standards

Moral Standards as Law, Moral Standards as Pleasure, Moral standards as Perfection. (Theories of various philosophers such as Kant, Spencer, John S. Mackenzie etc)

Unit 3: The concept of Ethics in Major Religions- Christianity, Judaism

Introduction of the Religion, Its Basic Concepts and major ethical teachings.

Unit 4: The concept of Ethics in Major Religions- Hinduism & Buddhism

Introduction of the Religion, Its Basic Concepts and major ethical teachings.

Unit 5: The concept of Ethics in Major Religions- Islam

Introduction of the Religion, Its Basic Concepts and major ethical teachings.

References/Recommended Books:

Books

1. Davis, N.K. (2023). *Elements of Ethics*, Legare Street Press.
2. Edmonds, D. (2019). *Ethics and the Contemporary World*, Taylor & Francis,
3. Hastings, J. Alexander, J. Gray S.L. (2023). *The Encyclopedia of Religion and Ethics*, Creative Media Partners, LLC
4. Robinson, D. Garratt C. (2008). *Introducing Ethics-a Graphic Guide*, Icon Books Ltd. UK.
5. اخلاق اور فلسفہ اخلاق، سیوہاروی، حفظ الرحمن، ندوۃ المصنفین، دہلی، ۱۹۷۶
6. دنیا کے بڑے مذاہب، فاروقی، عماد الحسن، مکتبہ جامعہ لمیٹڈ، دہلی، ۱۹۸۶

Websites & Articles

1. Articles on Ethics www.infotrac-college.com
2. Brown. (2017). The ethical dimensions of Global Environmental Issues. American Academy of Arts and Sciences. Retrieved July 7, 2017 from amacad.org
3. Business Ethics Magazine www.business-ethics.com/annual.htm
4. Bussmann, J. (2016). Top 9 ethical Issues in artificial intelligence. Retrieved 7 July 2017 from world Economic Forum weforum.org
5. Ethics and Religion, Shefali Narange <http://www.paperpublications.org/>
6. <http://www.jstor.com/stable/resrep12025.7>
7. <http://www.learnwell.org/ethicalproblems.htm>
8. Institute for Global Ethics www.globalethics.org
9. Klimes, Rudolf e. (2000). Ethical Problems.
10. Ten Ethical Problems of the Present World <https://www.lifepersona.com/10-ethical-problems-of-the-present-world>
11. Ward, Stephen J.A (March 2005). "Philosophical Foundations for Global Journalism Ethics" *Journal of Mass Media Ethics*:20(1)

Understanding of Quran/ Fehm e Quran

Course Title: Understanding of Quran - II

Course Code:

Credit Hours: 1

Pre-Requisites: Nil

Course Objectives:

This course will enable the students to understand the Holy Quran by learning Arabic in a simple and easy way. Through relating their basic Urdu vocabulary with Quran, and without engaging them in complex Arabic Grammar, Sarf or Balagha. Students will gradually build the skills to read and understand Quranic verses directly—without needing translation. The course focuses on making Arabic accessible for everyone, even those with no prior background.

Learning Outcomes:

This course will enable the students to:

1. Directly comprehend hundreds of Quranic sentences & verses.
2. Understand at least 80 to 85 % of each page of the holy Quran.
3. Understand common verses across different Quranic topics.
4. Achieve proficiency in the basic and advance linguistic aspects of the Arabic language.
5. Understand the difference between Quranic verbs in various forms, such as present, past and imperative.
6. Develop the ability to understand long verses of the holy Quran independently and then comprehend their interpretation.

Course Outline:

Unit 1: Past Tense

Muallim ul Quran: Book 4: Unit#7: Chapter 1: Lesson 1-9

Unit 2: Past Tense

Muallim ul Quran: Book 4: Unit#7: Chapter 2: Lesson 1-7

Unit 3: Past Tense

Muallim ul Quran: Book 4: Unit#7: Chapter 3: Lesson 1-9

Unit 4: Past Tense

Muallim ul Quran: Book 5: Unit#7: Chapter 4: Lesson 1-5

Unit 5: Past Tense & Passive Voice

Muallim ul Quran: Book 5: Unit#7: Chapter 5 - 9

Unit 6: imperative Verbs for Singulars

Muallim ul Quran: Book 6: Unit#8: Lesson 1-8

Reference Books:

1- بشير، دكتور. عبيد الرحمن - معلم القرآن - اسلام آباد: دار العلم، ۲۰۲۴. جلد ۳، ۴، ۵، ۶

Ethics (in lieu of Understanding of Quran)

Course Title: Ethics-II

Course Code:

Credit hours: 1

Pre-Requisites: Nil

Objectives

Upon successful completion of the course, students will be able to have better understanding of ethics in various walks of life like in workplace, in business, journalism etc. Moreover, they will be able to be familiarize with Contemporary World's Ethical Issues. And, try to develop answers about them.

Learning Outcomes:

- Students will be able to demonstrate their understanding about the importance of ethics in their lives today.
- Identify Contemporary World's Ethical Issues.
- Create problem solving for these contemporary Ethical issues.

Course Outline:

Unit 1: Professional Ethics & Bioethics

Meaning of Work/Professional Ethics, Professional Ethics and Human Values, Elements of professional Ethics:

Person attitude, Beliefs about work, Positive Attributes (honesty, integrity, dedication, commitment, responsibility, interpersonal relationship)

Genetic engineering, Organ Donation, Cloning, Head Transplant

Unit 2: Ethical Conduct in Business Ethics & it's important

Types of Business Ethics, Common Business Ethical Challenges

Conflict of interest, honesty & integrity, whistle blowing, loyalty vs truth

Unit 3: Journalism

Principles of Ethical Journalism:

Truth & Accuracy, Independence, Fairness & Impartiality, Humanity, Public Accountability

Unit 4: Environmental Ethics

Core Principles of environmental ethics:

Justice & sustainability, Sufficiency & compassion, Solidarity & public participation, Pollution prevention.

Current issues of environmental ethics:

Pollution, The depletion of natural resources, Loss of biodiversity, Destruction of ecosystem, Global climate change

Unit 5: Social Inequalities

Meaning of Social Inequalities, Issues related to social inequality

Difference in source of income, Health care, Freedom of speech, Gender inequality, Toxic workplace culture, Education, Political representation & participation

Unit 6: Social Media Ethics

Facebook, YouTube, WhatsApp, Instagram, TikTok, Snapchat, LinkedIn, X

Current Ethical issues in social media:

Plagiarism, Fake news, Harassment, Photo ethics, Post without caution, inappropriate behavior privacy

References/Recommended Books:

Books

1. Davis, N.K. (2023). *Elements of Ethics*, Legare Street Press.
2. Edmonds, D. (2019). *Ethics and the Contemporary World*, Taylor & Francis,
3. Hastings, J. Alexander, J. Gray S.L. (2023). *The Encyclopedia of Religion and Ethics*, Creative Media Partners, LLC
4. Robinson, D. Garratt C. (2008). *Introducing Ethics-a Graphic Guide*, Icon Books Ltd. UK.
5. اخلاق اور فلسفہ اخلاق، سیوہاروی، حفظ الرحمن، ندوة المصنفین، دہلی، ۱۹۷۶
6. دنیا کے بڑے مذاہب، فاروقی، عماد الحسن، مکتبہ جامعہ لمیٹڈ، دہلی، ۱۹۸۶

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7. Articles on Ethics www.infotrak-college.com
8. Brown. (2017). The ethical dimensions of Global Environmental Issues. American Academy of Arts and Sciences. Retrieved July 7, 2017 from amacad.org
9. Business Ethics Magazine www.business-ethics.com/annual.htm
10. Bussmann, J. (2016). Top 9 ethical Issues in artificial intelligence. Retrieved 7 July 2017 from world Economic Forum weforum.org
11. Ethics and Religion, Shefali Narange <http://www.paperpublications.org/>
12. <http://www.jstor.com/stable/resrep12025.7>
13. <http://www.learnwell.org/ethicalproblems.htm>
14. Institute for Global Ethics www.globalethics.org
15. Klimes, Rudolf e. (2000). Ethical Problems.

16. Ten Ethical Problems of the Present World <https://www.lifepersona.com/10-ethical-problems-of-the-present-world>
17. Ward, Stephen J.A (March 2005). "Philosophical Foundations for Global Journalism Ethics" Journal of Mass Media Ethics:20(1)