DEPARTMENT OF CHEMISTRY

Four –Year Undergraduate Programme
Course Structure
&
Syllabi (up to 8th semester)

Girijananda Chowdhury University, Assam

Summary of Minimum Credit Framework for UG Programme

SEM	Core (Major)	Core (Minor)	Multi-Disciplinary Course (MDC)*	Ability Enhancement courses (AEC)*	Skill Enhancement courses (SEC)	Common Value-Added Courses (VAC)*	Internship	Diss./Project	Total Credit Offered	Exit option
I	**4**	**4+4**	**3**	**2**	**3**	**2**	**-**		**22**	Certificate**
II	**4**	**4+4**	**3**	**2**	**3**	**2**	**-**		**22**	
III	**4**	**4+4**	**3**	**2**	**3**	**-**	**-**		**20**	Diploma**
IV	**16**	-	-	**2**	**-**	**2**	**-**		**20**	
V	**16**	-		**-**	**-**	**-**	**4**		**20**	**Degree (with Single Major and/or Minor /Double Minor) in Discipline(s)**
VI	**20**		**-**	**-**	**-**	**-**	**-**		**20**	
						Total			**124**	
VII	**8**	**4+4**	-	-	-	-		Project /Dissertation I (4) /Core (4)***	**20**	**Degree Honours with Research/Without Research (With Single Major and Minor(s) /Double Major) in Discipline(s)**
VIII	**12**	**-**	-	-	-	-		Project/ Dissertation II (8) /Core (4+4) ***	**20**	
						Total			**164**	

*Students have to choose one course from the pool of courses offered under MDC, AEC, SEC, VAC.

** Students, opting to exit from the programme at the end of 1st /2nd year, need to undertake a compulsory Internship/ Vocational Programme carrying 4 credits.

*** Students not opting for Research Project I and II have to undertake 3 courses of 4 credit each.

Department of Chemistry
Course Structure For Four –Year Undergraduate Programme
Bachelor of Science in Chemistry

YEAR 1

First Semester				
Code	**Course**	**Category of Course**	**L-T-P**	**Total Credit**
BCH23101T	Fundamentals of Chemistry – I	Core	3-0-2	4
	MINOR – 1	Minor	3-0-2	4
	MINOR – 2	Minor	3-1-0	4
	MDC – 1	MDC	3-0-0	3
	AEC – 1	AEC	2-0-0	2
	SEC – 1	SEC	3-0-0	3
	VAC – 1	VAC	2-0-0	2
			TOTAL	22

Second Semester				
Code	**Course**	**Category of Course**	**L-T-P**	**Total Credit**
BCH23103T	Fundamentals of Chemistry – II	Core	3-0-2	4
	MINOR – 3	Minor	3-0-2	4
	MINOR – 4	Minor	3-1-0	4
	MDC – 2	MDC	3-0-0	3
	AEC – 2	AEC	2-0-0	2
	SEC – 2	SEC	3-0-0	3
	VAC – 2	VAC	2-0-0	2
			TOTAL	22

EXIT OPTION WITH CERTIFICATION. Students who desire to exit after 1 year of study need to undertake Vocational Training/Course of 8 weeks / 4 credits.

YEAR 2

Third Semester				
Code	**Course**	**Category of Course**	**L-T-P**	**Total Credit**
BCH23201T	Inorganic Chemistry-I	Major/Core	3-0-2	4
	MINOR – 5	Minor	3-0-2	4
	MINOR – 6	Minor	3-0-2	4
	MDC – 3	MDC	3-0-0	3
	AEC – 3	AEC	2-0-0	2
	SEC – 3	SEC	3-0-0	3
			TOTAL	20

Fourth Semester				
Code	**Course**	**Category of Course**	**L-T-P**	**Total Credit**
BCH23204T	Organic Chemistry-I	Major/Core	3-0-2	4
BCH23205T	Physical Chemistry-I	Major/Core	3-0-2	4
BCH23206T	Inorganic Chemistry-II	Major/Core	3-0-2	4
BCH23220T/ BCH23221T	*Elective-I Analytical Chemistry / Polymer Chemistry	Elective	3-0-2	4
	AEC-4	AEC	2-0-0	2
	VAC-3	VAC	2-0-0	2
			TOTAL	20

EXIT OPTION WITH DIPLOMA. Students who desire to exit after 2 years of study and have not undertaken Vocational Training/Course of 8 weeks / 4 credits after 1 year, need to go for such training.

YEAR-3

Fifth Semester				
Code	**Course**	**Category of Course**	**L-T-P**	**Total Credit**
BCH23301T	Organic Chemistry-II	Major/Core	3-0-2	4
BCH23302T	Physical Chemistry-II	Major/Core	3-0-2	4
BCH23303T	Inorganic Chemistry-III	Major/Core	3-0-2	4
BCH23320T/ BCH23321T	*Elective -II Inorganic Materials of Industrial Importance / Instrumental Methods of Analysis	Elective	3-0-2	4
	Internship	Major/Core	0-0-8	4
			TOTAL	20

Sixth Semester				
Code	**Course**	**Category of Course**	**L-T-P**	**Total Credit**
BCH23304T	Organic Chemistry-III	Major/Core	3-0-2	4
BCH23305T	Physical Chemistry-III	Major/Core	3-0-2	4
BCH23306T	Inorganic Chemistry-IV	Major/Core	3-0-2	4
BCH23307T	Advanced Quantum Chemistry and Spectroscopy	Major/Core	3-0-2	4
BCH23322T/ BCH23323T	*Elective - III Food Chemistry / Green Chemistry	Elective	3-0-2	4
			TOTAL	20

EXIT OPTION WITH BACHELOR DEGREE IN CHEMISTRY

Students who want to undertake 3-year UG Programme will be awarded **UG Degree in the field of study** upon securing the **minimum credit requirements** prescribed by the university.

LIST OF COURSES OFFERED BY CHEMISTRY DEPARTMENT FOR OTHER DISCIPLINES

Sl. No	SEMESTER	Course Type	Course Name	Hours per Week			Credits
				L	T	P	C
1	I	MINOR-1	Fundamentals of Chemistry I(BCH23101T)	3	0	2	4
2	I	MINOR-2	Material Chemistry (BCH23102T)	3	1	0	4
3	II	MINOR-3	Fundamentals of Chemistry – II (BCH23103T)	3	0	2	4
4	II	MINOR-4	Fuel Chemistry (BCH23104T)	3	1	0	4
5	III	MINOR-5	Fundamentals of Chemistry-III (BCH23202T)	3	0	2	4
6	III	MINOR-6	Basic Analytical Chemistry (BCH23203T)	3	0	2	4

List of Multidisciplinary Courses (MDC) offered by Chemistry Department

Sl. No	SEMESTER	Course Type	Course Name	Hours per Week			Credits
				L	T	P	C
1	I	MDC	Chemistry in everyday Life (BCH23140T)	3	0	0	3
2	II	MDC	Molecules of Life (BCH23141T)	3	0	0	3
3	III	MDC	Fuel Science (BCH23240T)	3	0	0	3

List Of Skill Enhancement Courses (SEC) offered by Chemistry Department

Sl. No	SEMESTER	Course Type	Course Name	Hours per Week			Credits
				L	T	P	C
1	I	SEC	Fundamentals of Analytical Methods (BCH26160T)	3	0	0	3

FYUGP In Chemistry

Course Structure (Revised) and Syllabus of

UG 7th and 8th semester

Effective from 2026-2027 Academic session

DEPARTMENT OF CHEMISTRY
School of Natural Sciences
Girijananda Chowdhury University Azara, Guwahati-781017

GIRIJANANDA CHOWDHURY UNIVERSITY
Hathkhowapara, Azara, Guwahati 781017, Assam

DEPARTMENT OF CHEMISTRY

UG FOURTH YEAR FYUGP IN CHEMISTRY COURSE STRUCTURE

UG Degree (Honours) in Chemistry OR UG Degree (Honours) with Research in Chemistry

Seventh Semester					
Programme Mode	**Code**	**Course**	**Category of Course**	**L-T-P**	**Total Credit**
B.Sc. With Honours/ B.Sc. Honours with Research	BCH26400T	Physical Chemistry-IV	Major/Core	3-0-2	4
	BCH26401T	Research Methodology	Major/Core	4-0-0	4
		Minor Elective 1	Minor Elective	3-0-2	4
		Minor Elective 2	Minor Elective	3-0-2	4
	BCH26420T/ BCH26421T	*Elective - IV Medicinal Chemistry/ Applications of Computers in Chemistry	Elective	3-0-2	4
				TOTAL	20
	Eighth Semester				
Programme Mode	**Code**	**Course**	**Category of Course**	**L-T-P**	**Total Credit**
B.Sc. With Honours in Chemistry	BCH26402T	Organic Chemistry-IV	Major/Core	3-0-2	4
	BCH26403T	Inorganic Chemistry-V	Major/Core	3-0-2	4
	BCH26404T	Physical Chemistry-V	Major/Core	3-0-2	4
	BCH26405R	Project	Project	0-0-8	4
	BCH26426T/ BCH26427T	*Elective-V Industrial Chemicals and Environment/ Chemistry of Advanced Materials	Elective	3-1-0	4
				TOTAL	20
Programme Mode	**Code**	**Course**	**Category of Course**	**L-T-P**	**Total Credit**
B.Sc. Honours With Research in Chemistry	BCH26406T	Reactivity, Organic Transformations and Kinetics	Major/Core	4-0-0	4
	BCH26426T / BCH26427T	*Elective-V Industrial Chemicals and Environment/ Chemistry of Advanced Materials	Elective	3-1-0	4
	BCH26407R	Research Project/Dissertation	Project/Dissertation	0-0-24	12
				Total	20

Students will be awarded UG Degree (Honours) in Chemistry OR UG Degree (Honours) with Research in Chemistry

*Elective-Students has to choose anyone of the course from the two options

List of Minor Elective courses offered by Chemistry Department for other Disciplines

Si No.	Semester	Course Type	Course Name	L	T	P
1	VII	Minor Elective 1	(a) Sustainable Chemistry (BCH26422T) (b) Chemistry of Polymers (BCH26423T)	3	0	2
2	VII	Minor Elective 2	(a) Industrial Chemicals and Environment (BCH26424T) (b) Chemistry of Food (BCH26425T)	3	0	2

List of Elective courses offered by Chemistry Department

Si No.	Semester	Course Type	Course Name	L	T	P
1	VII	Elective	*Elective - IV Medicinal Chemistry (BCH26420T) / Applications of Computers in Chemistry (BCH26421T)	3	**1**	**0**
2	VIII	Elective	*Elective – V Industrial Chemicals and (BCH26422T) Environment/ Chemistry of Advanced Materials (BCH26423T)	**3**	**1**	**0**

Detailed Syllabus:

SEMESTER -I(CORE/MINOR)

BCH23101T	**FUNDAMENTALS OF CHEMISTRY – I**	**L**	**T**	**P**	**C**
		3	**0**	**2**	**4**

Pre-requisite: Knowledge of chemistry at (10+2) level

Course Objectives:

1. To provide knowledge of atomic structure and their periodicity.
2. To provide an insight into the kinetic theory of gases and behavior of ideal and real gases.
3. To make students understand the structure and properties of liquid.
4. To provide knowledge about different types of organic compounds, their reactivity and reaction intermediates.
5. To make students understand the stereo chemical aspects of organic chemistry.
6. To make students aware of qualitative analysis of organic molecules.

Course Outcome:

After successful completion of the course, the students will be able

CO1: To learn the concepts related to atomic structure and their periodicity.
CO2: To understand the fundamentals of kinetic theory of gases and relate the behavior of ideal and real gases.
CO3: To gain the knowledge of qualitative treatment of the structure of liquid along with the physical properties of liquid, viz, vapour pressure, surface tension and viscosity.
CO4: To identify different classes of organic compounds, relate their reactivity with different physical effects along with understanding of various types of reaction intermediates.
CO5: To explain the stereochemical aspects of organic compounds.
CO6: To detect the elements and functional groups present in organic molecules qualitatively.

Module 1: ATOMIC STRUCTURE — **8 hours**

Bohr's theory and its limitations, hydrogen atom spectra, dual behaviour of matter, de Broglie's relation, Heisenberg's Uncertainty Principle and its significance, Schrödinger's wave equation, significance of ψ and ψ^2. Quantum numbers and their significance, Radial and angular wave functions for hydrogen atom. Radial and angular distribution curves. Shapes of *s*, *p*, *d* and *f* orbitals, Aufbau's principle, Pauli's Exclusion Principle, Hund's rule of maximum multiplicity, Rules for filling electrons in various orbitals, Electronic configurations of the atoms, stability of half – filled and completely filled orbitals, concept of exchange energy.

Module 2: PERIODICITY OF ELEMENTS — **8 hours**

The general idea of Modern periodic table, s, *p*, *d*, *f* block elements, Detailed discussion of the following properties of the elements, with reference to *s* & *p*-block.

(a) Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table.
(b) Atomic radii(van der Waals)
(c) Ionic and crystal radii.
(d) Covalent radii(octahedral and tetrahedral)
(e) Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization energy. Applications of ionization enthalpy.
(f) Electron gain enthalpy, trends of electron gain enthalpy.
(g) Electronegativity, Pauling's/ Mulliken's/ Allred Rachow's/ and Mulliken-

Jaffé's electronegativity scales.Variation of electronegativity with bond order, partial charge, hybridization, group electronegativity.

Module 3: GASEOUS STATE	**10 hours**

Kinetic molecular model of a gas: postulates and derivation of the kinetic gas equation; collision frequency; collision diameter; collision number, mean free path and viscosity of gases, including their temperature and pressure dependence, relation between mean free path and coefficient of viscosity, calculation of σ from η ; variation of viscosity with temperature and pressure.
Maxwell distribution and its use in evaluating molecular velocities (average, root mean square and most probable) and average kinetic energy, principle of equipartition of energy.

Behaviour of real gases: Deviations from ideal gas behaviour, compressibility factor, *Z*, and its variation with pressure for different gases. Causes of deviation from ideal behaviour. Van der Waals equation of state, its derivation and application in explaining real gas behaviour, Boyle temperature. Continuity of states, critical phenomena, determination of critical temperature and pressure, relation between critical constants and Van der Waals constants, law of corresponding states.

Module 4: LIQUID STATE	**5 hours**

Qualitative treatment of the structure of the liquid state; physical properties of liquids; vapour pressure, surface tension and coefficient of viscosity, and their determination. Effect of addition of various solutes on surface tension and viscosity, surface energy. Explanation of cleansing action of detergents. Temperature variation of viscosity of liquids and comparison with that of gases.

Module 5: BASICS OF ORGANIC CHEMISTRY	**7 hours**

Physical effects, electronic displacements, inductive effect, electromeric effect, resonance and hyperconjugation, cleavage of bonds, homolysis and heterolysis.

Nomenclature, structure, shape and reactivity of organic molecules, nucleophiles and electrophiles. Reaction intermediates: Carbocations, carbanions and free radicals.
.
Introduction to types of organic reactions and their mechanism: Addition, Elimination and Substitution reactions.

Module 6: STEREOCHEMISTRY	**7 hours**

Fischer Projection, Newmann and Sawhorse Projection formulae and their interconversions; Geometrical isomerism: cis–trans and, syn-anti isomerism E/Z notations with C.I.P rules. **Optical Isomerism:** Optical Activity, Specific Rotation, Chirality/Asymmetry, Enantiomers,

Molecules with two or more chiral-centres, Distereoisomers, meso structures, Racemic mixtureand resolution. Relative and absolute configuration: D/L and R/S designations.

Total Lecture hours	**45 hours**

Practical BCH23101P

List of Laboratory Experiments:

1. Laboratory hazards and safety precautions.
2. Calibration and use of apparatus.
3. Study of Bunsen flame.
4. Detection of elements (N, Cl, Br, I & S) and functional groups (-COOH, Ph-OH, Alc-OH, -CHO, =CO, $-NH_2$ & $-NO_2$) in an organic compound. (Minimum 4 samples).
5. Preparation of potassium tris oxalato iron(II) complex.

Text Book(s)	
1.	Lee, J.D. Concise Inorganic Chemistry ELBS, 1991
2.	Shriver and Atkins Inorganic Chemistry, 5th Edition, Oxford University Press.
3.	Peter Atkins & Julio De Paula, Physical Chemistry 10th Ed., Oxford University Press (2014)
4.	Engel, T. & Reid, P. Physical Chemistry 3rd Ed., Prentice-Hall (2012
5.	Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
6.	Finar, I. L. Organic Chemistry (Volume 1&2), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
7.	Huheey, J.E., Keiter, E.A., Keiter, R.L. & Medhi, O.K. Inorganic Chemistry.
8.	Principles of Physical Chemistry, Puri, Sharma & Pathania, Vishal Publishing Co.
Reference Books	
1.	Graham Solomon, T.W., Fryhle, C.B. & Dnyder, S.A. Organic Chemistry, John Wiley & Sons (2014).
2.	McMurry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013
3.	Sykes, P. A Guidebook to Mechanism in Organic Chemistry, Orient Longman, New Delhi (1988).
4.	Cotton, F.A., Wilkinson, G. & Gaus, P.L. Basic Inorganic Chemistry, 3rd ed., Wiley.
5.	Douglas, B.E., McDaniel, D.H. & Alexander, J.J. Concepts and Models in Inorganic Chemistry, John Wiley & Sons.
6.	Levine, I .N. Physical Chemistry 6th Ed., Tata Mc Graw Hill (2010).
7.	Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009).
8.	A Text Book of Practical Chemistry By Dr. Sudarshan Barua

SEMESTER –I (MINOR)

BCH23102T	**MATERIAL CHEMISTRY**	**L**	**T**	**P**	**C**
		3	**1**	**0**	**4**

Pre-requisite: Knowledge of Chemistry at (10+2) level

Course Objectives:

1. To make students aware of manufacturing processes and properties of cement and ceramics.
2. To provide knowledge of the properties and applications of different polymeric compounds.
3. To provide knowledge of different types of composites, lubricants and refractories along with their applications.
4. To give an insight into characteristics properties and manufacturing methods of nanomaterials with their applications.
5. To make students familiar with structural aspects and chemical properties of liquid crystal.

Course Outcome:

After successful completion of the course, the students will be able

CO1: To gain knowledge of manufacturing processes and properties of cement and ceramics.
CO2: To learn the properties and applications of different polymeric compounds.
CO3: To know about different types of composites, lubricants and refractories along with their applications.
CO4: To become familiar with characteristics properties and manufacturing methods of nanomaterials with their applications in various fields.
CO5: To know the structural aspects and chemical properties of liquid crystal.

Module 1: CEMENT	**7 hours**

Cement and its classification, Portland cement, composition, manufacture and its setting and hardening, heat of hydration of cement.

Module 2: POLYMERS	**8 hours**

Classification of polymers, Types of polymerization, Molecular weight of polymers, Structure and properties of polymers, Important thermoplastic and thermosetting polymers, polyvinyl chloride (PVC), polystyrene (PS), Polymethyl methacrylate (PMMA), Polytetrafluoroethylene (PTFE), Polycarbonate polyamide and phenolic resins, Natural and Synthetic rubbers, Specialty polymers: Silicones, Conducting polymers and biodegradable polymers.

Module 3: CERAMICS	**4 hours**

Introduction, general properties, classification, applications.

Module 4: LUBRICANTS	**3 hours**

Lubricants: Mechanism of lubrication, classification of lubricants, their properties, grease, synthetic lubricants.

Module 5: REFRACTORIES	**6 hours**

Definition, classification, properties of refractories, manufacture of refractories, uses.

Module 6: COMPOSITES	**4 hours**

Composites and their constituents; Classification: particle reinforced composites, fiber reinforced composites and properties; Metal matrix, ceramic matrix and polymer matrix composites.	
Module 7: LIQUID CRYSTALS	**6 hours**
Introduction, structure of liquid crystal forming compounds, classification of liquid crystals, chemical properties of liquid crystals, applications of liquid crystals.	
Module 8: NANOMATERIALS	**7 hours**
Introduction, differences from bulk materials, Properties of nanomaterials, one, two and 3D nanomaterials, preparation of nanomaterials (top down and bottom-up approach), Fullerenes, Carbon nanotube, Nanowire, Application of Nanomaterial, Bio nanomaterials.	
Total Lecture hours	**45 hours**

Text Book(s)	
1.	Material Chemistry, Bradley D. Fahlman, Springer
2.	Introduction to Materials Chemistry, Harry R. Allcock, Wiley
3	Atkin P., Shriver & Atkins' Inorganic Chemistry 5th Ed. Oxford University Press (2010)
Reference Books	
1.	Polymer Science and Technology, J. R. Fired (Prentice Hall)
2.	Introduction to Polymers-R. J. Young.
3.	Polymer Science-V. R. Gowarikar (New Age International)
4.	Advance Inorganic Chemistry- Cotton et. Al. (John Willey)
5.	Poole, C. P., Ovens, F. J., Introduction to Nanotechnology, Wiley India, 2009.

Semester-II (CORE/MINOR)

BCH23103T	FUNDAMENTALS OF CHEMISTRY – II	L	T	P	C
		3	0	2	4

Pre-requisite: Knowledge of chemistry at (10+2) level

Course Objectives:

1. To understand different types of chemical bonding present in a molecule and its relation with the structure.
2. To make students familiar with the principles behind the acid base behaviour of different substances.
3. To explain the laws of thermodynamics and its applications.
4. To illustrate the preparation and different chemical reactions of aliphatic hydrocarbons.
5. To make students understand the properties and reactions of aromatic compounds.
6. To understand the concept of quantitative analysis and apply for different titrations.
7. To understand the properties of liquids by experimental methods.

Course Outcome:

After successful completion of the course, the students will be able

CO1: To gain knowledge of different types of chemical bonding present in a molecule and its relation with the structure.
CO2: To understand the principles behind acid base behaviour of different substances.
CO3: To know about the laws of thermodynamics and its application to chemical processes.
CO4: To describe the preparation and different chemical reactions of aliphatic hydrocarbons.
CO5: To learn different aspects of aromatic compounds.
CO6: To conduct quantitative analysis of a given substance by using different types of volumetric titrations.
CO7: To learn the physical properties like surface tension and viscosity of liquids by conducting experiments.

Module 1: CHEMICAL BONDING — **10 hours**

Ionic bond: General characteristics, Energy considerations in ionic bonding, lattice energy and solvation energy and their importance in the context of stability and solubility of ionic compounds, Born – Haber cycle and its applications.
Covalent bond: Valence Bond Theory and its limitations, various types of hybridization with suitable examples of linear, trigonal planar, square planar, tetrahedral, trigonal bipyramidal and octahedral arrangements. Shapes of some inorganic molecules and ions on the basis of Valence Shell Electron Pair Repulsion Theory (VSEPR). MO Approach: Rules for the LCAO method, bonding and antibonding MOs and their characteristics, MO treatment of homonuclear and heteronuclear diatomic molecules.
Covalent character in ionic compounds: Polarizing power and polarizability, Fajan's rules and effects of polarization
Metallic bond, Weak chemical forces – Vander Waal's forces, ion – dipole forces, dipole – dipole interactions, induced dipole interactions, Repulsive forces, Hydrogen bonding.

Module 2: ACIDS AND BASES — **5 hours**

Bronsted-Lowry concept of acid-base reactions, relative strength of acids, types of acid base reactions, levelling solvents, Lewis acid-base concept, classification of Lewis acids, Hard and Soft acids and Bases (HSAB), HSAB principle and its applications.

Module 3: LAWS OF THERMODYNAMICS	**14 hours**

Macroscopic properties, state variables, system, surroundings, intensive and extensive properties.

First Law of Thermodynamics-Statement, concept of internal energy, work, heat, heat capacity, relation between heat capacities. Calculation of Q, W, U, and H for reversible and irreversible work done under adiabatic and isothermal conditions, Joule-Thomson effect and Joule - Thomson coefficient, inversion temperature.

Second Law of Thermodynamics-
Second law of thermodynamics, Carnot cycle and its efficiency, Carnot theorem. Thermodynamic scale of temperature. Concept of entropy: entropy as a state function, entropy as a function of V and T, entropy as a function of P and T, Entropy change for reversible, irreversible condition. Entropy as criteria of spontaneity and equilibrium, Entropy change in ideal gases. Gibbs free energy and Helmholtz free energy. Variation of G and A with P, V and T, Gibbs-Helmholtz equation.

Module 4: ALIPHATIC HYDROCARBONS	**10 hours**

Alkanes : Preparation: Catalytic hydrogenation, Wurtz reaction, Kolbe'e synthesis, from Grignard's reagent. Reactions: Free radical substitution, halogenation – relative reactivity and selectivity

Alkenes: Preparation of alkenes by elimination reactions, Saytzeff and Hofmann eliminations. Reactions of alkenes: cis-addition (alk. $KMnO_4$) and trans addition (bromine), addition of HX (Markownikoff's and anti-Markownikoff's addition), Hydration, Ozonolysis, Oxymercuration-demercuration, Hydroboration-oxidation.

Alkynes: Preparation, Acidity, Reactions of alkynes : Formation of metal acetylides, addition of bromine and alkaline $KMnO_4$, Ozonolysis and oxidation with hot alkaline $KMnO_4$.

Module 5: AROMATIC HYDROCARBONS	**6 hours**

Aromaticity*:* Hückel's rule, aromatic character of arenes, cyclic carbocations/carbanions and heterocyclic compounds with suitable examples. Electrophilic aromatic substitution: halogenation, nitration, sulphonation and Friedel-Craft's alkylation/acylation with their mechanism. Directing effects of the groups.

Total Lecture hours	**45 hours**

Practical BCH23103P

List of Laboratory Experiments:

1. Preparation of solutions of different normality/molarity.
2. Estimation of iron (Fe^{2+}) by a standard solution of $KMnO_4$.
3. To determine the relative viscosity of a liquid at room temperature by Ostwald's viscometer. (Minimum three liquids)
4. To determine the surface tension of a liquid at room temperature by drop number method using a stalagmometer. (Minimum three liquids).
5. Conductometric titration between a strong acid and a strong alkali.

Textbook(s)	
1.	Lee, J.D. Concise Inorganic Chemistry ELBS, 1991
2.	Shriver and Atkins Inorganic Chemistry, 5th Edition, Oxford University Press.
3.	Peter Atkins & Julio De Paula, Physical Chemistry 10th Ed., Oxford University Press (2014)
4.	Engel, T. & Reid, P. Physical Chemistry 3rd Ed., Prentice-Hall (2012)
5.	Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
6.	Finar, I. L. Organic Chemistry (Volume 1&2), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
7.	Huheey, J.E., Keiter, E.A., Keiter, R.L. & Medhi, O.K. Inorganic Chemistry.
8.	Principles of Physical Chemistry, Puri, Sharma & Pathania, Vishal Publishing Co.
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1.	Graham Solomon, T.W., Fryhle, C.B. & Dnyder, S.A. Organic Chemistry, John Wiley & Sons (2014).
2.	McMurry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.
3.	Sykes, P. A Guidebook to Mechanism in Organic Chemistry, Orient Longman, New Delhi (1988).
4.	Finar, I.L. Organic Chemistry (Vol. I & II), E.L.B.S.
5.	Cotton, F.A., Wilkinson, G. & Gaus, P.L. Basic Inorganic Chemistry, 3rd ed., Wiley.
6.	Douglas, B.E., McDaniel, D.H. & Alexander, J.J. Concepts and Models in Inorganic Chemistry, John Wiley & Sons.
7.	Levine, I .N. Physical Chemistry 6th Ed., Tata Mc Graw Hill (2010).
8.	Khosla, B. D.; Garg, V. C. & Gulati, A., Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
9.	Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009.
10	A Textbook of Practical Chemistry By Dr. Sudarshan Barua

Semester-II (MINOR)

BCH23104T	FUEL CHEMISTRY	L	T	P	C
		3	1	0	4

Pre-requisite: Knowledge of chemistry at (10+2)level

Course Objectives:

1. To provide basic idea of fuel and calorific value.
2. To make the students aware of solid fuel, emphasis on coal and coke.
3. To provide an insight into liquid fuel and some important properties.
4. To make students understand gaseous fuel and their analysis.
5. To make the students aware of different types of energy sources.

Course Outcome:

After successful completion of the course, the students will be able

CO1: To understand fuel and its relation with calorific value.
CO 2: To explain important constituents of solid fuel and their impact on its calorific value.
CO 3: To know about liquid fuel, cracking, refining, reforming and their different properties.
CO 4: To know about different types of gaseous fuel.
CO 5: To know about different alternative sources of energy.

Module 1: INTRODUCTION OF FUEL	**10 hours**

Definition and classification of fuels, characteristics of a good fuel, calorific value, gross and net calorific value, Dulong's formula for theoretical calculation of calorific value, Determination of calorific value by Bomb calorimeter and Boy's gas calorimeter.

Module 2: SOLID FUELS	**8 hours**

Coal, classification of coal, proximate and ultimate Analysis of coal, carbonization of coal, caking and coking of coal, metallurgical coke and its manufacture.

Module 3: LIQUID FUEL	**10 hours**

Petroleum, origin of petroleum, composition, classification, Processing of crude petroleum, Refining of petroleum, cracking, Synthetic petrol, Refining of Gasoline, Knocking, octane rating, Diesel engine fuels, Reformimg, Benzol, power alcohol, kerosene.

Module 4: GASEOUS FUEL	**9 hours**

Natural gas, Producer gas, Water gas, Carburetted water gas, Coal gas, Oil gas, calculation of air required for combustion. Analysis of flue gases.

Module 5: ALTERNATIVE FUEL	**8 hours**

Non-conventional sources of energy-Solar Energy, CNG, LPG, P-series fuel, Ethanol, Biodiesel, Biomass, Biogas, nuclear fuel.

Total Lecture hours	**45 hours**

Text Book(s)

1. E. Stocchi: Industrial Chemistry, Vol -I, Ellis Horwood Ltd. UK.
2. B.K. Sharma: Industrial Chemistry, Goel Publishing House, Meerut

Reference Books

1. Fuel Chemistry by Dr. Biswajit Saikia
2. Fuel Chemistry by Debasis Mohanty

SEMESTER-III (MAJOR/CORE)

BCH23201T	**INORGANIC CHEMISTRY-I**	**L**	**T**	**P**	**C**
		3	**0**	**2**	**4**

Pre-requisite: Knowledge of chemistry at (10+2) level

Course Objectives:

1. To provide knowledge of redox chemistry in metallurgical processes.
2. To make students aware of stability of s – block elements in different oxidation states, diagonal relationship and complex forming abilities.
3. To give an insight into structure and bonding of compounds formed by p – block elements.
4. To give students knowledge of different chemical properties and bonding of noble gas compounds.
5. To provide basic idea of structures of some inorganic polymers along with their applications.
6. To make students aware of different volumetric titrations used for quantitative analysis of a given substance.

Course Outcome:

After successful completion of the course, the students will be able

CO1: To apply theoretical principles of redox chemistry in the understanding of metallurgical. Processes.

CO2: To understand about the stability of different oxidation states, diagonal relationship and complex forming abilities of s – block elements.

CO3: To gain knowledge of structure and bonding of compounds formed by p – block elements.

CO4: To learn various chemical properties and bonding of noble gas compounds.

CO5: To understand the structural aspects and applications of inorganic polymers.

CO6: To conduct quantitative analysis of a given substance by using different types of volumetric titrations.

Module 1: GENERAL PRINCIPLES OF METALLURGY — **8 hours**

Chief modes of occurrence of metals based on standard electrode potentials. Ellingham diagrams for reduction of metal oxides using carbon and carbon monoxide as reducing agent. Electrolytic Reduction, Hydrometallurgy. Methods of purification of metals: Electrolytic Kroll process, Parting process, van Arkel-de Boer process and Mond's process, Zone refining.

Module 2: CHEMISTRY OF s – BLOCK ELEMENTS — **10 hours**

Inert pair effect, Relative stability of different oxidation states, diagonal relationship and anomalous behaviour of first member of each group. Allotropy and catenation. Complex formation tendency of s block elements.

Module 3: CHEMISTRY OF p – BLOCK ELEMENTS — **12 hours**

Boric acid and borates, boron nitrides, borohydrides (diborane) carboranes and graphitic compounds, silanes, Oxides and oxoacids of nitrogen, Phosphorus, and chlorine. Peroxo acids of sulphur, interhalogen compounds, polyhalide ions, pseudo halogens and basic properties of halogens.

Module 4: NOBLE GASES — **8 hours**

Occurrence and uses, rationalization of inertness of noble gases, Clathrates; preparation and properties of XeF_2, XeF_4 and XeF_6; Nature of bonding in noble gas compounds (Valence bond treatment and MO treatment for XeF_2). Molecular shapes of noble gas compounds (VSEPR theory).

Module 5: INORGANIC POLYMERS	**7 hours**
Types of inorganic polymers, comparison with organic polymers, synthesis, structural aspects and applications of silicones and siloxanes. Borazines, silicates and phosphazenes, and polysulphates.	
Total Lecture hours	**45 hours**

BCH23201P List of Laboratory Experiments:

1. Estimation of hardness of water by a standard solution of EDTA.
2. Estimation of copper by a standard solution of $Na_2S_2O_3$.
3. Estimation of oxalic acid and sodium oxalate in a given mixture.
4. Estimation of sodium carbonate and sodium bicarbonate in their mixture.
5. Estimation of sodium carbonate and sodium hydroxide in their mixture.
6. Estimation of Fe(II) by $K_2Cr_2O_7$.
7. Estimation of free chlorine in bleaching powder.

Textbook(s)

1.	Lee J. D., Concise Inorganic Chemistry, ELBS, 1991
2.	Atkin P., Shriver & Atkins' Inorganic Chemistry 5th Ed. Oxford University Press (2010)

Reference Books

1.	Douglas B. E., Mc Daniel D. H., & Alexander J. J., Concepts & Models of Inorganic Chemistry 3rd Ed., John Wiley Sons, N.Y. 1994.
2.	Cotton, F.A., Wilkinson, G. & Gaus, P.L. Basic Inorganic Chemistry, 3rd ed., Wiley.
3.	Miessler, G. L. & Donald, A. Tarr. Inorganic Chemistry 4th Ed., Pearson, 2010.
4.	Greenwood, N.N. & Earnshaw, . Chemistry of the Elements, Butterworth Heinemann 1997.
5.	Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009.
6.	A Textbook of Practical Chemistry By Dr. Sudarshan Barua

SEMESTER-III (MINOR)

BCH23202T	**FUNDAMENTALS OF CHEMISTRY-III**	**L**	**T**	**P**	**C**
		3	**0**	**2**	**4**

Pre-requisite: Knowledge of chemistry at (10+2) level

Course Objectives:

1. To provide knowledge about patterns and trends exhibited by s- and p- block elements.
2. To make the students aware of kinetics of chemical reactions.
3. To provide an insight into different types of electrolytes and hydrolysis of salt.
4. To give better understanding of oxygen containing functional groups like alcohols and phenols.
5. To make students understand about different reaction pathways of carbonyl compounds.
6. To make students familiar with different quantitaive analysis.

Course Outcome:

After successful completion of the course, the students will be able

CO1: To explain the patterns and trends exhibited by s- and p- block elements.
CO2: To have understanding of rate law and rate of reaction.
CO3: To Explain the ionization of electrolytes with emphasis on weak acid and base and hydrolysis of salt.
CO4: To explain the preparation and properties of oxygen containing functional groups like alcohols and phenols.
CO5: To explain plausible mechanistic pathways of carbonyl compounds.
CO6: To conduct quantitative analysis of a given substance by using different types of volumetric titrations.

Module 1: CHEMISTRY OF s-BLOCK ELEMENTS — **8 hours**

General characteristics: melting point, flame colour, reducing nature, diagonal relationships and anomalous behavior of first member of the group. Reactions of alkali and alkaline earth metals with oxygen, hydrogen, and water. Common features such as ease of formation, thermal stability and solubility of the following alkali and alkaline earth metal compounds: hydrides, oxides, peroxides, superoxides, carbonates, nitrates, sulphates.

Module 2: CHEMISTRY OF p-BLOCK ELEMENTS — **8 hours**

Electronic configuration, atomic and ionic size, metallic/non-metallic character, melting point, ionization enthalpy, electron gain enthalpy, electronegativity, Catenation, Allotropy of C, P, S; inert pair effect, diagonal relationship between B and Si, trends in chemical reactivity of B and anomalous behaviour of first member of the group.

Module 3: CHEMICAL KINETICS — **7 hours**

Order and molecularity of a reaction, rate laws in terms of the advancement of a reaction, differential and integrated form of rate expressions up to second order reactions, experimental methods of the determination of rate laws, Temperature dependence of reaction rates; Arrhenius equation; activation energy. Collision theory of reaction rates, Lindemann mechanism, qualitative treatment of the theory of absolute reaction rates.

Module 4: IONIC EQUILIBRIA — **7 hours**

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect. Salt hydrolysis-calculation of hydrolysis constant, degree of

hydrolysis and pH for different salts. Buffer solutions.

Module 5: ALCOHOLS AND PHENOLS	**7 hours**

Alcohols: preparation, properties and relative reactivity of 1°, 2°, 3° alcohols, Bouveault-Blanc Reduction; Preparation and properties of glycols: Oxidation by periodic acid and lead tetraacetate, Pinacol-Pinacolone rearrangement;
Phenols: Preparation and properties; Acidity and factors effecting it, Ring substitution reactions, Reimer–Tiemann and Kolbe's–Schmidt Reactions, Fries and Claisen rearrangements with mechanism.

Module 6: CARBONYL COMPOUNDS-ALDEHYDES AND KETONES	**8 hours**

Nucleophilic additions, Nucleophilic addition-elimination reactions with ammonia derivatives with mechanism; Mechanisms of Aldol and Benzoin condensation, Knoevenagel condensation, Perkin, Cannizzaro and Wittig reaction, Beckmann and Benzil-Benzilic acid rearrangements, haloform reaction and Baeyer Villiger oxidation, oxidations and reductions (Clemmensen, Wolff-Kishner, $LiAlH_4$, $NaBH_4$).

Total Lecture hours	**45 hours**

Practical BCH23202P

List of Laboratory Experiments

1. Estimation of hardness of water by a standard solution of EDTA.
2. Estimation of Cu (II) ions iodometrically using $Na_2S_2O_3$.
3. Estimation of oxalic acid and sodium oxalate in a given mixture.
4. Estimation of Sodium carbonate and Sodium bicarbonate from their mixture.
5. Estimation of Sodium carbonate and Sodium hydroxide from their mixture.
6. Estimation of Fe(II) with $K_2Cr_2O_7$.
7. Estimation of free chlorine in bleaching powder.

Text Book(s)

1.	Lee, J.D. Concise Inorganic Chemistry ELBS, 1991
2.	Shriver and Atkins Inorganic Chemistry, 5th Edition, Oxford University Press.
3.	Peter Atkins & Julio De Paula, Physical Chemistry 10th Ed., Oxford University Press (2014)
4.	Engel, T. & Reid, P. Physical Chemistry 3rd Ed., Prentice-Hall (2012)
5.	Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
6.	Finar, I. L. Organic Chemistry (Volume 1&2), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
7.	Huheey, J.E., Keiter, E.A., Keiter, R.L. & Medhi, O.K. Inorganic Chemistry.
8.	Principles of Physical Chemistry, Puri, Sharma & Pathania, Vishal Publishing Co.

Reference Books

1.	Graham Solomon, T.W., Fryhle, C.B. & Dnyder, S.A. Organic Chemistry, John Wiley & Sons (2014).
2.	McMurry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.
3.	Sykes, P. A Guidebook to Mechanism in Organic Chemistry, Orient Longman, New Delhi (1988).

4.	Cotton, F.A., Wilkinson, G. & Gaus, P.L. Basic Inorganic Chemistry, 3rd ed., Wiley.
5.	Douglas, B.E., McDaniel, D.H. & Alexander, J.J. Concepts and Models in Inorganic Chemistry, John Wiley & Sons.
6.	Levine, I .N. Physical Chemistry 6th Ed., Tata Mc Graw Hill (2010).
7.	A Text Book of Practical Chemistry By Dr. Sudarshan Barua
8.	Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009.
9.	Marr, G. and Rockett, R.W. Practical Inorganic Chemistry, Van Nostrand Reinhold. 1972.

SEMESTER-III (MINOR)

BCH23203T	**BASIC ANALYTICAL CHEMISTRY**	**L**	**T**	**P**	**C**
		3	**0**	**2**	**4**

Pre-requisite: Knowledge of chemistry at (10+2)level

Course Objectives:

1. To give the concept of accuracy and types of errors in a chemical analysis.
2. To make students aware of different separation techniques and chromatographic methods.
3. To make students aware of different titrimetric analysis used for quantitative determination of a substance.
4. To give students theoretical knowledge to carry out analysis of soil and water sample.
5. To provide hands on experience of different analytical methods.

Course Outcome:

After successful completion of the course, the students will be able

CO1: To learn the concept of accuracy and types of errors in a chemical analysis.

CO2: To know about different separation techniques and chromatographic methods.

CO3: To apply titrimetric methods in quantitative analysis of a substance.

CO4: To gain theoretical knowledge to carry out analysis of soil and water samples.

CO5: To analyze different samples by paper chromatography, titrimetric methods and gravimetric methods.

Module 1: ERRORS IN CHEMICAL ANALYSIS	**7 hours**

Definition of Significant figures, accuracy and precision, mean, median, variance, deviation, relative mean deviation, standard deviation. Error-Determinate and indeterminate error, absolute errors, relative errors.

Module 2: SEPARATION AND PURIFICATION TECHNIQUES	**14 hours**

Introduction, instrumental separation, filtration, solvent extraction, crystallisation and precipitation, Basic principles of Thin Layer Chromatography, Paper Chromatography, Column Chromatography, Gas Chromatography, Ion exchange Chromatography.

Module 3: TITRIMETRIC METHODS OF ANALYSIS	**10 hours**

Introduction, standard solution- primary and secondary standard types of titrations – acid base titrations, theories of acid base indicators, redox titrations, iodometric titrations, precipitation titrations.

Module 4: ANALYSIS OF SOIL	**7 hours**

Composition of soil, Concept of pH and pH measurement, Complexometric titrations, Chelation, Chelating agents, use of indicators, Determination of pH of soil samples, Estimation of Calcium and Magnesium ions by complexometric titration.

Module 5: ANALYSIS OF WATER	**7 hours**

Definition of pure water, sources responsible for contaminating water, water sampling methods, water purification methods, Determination of pH, acidity and alkalinity of a water sample, Determination of dissolved oxygen (DO) of a water sample.

Total Lecture hours	**45 hours**

Practical BCH23203P

List of Laboratory Experiments:

1. Separation of amino acids from their mixture by paper chromatography.
2. Separation of sugars from their mixture by paper chromatography.
3. Separation of Group IIIB cations from their mixture by paper chromatography.
4. Determination of the water of crystallization in hydrated salt by gravimetric method.
5. To determine the water crystallization in Mohr's salt (ferrous ammonium sulphate), by titration with potassium permanganate ($KMnO_4$).
6. Determine the total dissolved solids in water by gravimetric method.
7. Determination of Vitamin C Content in Fruit Juice by Redox Titration.

Textbook(s)	
1.	Vogel's Textbook of Quantitative Chemical Analysis, G. H. Jeffery, J. Bassett, J. Mendham, R. C. Denney, John Wiley and Sons (1989)
2.	Fundamentals of Analytical Chemistry, S. P. J. Higson, Brooks/Cole (2003)
Reference Books	
1.	Analytical Chemistry, G. D. Christian, 6th Edition, John Wiley & Sons, New York (2004).
2.	Principles and Practice of Analytical Chemistry, Wiley (2000).
3.	Quantitative Analysis, R. A. Day, A. L. Underwood, Prentice Hall of India (1991).
4.	Mikes, O. and Chalmers, R. A. Ed. Laboratory Hand book of Chromatographic and Allied Methods, Elles Horwood Ltd. London.

SEMESTER -I(MDC)

BCH23140T	**CHEMISTRY IN EVERYDAY LIFE**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Pre-requisite: Knowledge of Basic Science

Course Objectives:

1. To make students aware of different air pollutants and their effects on the environment.
2. To provide scientific knowledge of daily used cosmetics and perfumes.
3. To make students identify different food additives, adulterants and contaminants.
4. To provide an insight into different polymeric compounds.
5. To give knowledge about composition and applications of soap, detergents, dyes and fertilizers.

Course Outcome:

After successful completion of the course, the students will be able

CO1: To learn about the sources and effects of different types of air pollutants.
CO2: To gain knowledge of science behind different cosmetics and perfumes.
CO3: To identify different food additives, adulterants and contaminants.
CO4: To know different types of polymers and their applications.
CO5: To understand the composition and uses of soap, detergents, dyes and fertilizers.

Module 1: AIR POLLUTION — **7 hours**

Air pollutants, sources and sinks of carbon monoxide pollution, sources and sinks of nitrogen. oxide pollution, photochemical smog, acid rain, ozone hole, CFCs, particulates – sources of particulates, inorganic particulate matter, organic particulate matter, fly ash, Bhopal disaster.

Module 2: COSMETICS & PERFUMES — **7 hours**

General study of the following: Hair dye, hair spray, shampoo, suntan lotions, face powder, lipsticks, talcum powder, nail enamel, creams (cold, vanishing and shaving creams), antiperspirants and artificial flavours. Essential oils and their importance in cosmetic industries.

Module 3: FODD ADDITIVES, ADULTERANTS AND CONTAMINANTS — **9 hours**

Food preservatives – benzoates, propionates, sorbates, disulphites. Artificial sweeteners: Aspartame, saccharin, dulcin, sucralose and sodium cyclamate. Flavours: Vanillin, alkyl esters (fruit flavours) and monosodium glutamate.
Introduction to adulteration, adulterants in some common food items like coffee powder, chilli powder, turmeric powder, coriander powder and pulses.
Artificial food colorants - Coal tar dyes and non-permitted colours and metallic salts.

Module 4: POLYMERS — **7 hours**

Classification of polymers, types of polymerization – addition and condensation polymerization, Some important polymers and their applications, polymers in medicines and surgery, Biodegradable polymers and their applications.

Module 5: SOAPS AND DETERGENTS — **5 hours**

Types of soaps, synthetic detergents, cleansing action of detergents, advantages and disadvantages of detergents over soaps.

Module 6: DYE	**5 hours**
Historical background, Classification, dyes and colours for Textiles, Synthetic dyes, General Study of Azo dyes, Mordant brown, Congo red and methyl orange.	
Module 7: FERTILIZERS	**5 hours**
Composition of fertilizers, uses of Urea, ammonium nitrate, calcium ammonium nitrate, ammonium phosphate, superphosphate of lime.	
Total Lecture hours	**45 hours**

Text Book(s)	
1.	Organic Chemistry by I. L. Finar, Vol. 1 & 2.
2.	Polymer Science and Technology, J. R. Fired (Prentice Hall)
Reference Books	
1.	Analysis of foods, H. E. Cox
2.	Introduction to Industrial Chemistry, B. K. Sharma, Goel Publishing (1998)
3.	Foods: Facts and Principles, N. S. Many, S. Swamy, New Age International (1998)
4.	Environmental Chemistry, A. K. De, New Age International
5.	Handbook of Fertilizer Technology by Swaminathan and Goswamy, 6th Edition, 2001, FAI

Semester - II (MDC)

BCH23141T	MOLECULES OF LIFE	L	T	P	C
		3	0	0	3

Pre-requisite: Knowledge of basic science

Course Objectives:

1. To provide knowledge about biomolecule which is a source of energy for life.
2. To make students aware of amino acids and proteins.
3. To make students realize the importance of enzymes.
4. To provide an introduction on selected components of hormones and vitamins.
5. To make students understand the role of metal ions in biological system.

Course Outcome:

After successful completion of the course, the students will be able

CO1: To understand the biological importance of carbohydrates.
CO 2: To know about amino acids and proteins.
CO 3: To explain the importance of enzymes.
CO 4: To explain the biological role of vitamins and hormones.
CO 5: To understand the value of metal ions.

Module 1: CARBOHYDRATES — **9 hours**

Carbohydrates and classification, Sugars, non-sugars, reducing and non-reducing sugars. Occurrence and general properties of glucose and fructose, Open chain and Haworth ring structures of glucose and fructose, Polysaccharides: Starch, cellulose – monomer units, glycosidic linkage, biological importance of carbohydrates.

Module 2: AMINO ACIDS, PEPTIDES AND PROTEINS — **11 hours**

Amino acids, Classification of amino acids as essential and non-essential- examples. Configuration of optically active α-amino acids (found in proteins), α- amino acids, general formula, zwitter ion form of α- amino acid, general formula, Isoelectric point, proteins, classification of proteins, denaturation of proteins.

Module 3: ENZYMES — **5 hours**

Definition, classification of enzymes, characteristics of enzymes, examples of some common enzymes, co-enzymes, applications of enzymes, enzyme deficiency diseases and their cure.

Module 4: NUCLEIC ACIDS — **7 hours**

Components of nucleic acids: Adenine, guanine, thymine and cytosine (Structure only), other components of nucleic acids, Nucleosides and nucleotides, polynucleotides, Structure of DNA (Watson-Crick model) and RNA (types of RNA).

Module 5: HORMONES AND VITAMINS — **7 hours**

Hormones, classification of hormones with examples, deficiency diseases of hormones. Vitamins, classification of vitamins with examples, importance of Vitamin B1, Vitamin B2, Vitamin B6, Vitamin B12, Niacin, Vitamin H, Folic Acid (Vitamin M), Vitamin C, Vitamin A, Vitamin D, Vitamin E, Vitamin K.

Module 6: ROLE OF METAL IONS — **6 hours**

Introduction to the Role of metal ions in biological systems-Fe^{+2}, Copper and Zinc, Cobalt, Manganese, selenium, chromium. Brief introduction about toxicity of metal ions ($Hg^{2+}$and

Cd^{2+}).	
Total Lecture hours	**45 hours**
Text Book(s)	
1.	Chittaranjan Bhakta, Organic Chemistry vol 2: Chemistry of Polymers and Biomolecules.
2.	Morrison, R. T. & Boyd, R. N. Organic Chemistry, sixth edition, (Pearson Education).
3.	Finar, I. L. Organic Chemistry (Volume 1), (Pearson Education).
Reference Books	
1.	Nelson, D. L. & Cox, M. M. Lehninger's Principles of Biochemistry 7th Ed.
2.	Finar, I. L. Organic Chemistry (Volume 2), (Pearson Education).

SEMESTER-III (MDC)

BCH23240T	**FUEL SCIENCE**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Pre-requisite: Knowledge of Basic Science

Course Objectives:

1. To provide basic idea of a fuel and calorific value.
2. To make the students aware of solid fuel, emphasis on coal and coke.
3. To provide an insight into liquid fuel and some important properties.
4. To make students understand gaseous fuel and their analysis.
5. To make the students aware of production and applications of biofuel.

Course Outcome:

After successful completion of the course, the students will be able

CO1: To understand fuel and its relation with caloric value.

CO2: To explain important constituents of solid fuel and their impact on its calorific value.

CO3: To know about liquid fuel, cracking, refining, reforming, and their properties.

CO4: To know about different types of gaseous fuel.

CO5: To know the importance of biofuel and its applications.

Module 1: INTRODUCTION TO FUEL	**9 hours**

Definition, classification based on physical state, classification based on occurrence, comparison of solid, liquid and gaseous fuel, characteristics of a good fuel, calorific value – gross and net calorific values, determination of calorific value, combustion.

Module 2: COAL	**10 hours**

Types of coal, uses of coal, Pulverized coal, Proximate and ultimate analysis of coal, coke, coke as metallurgical fuel, caking and coking coals, action of heat on different coal samples, different types of coal combustion techniques, coal tar distillation, coal liquefaction, direct liquefaction, indirect liquefaction, coal gasification.

Module 3: PETROLEUM AND LUBRICANTS	**17 hours**

Origin of petroleum, classification of petroleum, mining of petroleum, Exploration, of crude petroleum, composition of crude petroleum, Refining anddifferent types of petroleum products, cracking – Thermal cracking and catalytic cracking, synthetic petrol, reforming, knocking. Classification of lubricants – lubricating oils, semi solid lubricants or greases, solid lubricants, properties of lubricants – viscosity, flash and fire points, functions of lubricants, synthetic lubricants.

Module 4: GASES	**3 hours**

Natural gas and LPG, Producer gas, Water gas, Coal gas, Oil gas

Module 5: BIOFUEL	**6 hours**

Introduction and perspective of biofuels, environmental impact of biofuel, production and applications of biomass, biodiesel, biogas, bioethanol.

Total Lecture hours	**45 hours**

Textbook(s)

1	E. Stocchi: Industrial Chemistry, Vol -I, Ellis Horwood Ltd. UK.
2	Industrial Chemistry-B. K. Sharma.

Reference Books	
1.	Fuel Chemistry by Dr. Biswajit Saikia
2.	Fuel Chemistry by Debasis Mohanty

Detailed Syllabus:

SEMESTER-IV (CORE)

BCH23204T	ORGANIC CHEMISTRY – I	L	T	P	C
		3	0	2	4

Pre-requisite: Knowledge of chemistry at (10+2) level

Course Objectives:

1. To provide knowledge about the structure and reactivity of carbonyl compounds.
2. To impart understanding of different conformations.
3. To make students familiar with different arrays of compounds containing nitrogen, their preparation and reactions.
4. To provide theoretical knowledge and hands on experience with different laboratory techniques.

Course Outcome:

After successful completion of the course, the students will be able

CO1: To Recall carbonyl compounds, cycloalkanes and nitrogen containing functional groups.
CO2: To explain the differences between carbonyl compounds, cycloalkanes and nitrogen containing functional groups.
CO3: To identify the synthetic pathways of different types of compounds and conformations of cycloalkanes.
CO4: To inspect different types of organic compounds.

Module 1:Carbonyl Compounds — **14 hours**

Nucleophilic additions, Nucleophilic addition-elimination reactions with ammonia derivatives with mechanism; Mechanisms of Aldol and Benzoin condensation, Knoevenagel condensation, Claisen-Schmidt, Perkin, Cannizzaro and Wittig reaction, Beckmann and Benzil-Benzilic acid rearrangements, haloform reaction and Baeyer Villiger oxidation, α-substitution reactions, oxidations, and reductions (Clemmensen, Wolff-Kishner, $LiAlH_4$, $NaBH_4$, PDC and PCC).
Addition reactions of unsaturated carbonyl compounds: Michael addition.

Active methylene compounds: Keto-enol tautomerism. Preparation and synthetic applications of diethyl malonate and ethyl acetoacetate.

Module 2: Cycloalkanes and Conformational Analysis — **10 hours**

Types of cycloalkanes and their relative stability, Baeyer strain theory, Conformation analysis of alkanes: Relative stability: Energy diagrams of cyclohexane: Chair, Boat and Twist boat forms: Relative stability with energy diagrams.

Module 3:Nitrogen Containing Functional Groups — **21 hours**

Preparation and important reactions:
Nitro compounds- classification and general methods of preparation: from alkyl halides, alkanes, oxidation of amines and oximes and diazonium salts.
Nitriles- Preparation from the following reactions: Dehydration of amides and aldoximes, from Grignard reagents and from dehydrogenation of primary amines, Reaction with Grignard reagent, hydrolysis, addition reaction with HX, NH_3, reaction with aqueous ROH, Reduction reactions-catalytic reduction and Stephen's reaction, Condensation reactions-Thorpe Nitrile Condensation.

and sulphur, Grignard reaction, oxidation and rearrangement.
Amines: Effect of substituent and solvent on basicity: Preparation and properties: Gabriel phthalimide synthesis, Carbylamine reaction, Mannich Reaction, Hoffmann's exhaustive methylation, Hofmann-elimination reaction: Distinction between 1°, 2°, and 3°, amines with Hinsberg reagent and nitrous acid.
Diazonium Salts: Preparation and their synthetic applications.

Total Lecture hours	**45 hours**

LABORATORY EXPEIMENTS BCH23204P

List of Laboratory Experiments:

1. Purification of organic compounds by crystallization using the following solvents:
a. Water
b. Alcohol
c. Alcohol-Water
2. Chromatography
a. Separation of a mixture of two amino acids by ascending and horizontal paper chromatography.
b. Separation of a mixture of two sugars by ascending paper chromatography.
3. Acetylation of one of the following compounds: amines (aniline, o-, m-, p- toluidines and o-, m-, p-anisidine) and phenols (β-naphthol, vanillin, salicylic acid).
4. Iodoform reaction of Acetone
5. Selective reduction of meta dinitrobenzene to m-nitroaniline.
6. Benzil-Benzilic acid rearrangement.
7. Preparation of Methyl Orange from Sulphanilic acid.

Text Book(s)

1.	Clayden, J., Greeves, N. & Warren, S. Organic Chemistry,Second edition, Oxford University Press, 2012.
2.	Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3.	Finar, I. L. Organic Chemistry (Volume 1&2), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
4.	Nasipuri, D. Stereochemistry of Organic Compounds, Wiley Eastern Limited.
5.	Kalsi, P. S. Stereochemistry Conformation and Mechanism, New Age International, 2005.
6.	Vogel, A. I. Elementary Practical Organic Chemistry, Part 2: Qualitative Organic Analysis, CBS Publishers and Distributors.

Reference Books

1.	Graham Solomon, T.W., Fryhle, C.B. &Dnyder, S.A. Organic Chemistry, John Wiley & Sons (2014).
2.	McMurry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013
3.	Sykes, P. A Guidebook to Mechanism in Organic Chemistry, Orient Longman, New Delhi (1988).
4.	Carey, F. A.; Sundberg, R. J. Advanced Organic Chemistry: Reactions and Synthesis (Part B), Springers.
5.	Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009).
6.	A Text Book of Practical Chemistry By Dr. Sudarshan Barua
7.	Dutta, S, B. Sc. Honours Practical Chemistry, Bharati Book Stall.

BCH23205T	PHYSICAL CHEMISTRY – I	L	T	P	C
		3	0	2	4

Pre-requisite: Knowledge of chemistry at (10+2) level

Course Objectives:

1. To provide knowledge of chemical equilibrium.
2. To provide a fundamental insight into the macromolecules.
3. To make students understand the electrochemistry laws, equations, and cells.
4. To provide knowledge about colloidal states and applications.
5. To make students understand the phase rule and its applications.
6. To provide students concepts and skills of physical chemistry experiments.

Course Outcome:

After successful completion of the course, the students will be able to

CO1: Understand the concepts chemical equilibrium, electrochemistry and apply it to solve related mathematical problems and to predict feasibility of reactions.

CO2: Acquire the fundamental knowledge of macromolecules, polymerization reactions, molecular weight and apply the knowledge to evaluate the molecular weight of polymers.

CO3: Understand and apply the concept of the colloidal state and its application in different fields.

CO4: Acquire the fundamental knowledge of Phase rule and apply it.

CO5: Acquire the practical concepts, develop the competencies and skills of physical chemistry experiments, apply it in different fields, analyze and evaluate them.

Module 1:CHEMICAL EQUILIBRIUM — **10 hours**

Reversible reactions, Chemical equilibrium and its Characteristics, Law of mass action, Law of chemical equilibrium, Vant Hoff's reaction isotherm, chemical equilibrium of Homogeneous and Heterogeneous systems, Derivation of expression of equilibrium constants- temperature- pressure and concentration dependence of equilibrium constants (K_P, K_C, K_X)- Le Chatelier's principle of dynamic equilibrium. Temperature dependence of equilibrium constants, Vant Hoff's equation, Hydrogen-Iodine equilibrium, dissociation of PCl_5, dissociation of $CaCO_3$, Mathematical problems and solutions.

Module 2: ELECTROCHEMISTRY — **10 hours**

Molar conductance and Kohlraursh's law of ionic conductance-Application of Kohlraursh's law-Debye–Huchel theory of strong electrolyte- Activity co-efficient- mean activity co-efficient- Ionic strength- Salt effect–primary and secondary salt effect.

Galvanic cell and electrochemical series- Nernst equation- Concentration cell- liquid junction potential- reference electrode-standard Hydrogen electrode- calomel electrode- glass electrode-quinhydrone electrode and measurement of pH- Different types of electrochemical cells- Fuel cell-Potentiometric titrations- concept of polarography and Half wave potential.

Module 3: MACROMOLECULES — **10 hours**

Macromolecules, Historical background, Classification of polymers, Tacticity, Isotactic, Atactic and Syndiotactic polymers, Homopolymers and Copolymers, Random, Alternating, Block and Graft polymers; Rubbers, Plastics and Fibres; Linear, branched and cross-linked polymers; Molecular weight of polymer, Number average and Weight average molecular weight, Viscosity average

Viscometry, Osmometry,
Commodity and Engineering plastics, Synthesis and uses of some important Commodity and Engineering plastics, Thermosetting and Thermoplastics- Synthesis of Bakelite- Biodegradable Polymer.

Module 4: COLLOIDAL STATE	**10 hours**

Difference between true solution, colloidal solution and suspension, Phases of colloidal solutions, Classification of colloids, Lyphilic and Lyphobic colloids, Micelles, Preparation of colloids, Dialysis, Properties of colloidal solutions, Tyndall effect, Sedimentation, Electrophoresis, Origin of charge, Doble layer theory, protective colloids, Gold number, Emulsions, Determination of size of colloidal particles, Application of Colloids in different fields.

Module 5: Phase Rule	**5 hours**

Phase, Component and Degree of Freedom, The Phase rule and its applications, Derivation of Phase rule, Phase diagram, Overview of Application of phase rule to one and two component systems.

Total Lecture hours	**45 hours**

BCH23205P List of Laboratory Experiments

1. Laboratory safety and precautions.
2. Calibration and use of apparatus and instruments.
3. Determination of surface tension of a given liquid by using a Stalagmometer.
4. Determination of viscosity of a liquid by using Ostwald viscometer.
5. Determination of rate constant and energy of activation of given ester catalyzed by acid. (first order / second order)
6. Study of a redox reaction: Standardization of potassium permanganate solution by standard oxalic acid solution
7. Standardization of sodium thiosulphate solution by standard potassium dichromate solution by Iodometric method.
8. Determination of Strength of HCl solution by titrating it against NaOH solution conductometrically.
9. Determination of the strength of an unknown acetic acid solution by conductometric titration against a strong base.
10. To determine the strength of mixture of strong acid and weak acid by conductometric method.
11. Spectrophotometric determination of concentration of $KMnO_4$ solution

Text Book(s)

1. B.R. Puri, L.R Sharma, M.S. Pathania, “Principles of Physical Chemistry” Vishal Publishing Co. India
2. P.W. Atkins, “Physical Chemistry”, 8th Edition, Oxford University Press, New York.
3. F.W. Billmeyer, Jr.”Text Book of Polymer Science” 3rd Edition, 1984, Willey – Interscience, New York.

Reference Books

1. J. O’M. Bockris& A.K.N. Reddy,” Modern Electrochemistry”, Vol. 2 A & B, 2nd Edition, Plenum Press, New York, 1998.
2. N.Karak., “Fundamentals of Polymers”, PHI Learning Private Limited, 2009.
6. Levine, I .N. “Physical Chemistry”, 6th Ed., Tata Mc Graw Hill (2010).
8. A Text Book of Practical Chemistry By Dr. Sudarshan Barua

BCH23206T	INORGANIC CHEMISTRY – II	L	T	P	C
		3	0	2	4

Pre-requisite: Knowledge of chemistry at H.S. level

Course Objectives:

The course is being offered with the following objectives:

1. To make students familiar with molecular symmetry.
2. To provide basic concepts of coordination compounds.
3. To discuss the basics and applications of acids and bases.
4. To provide knowledge of oxidation and reduction.
5. To provide knowledge of qualitative inorganic salt analysis.

Course Outcome:

After successful completion of the course, the students will be able

CO1: To define molecular symmetry, coordination compounds, acids, bases, oxidation and reduction.

CO2: To explain the basics of molecular symmetry, coordination compounds, acids-bases and oxidation and reduction.

CO3: To identify symmetry elements, symmetry operations and acid-base strength.

CO4: To apply the acquired knowledge for solving problems of coordination compounds and oxidation -reduction.

CO5: To analyse inorganic salts qualitatively.

Module 1:INTRODUCTION TO MOLECULAR SYMMETRY — **8 hours**

Symmetry elements and operations, molecular point groups, symmetry elements present in C_{2v}, C_{3v}, T_d and O_h point group (pictorial representation), introductory idea of character tables, Mulliken symbols.

Module 2:COORDINATION CHEMISTRY-I — **12 hours**

Introduction to coordination complexes (Werner theory, types of ligands) IUPAC nomenclature, isomerism in coordination complexes, stereochemistry of complexes with coordination numbers 4, 5, and 6.

Module 3: CONCEPTS OF ACIDS AND BASES — **12hours**

Acid-base concepts, measure of acid and base strength, proton affinity, acidity and basicity of binary hydrogen compounds, inductive effect and strength of oxyacids, acidity of aqua ions, steric effect, proton sponge, solvation and acid base strength, non-aqueous solvents and acid base strength, superacids and superbases. Applications of hard and soft acid base (HSAB) principle, and symbiosis.

Module 4: OXIDATION AND REDUCTION — **13 hours**

Reduction potentials: Redox half-reactions, standard potentials and spontaneity, trends in standard potentials, the electrochemical series, Nernst equation (Influence of pH and concentration on electrode potential). Principles of redox titration and choice of redox indicators.

Total Lecture hours — **45 hours**

BCH23206P **LABORATORY EXPERIMENTS**

Inorganic qualitative analysis:

Qualitative analysis of mixtures containing four cations and anions. Emphasis should be given to the understanding of reactions. The following radicals are suggested: CO_3^{2-}, NO_2^-, S^{2-}, SO_3^{2-}, $S_2O_3^{2-}$, CH_3COO^-, F^-, Cl^-, Br^-, I^-, NO_3^-, BO_3^{3-}, $C_2O_4^{2-}$, PO_4^{3-}, NH_4^+, K^+, Pb^{2+}, Cu^{2+}, Cd^{2+}, Bi^{3+}

Mixtures should preferably contain one interfering anion, or insoluble component ($BaSO_4$, $SrSO_4$, $PbSO_4$, CaF_2 or Al_2O_3) or combination of anions such as CO_3^{2-} and SO_3^{2-}, NO_2^- and NO_3^-, Cl^- and Br^-, Cl^- and I^-, Br^- and I^-, NO_3^- and Br^-, NO_3^- and I^-.
Spot tests should be done whenever possible.

Text Book(s)

1.	General and Inorganic Chemistry, R.P. Sarkar (part 1), 3rd edition, NCBA.
2.	Concise Coordination Chemistry, R. Gopalan, V. Ramalingam, 1st edition, Vikash PublishingHouse.
3.	Inorganic Chemistry (Principles of Structure and Reactivity), J. E. Huheey, E. A. Keiter, R. L. Keiter, O. K. Medhi, 5thedition, Pearson Education.
4.	Principles of Inorganic Chemistry, 7th edition, Puri, Sharma, Kalia, Vishal Publishing Co.
5.	**Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009.**
6.	**A Textbook of Practical Chemistry By Dr. Sudarshan Barua**

Reference Books

1.	Inorganic Chemistry, G.L. Meissler and D. A. Tarr, 5th edition, Pearson.
2.	Inorganic Chemistry, P. Atkins, Overtone Rourke, Weller and Armstrong 5th edition, Oxford.
3.	Inorganic Chemistry (Principles of Structure and Reactivity), J. E. Huheey, E. A. Keiter, R. L. Keiter, O. K. Medhi, 5th edition, Pearson Education.
4	Advanced Inorganic Chemistry, F. Albert Cotton, Geoffrey Wilkinson, Carlos A. Murillo, Manfred Bochmann, Wiley.

Elective-I

BCH23220T	ANALYTICAL CHEMISTRY	L	T	P	C
		3	0	2	4

Pre-requisite: Knowledge of chemistry at (10+2) level

Course Objectives:

1. To provide knowledge of different quantitative analysis.
2. To make students aware of the treatment of analytical data.
3. To give an insight into different separation techniques in chemical analysis.
4. To give students knowledge of different chromatographic techniques.

Course Outcome:

After successful completion of the course, the students will be able

CO1: To explain principles of quantitative and separation techniques in different chemical analysis.

CO2: To analyze various redox, complexometric, iodometric and precipitation reactions through titrations and chromatography along with treatment of data by different methods.

CO3: To estimate a compound using volumetric and gravimetric analysis.

CO4: To apply the methods of solvent extraction, ion exchange and chromatography in various processes.

Module 1:QUANTITATIVE ANALYSIS — **10 hours**

a) Importance in various fields of science, steps involved in chemical analysis. Principles of volumetric analysis: Theories of acid-base, redox, complexometric, iodometric and precipitation titrations - choice of indicators for these titrations.

b) Principles of gravimetric analysis: precipitation, coagulation, peptization, coprecipitation, post precipitation, digestion, filtration and washing of precipitate, drying and ignition

Module 2: TREATMENT OF ANALYTICAL DATA — **7 hours**

Types of errors, significant figures and its importance, accuracy - methods of expressing accuracy, error analysis and minimization of errors, precision - methods of expressing precision, standard deviation and confidence limit.

Module 3: SEPARATION TECHNIQUES IN CHEMICAL ANALYSIS — **8 hours**

SOLVENT EXTRACTION: Introduction, principle, techniques, factors affecting solvent extraction, Batch extraction, continuous extraction and counter current extraction. Synergism., Application - Determination of Iron (III)

ION EXCHANGE: Introduction, action of ion exchange resins, separation of inorganic mixtures, applications, Solvent extraction: Principle and process

Module 4:PURIFICATION TECHNIQUE 1 — **10 hours**

Chromatography: Classification of chromatography methods, principles of differential migration adsorption phenomenon, Nature of adsorbents, solvent systems, Rf values, factors affecting Rf values.

Paper Chromatography: Principles, Rf values, experimental procedures, choice of paper and solvent systems, developments of chromatogram - ascending, descending and radial. Two-dimensional chromatography, applications.

Module 5:PURIFICATION TECHNIQUE 2 — **10 hours**

Thin layer Chromatography (TLC): Advantages. Principles, factors affecting Rf values. Experimental procedures. Adsorbents and solvents. Preparation of plates. Development of the chromatogram. Detection of the spots. Applications.

HPLC: Basic principles and applications.

Total Lecture hours	**45 hours**

BCH23220P **LABOATORY EXPERIMENTS**

List of Laboratory Experiments:

1. Determination of Rf value of amino acids using paper chromatography.
2.Separation and identification of monosaccharides present in a given mixture by paper chromatography.
3.Determination of equivalent conductance of a weak electrolyte (acetic acid) at different concentrations.

4. Analysis of soil
i) Determination of pH of soil.
ii) Determination of total soluble salts.
iii) Determination of carbonate and bicarbonate.
iv) Determination of calcium, magnesium and iron.

5. Determination of adulterant in some common food items
i) Chicory in coffee powder
ii) Foreign resin in asafetida
iii) Chilli powder
iv) Turmeric powder
v) Pulses

Text Book(s)

1.	Skoog, D.A.; West, D.M. & Holler, F.J. Analytical Chemistry: An Introduction 6th Ed., Saunders College Publishing, Fort Worth, Philadelphia (1994).
2.	Dean, J. A. Analytical Chemistry Handbook, McGraw Hill, 2004.
3.	Christian, G.D. Analytical Chemistry, 6th Ed. John Wiley & Sons, New York, 2004.

Reference Books

1.	Willard, H.H., Merritt, L.L., Dean, J. &Settoe, F.A. Instrumental Methods of Analysis, 7th Ed. Wadsworth Publishing Company Ltd., Belmont, California, USA, 1988.
2.	Skoog, D.A., Holler, F.J. & Crouch, S. Principles of Instrumental Analysis, Cengage Learning India Edition, 2007.
3.	Harris, D. C. Quantitative Chemical Analysis, 9th ed. Macmillan Education, 2016
4.	Day, R. A. & Underwood, A. L. Quantitative Analysis, Prentice Hall of India, 1992.
5.	Freifelder, D.M. Physical Biochemistry 2nd Ed., W.H. Freeman & Co., N.Y. USA (1982).
6.	Vogel, A. I. Vogel's Qualitative Inorganic Analysis 7th Ed., Prentice Hall, 1996.
7.	Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009.

Elective -I

BCH23221T	**POLYMER CHEMISTRY**	**L**	**T**	**P**	**C**
		3	**0**	**2**	**4**

Pre-requisite: Knowledge of chemistry at (10+2) level

Course Objectives:

1. To provide knowledge of polymers, their unique properties, scope and challenges.
2. To provide an insight into the raw materials and methods in polymer synthesis.
3. To make students understand about structure, property and testing of polymers.
4. To provide knowledge about thermoplastic polymers.
5. To provide knowledge about natural rubber latex and resins.

Course Outcome:

After successful completion of the course, the students will be able to

CO1: Understand the concepts of polymers, their unique properties, raw materials, fundamentals of synthesis of polymers and structure property relationships.

CO2: Apply the knowledge of synthesis and properties of polymers to predict structure-based property, testing and analyzing of polymers and investigate their properties to obtain desired applications.

CO3: Acquire the knowledge of thermoplastics, natural rubber latex and synthetic resins.

CO4: Acquire the laboratory skills of synthesis of polymers, analyzing, testing and applying the skills to utilize in solving real world problems related to polymers.

Module 1:INTRODUCTION TO POLYMERS — **10 hours**

Introduction to polymers, historical background, Uniqueness of polymers, Difference of polymers over other categories of materials, Difference between polymers and fine chemicals, Nomenclature, Classification depending on source, mode of formation, chemical linkage, structure, thermal response, type of repeating units and physical properties. Scopes and challenges of polymers.

Module 2: Materials and Methods in Polymer Synthesis — **10 hours**

Raw materials, monomers and starting materials, Initiators, Catalyst, Inhibitor, Retarder, Chain transfer agents, Polymer forming processes-Chain polymerization and Step growth polymerization, Techniques of polymerization- Mass or bulk technique, Solution technique, Suspension technique, Emulsion polymerization technique and other special techniques.

Additives for polymers-types of additives, Process aid, Antidegradant, Fillers, coupling agent, Curing agent, Flame retardant, Blowing agent, Thixotopic agent, etc.

Module 3: Structure, Property and Testing of Polymers — **10 hours**

Molecular weight of polymer, Number average and Weight average molecular weight, Viscosity average molecular weight, Poly disparsity index (PDI), Determination of molecular mass of polymers. Glass transition temperature and factors affecting glass transition temperature. Thermosetting and Thermoplastics.

Testing of Polymers- MFI, LOI, Processibility testing, rheological behavior testing by viscometer and rheometer, Physical testing, Durability testing, Mechanical testing, Flammability testing, Adhesion, Electrical testing.

Module 4: Thermoplastic Polymers — **10 hours**

Commodity, Engineering and Specialty plastics, Synthesis, properties, and applications of the following polymers-

Condensation Plastics- PET and Polyamides
Rearrangement Polymers- Polyurethane
Natural and Modified Plastics- Cellulose, Cellulose nitrate, Cellulose acetate, Carboxy methyl cellulose, regenerated cellulose, Chitin and Chitosan, Carrageenans.

Module 5: Elastomers and Resins	**5 hours**
Characteristic properties of elastomers or rubbers, Natural Rubber (NR), Isolation and collection of Latex, Processing of latex, The composition and functions of NR latex, Grades of NR, Structure and Property, Application. Overview of synthetic rubbers. Synthesis, properties and applications of Phenolic and Amino resins. Concept of thermosetting resins, biodegradable polymers, andGreen chemistry.	
Total Lecture hours	**45 hours**

BCH23221P Polymer Chemistry Laboratory

List of Laboratory Experiments:

1. Preparation of Phenol – Formaldehyde resin.
2. Preparation of Urea – Formaldehyde resin.
3. Synthesis of Melamine- Formaldehyde
4. Determination of viscosity of a polymer solution by using Brookfield viscometer.
5. Measurement of MFI.
6. Determination of LOI.
7. Determination of hardness by using hardness tester.
5. Synthesis of Polystyrene by suspension polymerization method.
7. Synthesis of PMMA by emulsion polymerization method.
8. Plastic processing and moulding experiments.
9. Determination of Adhesive strength.
10. Study of Rheological behavior of polymers by viscometer and rheometer.

Text Book(s)

1.	P. Ghosh, Polymer Science and Technology: Plastics, Rubbers, Blends and Composites, Third Edition, McGraw Hill Education Private Limited (India), 2011
2.	N.Karak., “Fundamentals of Polymers”, PHI Learning Private Limited, 2009.
3.	F.W. Billmeyer, Jr.”Text Book of Polymer Science” 3rd Edition, 1984, Willey – Interscience, New York.

Reference Books

1.	J. A. Brydson, Plastics Materials, 4th edn., Butterworths, London, 1982
2.	Odian, G. Principles of Polymerization (Wiley, 2004).

BCH23301T	**Organic Chemistry-II**	**L**	**T**	**P**	**C**
		3	**0**	**2**	**4**

Pre-requisite: Knowledge of Basic Science

Course Objectives:

1. To provide knowledge about carbohydrates.
2. To impart understanding of amino acids, proteins and Lipids.
3. To make students familiar with enzymes and their actions

Course Outcome:

After successful completion of the course, the students will be able

CO1: To understand the structure and reactivity of biological molecules.
CO2: To apply the acquired knowledge to find solutions.
CO3: To Analyze the properties and functions of biological molecules.
CO4: To Evaluate multiple dimensions of biological molecules and effectively defend scientific perspectives with the help of experimental techniques.

Module 1: Carbohydrates — **14hours**

Monosaccharides: Constitution and absolute configuration of glucose and fructose, epimers and anomers, mutarotation, determination of ring size of glucose and fructose, Haworth projection and conformational structures; Interconversion of aldoses and ketoses; Killiani-Fischer synthesis and Ruff degradation; Linkage between monosaccharides: Comparative study of the structure of disaccharides (sucrose, maltose, lactose) and polysaccharides (starch, cellulose and glycogen) excluding their structure elucidation.

Module 2: Amino Acids, Peptides and Proteins — **12 hours**

Amino acids and their classification; α-amino acids - Synthesis, ionic properties, and reactions. zwitterions, pKa values, isoelectric point, and electrophoresis; Study of peptides: determination of their primary structure-end group analysis; Synthesis of peptides using N-protecting, C-protecting and C-activating groups, Solid-phase synthesis; Overview of primary, secondary and tertiary structures of protein and protein denaturation.

Module 3: Enzymes — **7hours**

Introduction, classification, and characteristics of enzymes. Salient features of active site of enzymes. Mechanism of enzyme action, factors affecting enzyme action, coenzymes, and cofactors (including ATP, NAD, FAD), specificity of enzyme action (including stereospecificity). Enzyme inhibitors and their importance, phenomenon of inhibition (competitive, uncompetitive, and non-competitive inhibition including allosteric inhibition).

Module 4: Lipids and Nucleic acids. — **8hours**

Components of Nucleic acids, structure of DNA (Watson-Crick model) and RNA (types of RNA), difference between DNA and RNA, genetic code, biological roles of DNA and RNA: replication, transcription and translation.
Lipids: Introduction to lipids, classification. Oils and fats: Common fatty acids present in oils and fats, Omega-3&6 fatty acids, trans fats, hydrogenation, hydrolysis, acid value, saponification value, iodine number.

Module 5: Vitamins, Hormones and steroids — **4hours**

Introduction of vitamins, fat soluble and water-soluble vitamins.
Hormones, classification and functions.
Steroids-Introduction, occurrence, structure, Diel's hydrocarbon biological importance of steroids (cholesterol).

Total Lecture hours	**45 hours**

Practical BCH23301P Total Lab Hours: **30 hours**

List of Laboratory Experiments:

1. Estimation of glucose by Fehling's solution.
2. To estimate glycine by formal titration.
3. Estimation of proteins by Lowry's method.
4. Qualitative analysis of (2-3) plant extract.
5. Determination of Vitamin C Content in Fruit Juice by Redox Titration.
6. Saponification value of vegetable oil or fat.

Textbook(s)	
1	Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2	Finar, I. L. Organic Chemistry (Volume 1&2), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3	Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. (2012), Vogel's Textbook of Practical Organic Chemistry, Pearson Education India.
4	Greeves N., Clayden J., Warren S., Organic Chemistry, 2nd Ed., Oxford University Press, New Delhi, 2012.
5	Organic Chemistry by Paula Yurkanis Bruice, Organic Chemistry, Eight Edition, Pearson.
Reference Books	
1	Nelson, D. L. & Cox, M. M. Lehninger's Principles of Biochemistry 7th Ed., W. H. Freeman
2	Berg, J.M., Tymoczko, J.L. & Stryer, L. Biochemistry, W.H. Freeman, 2002.
3	Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009).
4	A Textbook of Practical Chemistry By Dr. Sudarshan Barua.
5	Dutta, S, B. Sc. Honours Practical Chemistry, Bharati Book Stall.

BCH23302T	PHYSICAL CHEMISTRY – II	L	T	P	C
		3	0	2	4

Pre-requisite: Knowledge of chemistry at (10+2) level

Course Objectives:

1. To provide knowledge of dilute solutions and colligative properties.
2. To provide fundamental insight into the chemical kinetics and catalysis.
3. To make students understand the laws of thermodynamics and partial molar quantities.
4. To provide fundamental knowledge of surface chemistry and its applications.
5. To provide students with concepts and skills of physical chemistry experiments.

Course Outcome:

After successful completion of the course, the students will be able

CO1: To explain the concepts of colligative properties, chemical kinetics, thermodynamics and surface chemistry.

CO2: To apply the fundamental knowledge of dilute solutions, chemical kinetics, thermodynamics and surface chemistry for solving problems.

CO3: To elaborate the derivations related to different isotherms, reaction kinetics, colligative properties and thermodynamics in physical chemistry.

CO4: To apply the concepts of physical chemistry for performing different laboratory experiments of physical chemistry.

Module 1: SOLUTIONS AND DILUTE SOLUTIONS — **10 hours**

Solutions and dilute solutions, Raoult's Law, Henry's Law, Duhem-Margules Equation, Solutions of solids in liquids, Solutions of liquids in liquids, Solutions of gases in Liquids, Study of completely miscible liquids, Study of immiscible liquids, Study of partially miscible liquids, Colligative properties- (i) relative lowering of vapour pressure, (ii) elevation of boiling point, (iii) depression of freezing point, (iv) osmotic pressure, Abnormal behaviour of electrolytes, Molecular mass and other properties of solute from colligative properties.

Module 2: CHEMICAL KINETICS I AND CATALYSIS — **13 hours**

Kinetics of reactions, Experimental determination of order of reactions, The method of Integration, Differential method, Isolation method, Comparison of methods, Kinetic equations for flow systems, Relaxation theory, Temperature dependence of reaction rate, Arrhenius equation, Pre-exponential Factor and failure of Arrhenius Equation.

Difference between equilibrium and steady state. Limiting reagents, rate-determining step and steady-state approximation-explanation with suitable examples (e.g. dissociation of HBr and acetaldehyde). Opposing reactions, consecutive reactions and parallel reactions (with examples and explanation of kinetic and thermodynamic control of products; all steps first order). Idea on explosive reactions.

General characteristics of catalytic reactions, Acid-base catalysis, Enzyme catalysis, Mechanism and kinetics of enzyme-catalysed reactions. Derivation of Michaelis-Menten

equation. Turn-over number, Catalysis in Chain reactions.	
Module 3: THERMODYNAMICS	**12 hours**
Gibbs free energy and its variation, Gibbs free energy and derivation of Clausius-Clapeyron Equation, applications of Clausius-Clapeyron Equation, Concept of fugacity and activity, Nernst heat theorem, Third law of thermodynamics, Validity and importance of third law of thermodynamics, absolute entropies. Partial molar quantities, Chemical potential, dependence of thermodynamic parameters on composition, Gibbs-Duhem equation, Variation of chemical potential with temperature and pressure, criteria for phase equilibria for single and multi-component system, chemical potential of ideal mixtures, change in thermodynamic functions in mixing of ideal gases.	
Module 4: SURFACE CHEMISTRY	**10 hours**
Adsorption and absorption, Factors affecting the adsorption of gases by solids, Types of adsorptions, Adsorption isotherms, Freundlich Adsorption isotherm, Langmuir adsorption isotherm, Behaviour of Langmuir isotherm at very high and low temperature, BET equation, Application of BET equation for the determination of surface area, Gibbs adsorption equation and its applications, positive and negative adsorption, Adsorption isobars, Application of adsorption in different fields.	
Total Lecture hours	**45 hours**
BCH23302P Physical Chemistry II Laboratory	**(30 hours)**
List of Laboratory Experiments 1. Determine the rate constant of the acid catalyzed hydrolysis of methyl acetate. 2. Determine the rate constant of saponification of ethyl acetate. 3.Determine the activation energy of the hydrolysis of methyl acetate catalyzed by hydrochloric acid. 4. Verify the Freundlich isotherm for the adsorption of oxalic acid/acetic acid on activated charcoal. 5. Verify the Langmuir isotherm for the adsorption of oxalic acid/acetic acid on activated charcoal. 6. Determine the critical micelle concentration of a surface-active agent by surface tension measurements. 7. Study the kinetics of the Iodide-persulphate reaction by Initial rate method. 8. To measure the depression of freezing point of water for aqueous solutions of urea/glucose and of sodium/potassium chloride. 9. Determine the vapour pressure of water at different temperatures and hence evaluate the enthalpy of vaporization of water.	

Text Book(s)

1.	B.R. Puri, L.R Sharma, M.S. Pathania, “Principles of Physical Chemistry” Vishal Publishing Co. India
2.	P.W. Atkins, “Physical Chemistry”, 8th Edition, Oxford University Press, New York.
3.	K. L. Kapoor, A Textbook of Physical Chemistry, Volume V, Macmillan.

Reference Books	
1.	P C Rakshit, Physical Chemistry.
2.	R.L. Madan, G.D. Tuli, Physical Chemistry, S Chand & Company.
6.	Levine, I .N. "Physical Chemistry", 6th Ed., Tata Mc Graw Hill (2010).
8.	A Text Book of Practical Chemistry By Dr. Sudarshan Barua

BCH23303T	**INORGANIC CHEMISTRY – III**	**L**	**T**	**P**	**C**
		3	**0**	**2**	**4**

Pre-requisite: Knowledge of chemistry at H.S. level

Course Objectives:

The course is being offered with the following objectives:

1. To identify the roles of essential and trace metal ions in biological systems and classify elements based on biological action.
2. To explain physiological processes involving metals, such as the Na^+/K^+ pump, and the action of metalloenzymes like carbonic anhydrase and carboxypeptidase.
3. To analyze the impact of trace metal deficiencies or excess in biological systems.
4. To evaluate the toxicity of heavy metals (Hg, Pb, Cd, As), their biological implications, and the medical use of chelating agents.
5. To understand the function of iron in oxygen transport and storage via hemoglobin and other iron-containing biomolecules.

Course Outcome:

After successful completion of the course, the students will be able

CO1: To explain the principles of Crystal Field Theory, CFSE, ligand field theory, and MO theory to interpret the geometry and stability of coordination complexes. (Understand & Apply)

CO2: To analyze the periodic trends and properties of transition elements, including their oxidation states, colour, magnetic behaviour and catalytic activity. (Analyze)

CO3: To compare and contrast the chemistry of lanthanoids and actinoids in terms of electronic configuration, oxidation states, lanthanide contraction, and separation methods. (Analyze & Understand)

CO4: To evaluate the biological roles of metal ions, such as Na^+/K^+ pump, iron in haemoglobin and the action of metalloenzymes like carbonic anhydrase and carboxypeptidase. (Evaluate & Understand)

CO5: To assess the environmental and health impacts of toxic metals (Hg, Pb, Cd, As) and justify the use of chelating agents in medical treatments. (Evaluate & Apply)

Module 1: COORDINATION CHEMISTRY-II	**15 hours**

Crystal field theory, measurement of CFSE weak and strong fields, pairing energies, factors affecting the magnitude of 10 Dq in octahedral vs. tetrahedral coordination, tetragonal distortions from octahedral geometry, Jahn-Teller theorem, square planar geometry. Qualitative aspects of ligand field and MO Theory, Chelate effect, Labile and inert complexes,

Module 2: TRANSITION ELEMENTS	**15 hours**

General group trends with special reference to electronic configuration, colour, variable valency, magnetic and catalytic properties, and ability to form complexes. Stability of various oxidation states and e.m.f. (Latimer diagram). Difference between the first, second and third transition series. Chemistry of Ti, V, Cr Mn, Fe and Co in various oxidation states (excluding their metallurgy)

Module 3: LANTHANOIDS AND ACTINOIDS	**6 hours**

Electronic configuration, oxidation states, colour, spectral and magnetic properties, lanthanide contraction, separation of lanthanides (ion-exchange method only).

Module 4: BIOINORGANIC CHEMISTRY	**9 hours**

Metal ions present in biological systems, classification of elements according to their action in biological system. Geochemical effect on the distribution of metals. Sodium / K-pump, carbonic anhydrase and carboxypeptidase. Excess and deficiency of some trace metals. Toxicity of metal ions (Hg, Pb, Cd and As), reasons for toxicity, Use of chelating agents in medicine. Iron and its application in bio-systems, Haemoglobin; Storage and transfer of iron.

Total Lecture hours	**45 hours**

BCH23303P **LABORATORY EXPERIMENTS (Total Lab Hours : 30)**

1. Gravimetric Analysis:
(i) Estimation of nickel (II) using Dimethylglyoxime (DMG)
(ii) Estimation of copper as CuSCN
(iii) Estimation of iron as Fe_2O_3 by precipitating iron as $Fe(OH)_3$
(iv) Estimation of Al (III) by precipitating with oxine and weighing as $Al(oxine)_3$ (aluminium oxinate)
2. Inorganic Preparations:
(i) Tetraamminecopper (II) sulphate, $[Cu(NH_3)_4]SO_4.H_2O$
(ii) Acetylacetonate complexes of Cu^{2+}/Fe^{3+}
(iii) Tetraamminecarbonatocobalt (III) nitrate
3. Chromatography of metal ions
Principles involved in chromatographic separations. Paper chromatographic separation of following metal ions:
(i) Ni(II) and Co(II)
(ii) Fe(III) and Al(III)

Text Book(s)

1.	Purcell, K.F & Kotz, J.C. Inorganic Chemistry W.B. Saunders Co, 1977
2.	Huheey J. E., Keiter E. A. and Keiter R. L., Inorganic Chemistry – Principles of structure and reactivity, , Pearson Education, 4th Ed. 2002.
3.	Lippard, S.J. & Berg, J.M. Principles of Bioinorganic Chemistry Panima Publishing Company 1994.
4.	Cotton, F.A. & Wilkinson, G, Advanced Inorganic Chemistry Wiley-VCH, 1999
5.	Basolo, F, and Pearson, R.C. Mechanisms of Inorganic Chemistry, John Wiley & Sons, NY, 1967.
6.	Greenwood, N.N. & Earnshaw A. Chemistry of the Elements, Butterworth Heinemann, 1997.

Reference Books

1.	Lee J. D., Concise Inorganic Chemistry, Wiley India, 5th Edn., 2008.
2.	Puri, Sharma, Kalia, Principles of Inorganic Chemistry, Vishal Pub. Co., 33rd ed., 2017.

3.	Shriver D. E.,Atkins P. W., InorganicChemistry, Oxford University Press,5thEdn..
4	Bioinorganic Chemistry, Asim Kumar Das, Books & Allied (P) Ltd. 1st ed. 2015.

BCH23320T	INORGANIC MATERIALS OF INDUSTRIAL IMPORTANCE	L	T	P	C
		3	0	2	4

Pre-requisite: Knowledge of chemistry at (10+2) level

Course Objectives:

1. To provide knowledge of inorganic engineering materials used in industries.
2. To provide an insight into the fertilizers, batteries and explosives.
3. To make students understand about surface coating and composite materials.
4. To provide knowledge about natural rubber latex and resins.

Course Outcome:

After successful completion of the course, the students will be able

CO1: To explain the conceptual chemistry behind industrially important inorganic materials.
CO2: To apply the fundamental knowledge of industrially important inorganic materials for solving problems.
CO3: To elaborate the characteristics, composition, and manufacturing processes of industrially important inorganic materials.
CO4: To apply the concepts of industrial and inorganic chemistry for performing different laboratory experiments related to inorganic materials of industrial importance.

Module 1: Industrial Engineering Materials — **15 hours**

Ceramics: Chemistry of Ceramics, Early potteries and glasses, new and advanced ceramic technologies, Ceramic superconductors, Ceramic Insulators, Bio ceramics.

Glass: Glassy state and its properties, classification (silicate and non-silicate glasses). Manufacturing and processing of glass. Composition and properties of the following types of glasses: Soda lime glass, lead glass, borosilicate glass, fused silica glass, armoured glass, safety glass, coloured glass, photosensitive glass.

***Cements*-**Cement and its classification, Portland cement, raw materials, manufacturing, setting and hardening.

Refractory materials-Definition, characteristics, classification into acidic, basic and neutral refractories and their uses.

Lubricants–Definition, characteristics, properties, function of lubricants, classification and uses.

Other Engineering materials-Lime, Gypsum, Plaster of Paris, fullerenes, nano clays, carbon nanotubes and carbon fibres.

Module 2: Fertilizers — **10 hours**

Overview of plant nutrients and their functions, Different types of fertilizers (N, P and K). Manufacture of the following fertilizers: Ammonium nitrate, Ammonium sulphate, Ammonium sulphate nitrate, Urea, Calcium ammonium nitrate, ammonium phosphates, superphosphate of lime.

Module 3: Surface Coatings and Composites Materials — **10 hours**

Brief introduction to and classification of surface coatings. Paints - formulation, composition,

and related properties. Pigments, Fillers, Thinners, Enamels, emulsifying agents. Special paints (Heat retardant, Fire retardant, Eco-friendly paint, Plastic paint), Dyes, Wax polishing, Water and Oil paints, Metallic coatings (electrolytic and electroless), metal spraying and anodizing. Introduction to composite materials, limitations of conventional materials, role of matrix in composites, classification, matrix materials, reinforcements, metal-matrix composites, polymer-matrix composites, fibre-reinforced composites, examples, clay-based nanocomposites and applications.	
Module 4: Chemical explosives	**5 hours**
Origin of explosive properties in organic compounds, preparation and explosive properties of lead azide, PETN, cyclonite (RDX). Introduction to rocket propellants.	
Module 5: Batteries	**5 hours**
Working of the following batteries: Pb acid, Li-Battery, Solid state electrolyte battery. Fuel cells, Solar cell and polymer cell.	
Total Lecture hours	**45 hours**
BCH23320P	**INORGANIC MATERIALS OF INDUSTRIAL IMPORTANCE LABORATORY (30 hours)**

List of Laboratory Experiments

1. Determination of free acidity in ammonium sulphate fertilizer.
2. Estimation of Calcium in Calcium ammonium nitrate fertilizer.
3. Estimation of phosphoric acid in superphosphate fertilizer.
4. Electroless metallic coatings on ceramic and plastic material.
5. Determination of composition of dolomite (by complexometric titration).
6. Analysis of (Cu, Ni); (Cu, Zn) in alloy or synthetic samples.
7. Analysis of Cement.
8. Preparation of pigment (zinc oxide/TiO2/any other etc).

Textbook(s)

1.	Kent, J. A. (ed) *Riegel's Handbook of Industrial Chemistry*, *9thEd.,* CBS Publishers, New Delhi, 1997 .
2.	Sharma, B. K. *Engineering Chemistry*, Goel Publishing House, Meerut, 2006.
3.	Jain, P. C. and Jain, M. *Engineering Chemistry,* Dhanpat Rai & Sons, Delhi 2005

Reference Books

1.	Gopalan, R., Venkappayya, D. and Nagarajan, S. *Engineering Chemistry,* Vikas Publications, New Delhi, 2004.
2.	Kingery, W. D., Bowen H. K. and Uhlmann, D. R. *Introduction to Ceramics,* Wiley Publishers, New Delhi, 1976.

BCH23321T	Instrumental Methods of Analysis	L	T	P	C
		3	0	2	4

Pre-requisite: Knowledge of Basic Science

Course Objectives:

3. To provide knowledge about separation techniques
4. To make students familiar with different instrumental methods of analysis.
5. To make students aware of the basic components of IR, UV-Visible, Atomic Absorption Spectroscopy, NMR spectroscopy.

Course Outcome:

After successful completion of the course, the students will be able

CO1: To understand various instrumental analytical methods.
CO2: To apply analytical techniques for chemical analysis.
CO3: To Analyse the chemical substances using appropriate analytical techniques.
CO4: To evaluate the various instrumental methods of analysis to defend the solutions to various problems.

Module 1: CHROMATOGRAPHIC TECHNIQUES — **12hours**

Gas Chromatography (GC)-Mass Spectrometry (GC-MS), Liquid Chromatography- Mass Spectrometry (LCMS), High Performance Liquid Chromatography (HPLC), Gel permeation Chromatography (GPC): Techniques, Instrumentation and Applications.

Module 2: Atomic Absorption Spectroscopy — **12 hours**

Atomic absorption, atomic emission, and atomic fluorescence. Excitation and getting sample into gas phase (flames, electrical discharges, plasmas), Wavelength separation and resolution (dependence on technique), Detection of radiation (simultaneous/scanning, Signal-to-Noise Ratio (SNR), Interpretation.

Module 3: Thermal and Diffraction Techniques — **7hours**

X-Ray Diffraction (XRD), Thermogravimetric Analysis (TGA), Differential Thermal Analysis (DTA), Derivative Thermogravimetry (DTG), Differential scanning calorimetry (DSC), Principle, Instrumentation and uses.

Module 4: Microscopy — **5hours**

Electron Microscopy: Scanning Electron Microscopy (SEM) and Transmission Electron Microscopy (TEM), Energy Dispersive X-ray Technique EDX, instrumentation, scanning probe microscopy SPM (Atomic Force Microscopy AFM, Scanning Tunneling Microscopy (STM) and applications.

Module 5: UV-Visible, NMR and IR Spectroscopy — **4hours**

Infrared spectroscopy: Interaction of radiation with molecules: absorption and scattering. Means of excitation (light sources), separation of spectrum (wavelength dispersion, time resolution), detection of the signal (heat, differential detection), interpretation of spectrum (qualitative, mixtures, resolution).
UV-Visible/ Near IR Spectroscopy: Emission, absorption, fluorescence and photoacoustic imaging. Excitation sources (lasers, time resolution), wavelength dispersion (gratings, prisms, interference filters), Detection of signals (photocells, photomultipliers, diode arrays and S/N),

Single and double beam instruments and Interpretation.
NMR spectroscopy: Principle, Instrumentation, Factors affecting chemical shift, Spin-coupling, Applications.

Module 6: Electroanalytical Methods and Radiochemical Methods	**5hours**
Potentiometry & Voltammetry, Basics and applications of radiochemical techniques.	
Total Lecture hours	**45 hours**

Practical BCH23321P **Total Lab hours: 15hours**

List of Laboratory Experiments:

1. Separation of mixture of compounds using TLC.
2. Separation of mixture of compounds by column chromatography.
3. Interpretation of simple organic compounds by IR spectra
4. Synthesis of compounds and analysis by UV and IR spectrum.
5. Separation of compounds by paper chromatography.
6. Determination of λ_{MAX} of paracetamol solution by UV-Visible spectrophotometer.
7. Determination of cell constant of a conductivity cell.
8. Perform the following conductometric titrations:
   (a) Weak acid vs. strong base
   (b) Mixture of strong acid and weak acid vs. strong base
   (c) Strong acid vs. weak base

Textbook(s)

1	Banwell, C.N. (2006), Fundamentals of Molecular Spectroscopy, Tata McGraw-Hill Education
2	D. B. Williams, C. B. Carter, Transmission Electron Microscopy A Textbook for Materials Science, Springer, 2009.
3	Cullity, B.D. & Stock, S.R. Powder X-Ray Diffraction, 3rd edition, Kindle Publisher 2001.
4	Willard, H. H. Instrumental Methods of Analysis, East West Press, 1998.
5	NMR Spectroscopy, 2nd Edition, Harald Günther

Reference Books

1	D. B. Williams, C. B. Carter, Transmission Electron Microscopy A Textbook for Materials Science, Springer, 2009
2	Skoog, D.A.; Holler, F. J.; Crouch, S. (2006), Principles of Instrumental Analysis, Thomson Brooks/Cole.
3	Christian, Gary D: Analytical Chemistry, 6th Ed. Wiley India (P) Ltd., 2004.
4	Khopkar, S.M.: Basic Concepts of Analytical Chemistry, 3rd Ed. New Age, International Publisher, 2009
5	Organic Spectroscopy, 3rd Edition, William Kemp.
6	Physical Methods in Inorganic Chemistry, Russel S. Drago.
7	Instrumental Methods of Analysis, 7th ed, Willard, Merritt, Dean, Settle.

BCH23304T	**Organic Chemistry-III**	**L**	**T**	**P**	**C**
		3	**0**	**2**	**4**

Pre-requisite: Knowledge of Basic Science

Course Objectives:

1.To provide knowledge about different types of organic compounds.
2.To make students familiar with organic heterocyclic compounds and terpenoids.
3.To make students aware of the pericyclic reactions.

Course Outcome:

After successful completion of the course students will be able
CO1: To understand the basic concepts of organic compounds.
CO2: To apply the concepts in solving problems.
CO3: To Analyze the reaction pathways, properties of different types of compounds.
CO4: To evaluate the reactivity patterns and reaction conditions.

Module 1: ALCOHOLS, PHENOLS, ETHERS, EPOXIDES, THIOLS, SULFIDES — **10hours**

Alcohols: preparation, properties and relative reactivity of 1°,2°,3°alcohols, Bouveault-Blanc Reduction; Preparation and properties of glycols: Oxidation by periodic acid and lead tetraacetate.
Phenols: Preparation and properties; Acidity and factors effecting it, Ring substitution reactions, Reimer–Tiemann and Kolbe's–Schmidt Reactions, Fries and Claisen rearrangements with mechanism.
Ethers and Epoxides: Preparation and reactions with acids. Reactions of epoxides with alcohols, ammonia derivatives and $LiAlH_4$.
Thiols and sulfides.

Module 2: CARBOXYLIC ACIDS AND THEIR DERIVATIVES — **10hours**

Preparation, physical properties and reactions of monocarboxylic acids: Typical reactions of dicarboxylic acids, hydroxy acids and unsaturated acids: succinic/phthalic, lactic, malic, tartaric, citric, maleic and fumaric acids.
Preparation and reactions of acid chlorides, anhydrides, esters and amides; Comparative study of nucleophilic substitution at acyl group -Mechanism of acidic and alkaline hydrolysis of esters, Dieckmann and Reformatsky reactions, Hofmannbromamide degradation and Curtius rearrangement.

Module 3: CHEMISTRY OF HALOGANETED HYDROCARBONS — **8hours**

Alkyl halides: properties, nucleophilic substitution reactions – SN1, SN2 and SNi mechanisms with stereochemical aspects and effect of solvent; nucleophilic substitution vs. Elimination.
Aryl halides: properties, nucleophilic aromatic substitution; SNAr, Benzyne mechanism.
Relative reactivity of alkyl, allyl, benzyl, vinyl and aryl halides towards nucleophilic substitution reactions.
Organometallic compounds of Mg (Grignard reagent) – Use in synthesis of organic compounds.

Module 4: PERICYCLIC REACTIONS — **7hours**

Introduction, general orbital symmetry rules, types: electrocyclic reaction, sigmatropic rearrangement, cycloaddition reaction, 1,3 – dipolar cycloaddition, cheletropic reactions, Cope rearrangement.

Module 5: HETEROCYCLIC COMPOUNDS — **6hours**

Classification and nomenclature (5-numbered and 6-membered rings with one heteroatom); synthesis and reactions of furan, pyrrole, thiophene and indoles: selected name reactions (Paal-Knorr synthesis, Knorr synthesis, Hantzsch synthesis, Fischer indole synthesis, Madelung synthesis)

Module 6: TERPENOIDS	**4hours**

Occurrence of terpenes; structure and classification of terpenes, isoprene rule; synthesis of Citral and α-terpineol; biosynthesis of limonene, geraniol, citronellol, citronellal.

Practical BCH23304P **Total Lab Hours:30hours**

List of Laboratory Experiments:

1. Determination of Iodine number of vegetable oil or fat.
2. Determination of equivalent mass of acid by direct titration method.
3. Synthesis
   (i) Preparation of p-bromo-acetanilide from aniline.
   (ii) Cyclohexanone oxime from cyclohexanone
   (iii) Dibenzalacetone from benzaldehyde.
4. Extraction of limonene from orange peel/Chlorophyll from plant.
5. Oxidation of ethanol/ isopropanol (iodoform reaction).

Textbook(s)

1	Morrison R. T., Boyd R. N., Bhattacharjee S. K., Organic Chemistry, 7th Edition, Pearson Education India, 2010.
2	Solomons T. W. G., Fryhle C. B., Snyder S. A., Organic Chemistry, 12th Edition, Wiley, 2017.
3	Greeves N., Clayden J., Warren S., Organic Chemistry, 2nd Ed., Oxford University Press, New Delhi, 2012.
4	Organic Chemistry by Paula Yurkanis Bruice, Organic Chemistry, Eight Edition, Pearson.

Reference Books

1	Finar, I. L. Organic Chemistry (Volume 1&2), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2	A Textbook of Practical Chemistry By Dr. Sudarshan Barua
3	V. K. Ahluwalia, S. Dhingra, Comprehensive Practical Organic Chemistry, University Press.
4	F. G. Mann, B. C. Saunders, Practical Organic Chemistry, 3rd Edition Longman, 1978.

BCH23305T	PHYSICAL CHEMISTRY – III	L	T	P	C
		3	0	2	4

Pre-requisite: Knowledge of chemistry at (10+2) level

Course Objectives:

1. To provide the basic and applied knowledge of thermochemistry.
2. To provide fundamental insight of photochemistry principles and applications.
3. To make students understand the concepts of ionic equilibria and its applications.
4. To provide fundamental knowledge of solid-state chemistry and liquid crystals.
5. To provide students concepts and skills of physical chemistry experiments.

Course Outcome:

After successful completion of the course, the students will be able

CO1: To explain the concepts of thermochemistry, photochemistry, ionic equilibria, and solid-state chemistry.

CO2: To apply the fundamental knowledge of thermochemistry, photochemistry, ionic equilibria, and solid-state chemistry for solving problems.

CO3: To elaborate different laws, equations and states in thermochemistry, photochemistry, equilibria, and solid and liquid crystals in physical chemistry.

CO4: To apply the concepts of physical chemistry for performing different laboratory experiments of physical chemistry.

Module 1: Thermochemistry — **10 hours**

Heat of reactions, standard states, exothermic and endothermic reactions, change of internal energy in a chemical reaction, change of enthalpy in a chemical reaction, Enthalpy of reaction at constant volume and at constant pressure, Enthalpy of combustion, neutralization, dissociation and formation, Enthalpies of compounds, Enthalpies of formation of ions, Effect of temperature (Kirchhoff's equation) and pressure on enthalpy of reactions, Calculation of different enthalpies, Flame and explosion temperatures, Hess's law of constant Heat Summation, Applications of Hess's law, Measuring the enthalpy of combustion, Bomb calorimeter, Bond energies, Applications of bond energies and related mathematical problems.

Module 2: Photochemistry — **15 hours**

Photophysical and photochemical reactions, Thermochemical vs photochemical reactions, Laws governing of transmission and absorption of Light, extinction-co-efficient, Laws of photochemistry-Grotthus law, Stark-Einstein law, Interpretation of Einsteins law, Introduction of the term Quantum efficiency, Calculation of quantum efficiency, Experimental determination of Quantum shield of a photochemical reaction, Some examples of photochemical reactions, Photochemical decomposition of hydrogen iodide and hydrogen bromide, Photosynthesis with examples, Photolysis (ammonia and acetone), Chemiluminescence, Fluorescence and Phosphorescence in terms of excitation of electrons, Photosensitization, Photo-inhibitors, Photochemical equilibrium. Mathematical problems and solutions.

Module 3: Ionic Equilibria — **15 hours**

Introduction to strong, moderate and weak electrolytes, Arrhenius concept of acids and bases,

proton transfer theory, Lewis concept, Dissociation of a weak acid, dissociation constants of polybasic acids, Dissociation of a weak base, Ionic product of water, The pH scale, Buffer solutions, Buffer mixture of a weak acid and its salt, Calculation of pH values of buffer mixtures-Henderson's equation, Buffer mixture of a weak acid and its salt, Hydrolysis of salts, Hydrolysis constant, Relation between Kh, Ka, Kw, Degree of hydrolysis, pH of hydrolysed salt solution, Salts of weak bases and strong acids, Salta of weak acids and weak bases, Determination of degree of hydrolysis, Acid-base indicators, The theory of indicators, Action of Phenolphthalein, Action of methyl orange, Acid-base titrations and use of indicators, Mathematical treatment of acid-base titrations, Solubility product, Applications of solubility product principle, Ionic equilibria involving complex ions.

Module 4: The Solid and Liquid Crystalline State	**5 hours**

Structures of solids and liquids, Difference between crystalline and amorphous solid, Isotropy and anisotropy, X-ray diffraction, Bragg's equation, Reactions on solid surfaces, Diffusion in solids, Solid state reactions.

Introduction to Liquid crystals, Smectic liquid crystals, Nematic liquid crystals, Cholesteric liquid crystals, Disc shaped liquid crystals, Polymer liquid crystals. Polymorphism in thermotropic liquid crystals.

Total Lecture hours	**45 hours**

BCH23305P Physical Chemistry III Laboratory (30hours)

List of Laboratory Experiments(minimum two instrumental experiment should be carried out)

1. Measurement of pH of different solutions like aerated drinks, fruit juices, shampoos and soaps (use dilute solutions of soaps and shampoos to prevent damage to the glass electrode) using pH meter.
2. Preparation of buffer solutions:
(i) Sodium acetate-acetic acid
(ii) Ammonium chloride-ammonium hydroxide
[Measurement of pH of the prepared buffer solutions and comparison of the values with theoretical values.]
3. Determination of dissociation constant of a weak acid.
4. Determine the transition temperature of a salt hydrate
5.Study of the solubility of benzoic acid in water and determination of ΔH
6. Determine the dissociation constant of an indicator
7. Determination of heat capacity of a calorimeter by using hot and room-temperature water.
8. Determination of heat capacity of the calorimeter and enthalpy of neutralisation of hydrochloric acid with sodium hydroxide.
9. Determination of heat capacity of the calorimeter and enthalpy of neutralisation of acetic acid with sodium hydroxide.
10. Fluorescence analysis of Quinine (or Fluorescent Dye)
11. Characterization of a given sample by using X-ray diffraction ** Other related experiments may also be introduced.

Text Book(s)	
1.	B.R. Puri, L.R Sharma, M.S. Pathania, "Principles of Physical Chemistry" Vishal Publishing Co. India
2.	P.W. Atkins, "Physical Chemistry", 8th Edition, Oxford University Press, New York.
3.	K. L. Kapoor, A Textbook of Physical Chemistry, Volume V, Macmillan.
4	Mortimer, R. G. Physical Chemistry 3rd Ed. Elsevier: NOIDA, UP (2009).
5	Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
Reference Books	
1.	P C Rakshit, Physical Chemistry.
2.	R.L. Madan, G.D. Tuli, Physical Chemistry, S Chand & Company.
3.	Levine, I .N. "Physical Chemistry", 6th Ed., Tata Mc Graw Hill (2010).
4	Castellan, G. W. Physical Chemistry 4th Ed. Narosa (2004).
5	Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry 8th Ed., McGraw-Hill: New York (2003).
6	Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H. Freeman & Co., New York (2003).

BCH2330 6T	INORGANIC CHEMISTRY – IV	L	T	P	C
		3	0	2	4

Pre-requisite: Knowledge of chemistry at H.S. level

Course Objectives:

The course is being offered with the following objectives:

1. To introduce the classification and bonding concepts of organometallic compounds, including hapticity and the 18-electron rule, with a focus on metal carbonyls and π-acceptor ligands.
2. To develop an understanding of the structural and bonding features of metal alkyls and metallocenes such as ferrocene, including their synthesis, reactions, and aromatic character.
3. To explore the role of organometallic compounds in homogeneous catalysis, and to understand the mechanisms of key industrial catalytic processes like hydrogenation, hydroformylation, Wacker process, and Fischer–Tropsch synthesis.
4. To examine the thermodynamic and kinetic aspects of complex formation and substitution reactions in coordination compounds, including trans effect and ligand exchange mechanisms in square planar and octahedral complexes.
5. To apply theoretical models such as MO theory, Valence Bond Theory, and IR spectral analysis to interpret the bonding and reactivity in organometallic and coordination compounds.

Course Outcome:

After successful completion of the course, the students will be able

CO1: To classify organometallic compounds based on bond types and explain the concepts of hapticity and the 18-electron rule with application to metals carbonyls of the 3d series. (Understand & Apply)

CO2: To interpret the structures and bonding in mononuclear and binuclear carbonyls using VBT and MO theory and Analyze the π-acceptor behaviour of CO through synergic bonding and IR spectral data. (Analyze)

CO3: To describe the structural features and multicentre bonding in metal alkyls and Grignard reagents and compare the aromaticity and reactivity of ferrocene with benzene. (Understand & Analyze)

CO4: To explain the role of organometallic compounds in industrial catalysis and discuss the mechanisms of key processes such as hydrogenation, hydroformylation, Wacker process, and Fischer-Tropsch synthesis. (Understand & Apply)

CO5: To evaluate the thermodynamic and kinetic aspects of metal-ligand complex formation and analyze the mechanisms of substitution reactions in square planar and octahedral complexes, including the trans effect. (Analyze & Evaluate)

Module 1: ORGANOMETALLIC COMPOUNDS – I **15 hours**

Definition and classification of organometallic compounds on the basis of bond type. Concept of hapticity of organic ligands. Metal carbonyls: 18 electron rule, electron count of mononuclear, polynuclear and substituted metal carbonyls of 3d series. General methods of preparation (direct combination, reductive carbonylation, thermal and photochemical decomposition) of mono and binuclear carbonyls of 3d series. Structures of mononuclear and binuclear carbonyls of Cr, Mn, Fe, Co and Ni using VBT. π-acceptor behaviour of CO (MO diagram of CO to be discussed), synergic effect and use of IR data to explain extent of back bonding.

Zeise's salt: Preparation and structure, evidences of synergic effect and comparison of synergic effect with that in carbonyls.

Module 2: ORGANOMETALLIC COMPOUNDS – II	**15 hours**
Metal Alkyls: Important structural features of methyl lithium (tetramer) and trialkyl aluminium (dimer), concept of multicentre bonding in these compounds. Role of triethylaluminium in polymerisation of ethene (Ziegler – Natta Catalyst). Species present in ether solution of Grignard reagent and their structures. Ferrocene: Preparation and reactions (acetylation, alkylation, metallation, Mannich Condensation), structure and aromaticity, comparison of aromaticity and reactivity with that of benzene.	
Module 3: CATALYSIS BY ORGANOMETALLIC COMPOUNDS	**6 hours**
Study of the following industrial processes and their mechanism: 1. Alkene hydrogenation (Wilkinson's Catalyst) 2. Hydroformylation (Co salts) 3. Wacker Process 4. Synthetic gasoline (Fischer Tropsch reaction)	
Module 4: THERMODYNAMIC & KINETIC ASPECTS AND REACTION MECHANISM OF METAL COMPLEXES	**9 hours**
Thermodynamic and kinetic stability, Stepwise and overall formation constants and their relationship, factors affecting stability. Introduction to inorganic reaction mechanisms-types of reaction and classification of substitution reaction. Substitution reaction of square planar complexes, Trans effect and its applications, theories of trans-effect (electrostatic polarization and Static π-Bonding Theory). Kinetics of octahedral substitution (classification of metal ions based on water exchange rate), General mechanism of ligand substitution reactions in octahedral complexes (D, I, Id, Ia).	
Total Lecture hours	**45 hours**

BCH23306P **Total Lab Hours:30 Hours**

LABORATORY EXPERIMENTS

1. To determine volumetrically the amount of ammonia in the given solution.
2. To estimate the amount of the given Mohr's salt by titrating against a standard N/10 $K_2Cr_2O_7$ solution.
3. Gravimetric estimation of chloride.
4. Preparation of nickel ammonium sulphate, $NiSO_4(NH_4)_2SO_4.6H_2O$.
5. Preparation of copper glycinate.

Text Book(s)

1.	Purcell, K.F & Kotz, J.C. Inorganic Chemistry W.B. Saunders Co, 1977
2.	Huheey J. E., Keiter E. A. and Keiter R. L., Inorganic Chemistry – Principles of structure and reactivity, , Pearson Education, 4th Ed. 2002.
3.	Lippard, S.J. & Berg, J.M. Principles of Bioinorganic Chemistry Panima Publishing Company 1994.
4.	Cotton, F.A. & Wilkinson, G, Advanced Inorganic Chemistry Wiley-VCH, 1999
5.	Basolo, F, and Pearson, R.C. Mechanisms of Inorganic Chemistry, John Wiley & Sons, NY, 1967.
6.	Greenwood, N.N. & Earnshaw A. Chemistry of the Elements, Butterworth Heinemann, 1997.

Reference Books

1.	Lee J. D., Concise Inorganic Chemistry, Wiley India, 5th Edn., 2008.
2.	Puri, Sharma, Kalia, Principles of Inorganic Chemistry, Vishal Pub. Co., 33rd ed., 2017.
3.	Shriver D. E.,Atkins P. W., InorganicChemistry, Oxford University Press,5thEdn..

4	Bioinorganic Chemistry, Asim Kumar Das, Books & Allied (P) Ltd. 1st ed. 2015.
5	Mehrotra R.C. and Singh, A. Organometallic Chemistry, New Age International Publishers, 2ndEdn, 2000.
6	Gupta B. D. and Elias A. J., Basic organometallic Chemistry, 2ndEdn., University Press (2013).

BCH23307T	ADVANCED QUANTUM CHEMISTRY AND SPECTROSCOPY	L	T	P	C
		3	0	2	4

Pre-requisite: Knowledge of chemistry at H.S. level

Course Objectives:

The course is being offered with the following objectives:

1. To provide a fundamental understanding of the postulates of quantum mechanics, Schrödinger equation, and their applications to atomic and molecular systems.
2. To develop the conceptual framework of chemical bonding using valence bond and molecular orbital theories and to understand their qualitative applications to diatomic and polyatomic molecules.
3. To introduce the principles governing the interaction of electromagnetic radiation with matter and to analyze various molecular spectra (rotational, vibrational, Raman, and electronic) for determining molecular parameters.
4. To familiarize students with the principles and applications of magnetic resonance techniques (NMR and ESR) for elucidating molecular and electronic structures.

Course Outcome:

After successful completion of the course, the students will be able

CO1: To explain the fundamental postulates of quantum mechanics, Schrödinger equation, and their applications to simple systems such as the particle-in-a-box, harmonic oscillator, and hydrogen atom. (Understand)

CO2: To apply quantum mechanical models to interpret atomic and molecular structures, including angular momentum quantization and approximation methods for multi-electron systems. (Apply)

CO3: To compare and analyze valence bond and molecular orbital theories for describing chemical bonding in homonuclear and heteronuclear diatomic molecules and evaluate their extensions to polyatomic molecules. (Analyze / Evaluate)

CO4: To interpret and correlate different molecular spectra (rotational, vibrational, Raman, electronic, and magnetic resonance) with molecular structure, bonding, and energy transitions using appropriate quantum mechanical principles. (Apply / Analyze)

Module 1: QUANTUM MECHANICS AND ATOMIC STRUCTURE — **15 hours**

Postulates of quantum mechanics, quantum mechanical operators, Eigen functions and Eigen values, Schrödinger equation and its application to free particle and "particle-in-a-box" (rigorous treatment), quantization of energy levels, zero-point energy and Heisenberg Uncertainty principle; wavefunctions, probability distribution functions, nodal properties, Extension to two and three dimensional boxes, separation of variables, degeneracy. Qualitative treatment of simple harmonic oscillator model of vibrational motion: Setting up of Schrödinger equation and discussion of solution and wavefunctions. Vibrational energy of diatomic molecules and zero-point energy. Angular momentum: Commutation rules, quantization of square of total angular momentum and z-component. Rigid rotator model of rotation of diatomic molecule. Schrödinger equation, transformation to spherical polar coordinates. Separation of variables. Spherical harmonics. Discussion of solution. Qualitative treatment of hydrogen atom and hydrogen-like ions: setting up of Schrödinger equation in spherical polar coordinates, radial part, quantization of energy (only final energy expression). Average and most probable distances of electron from nucleus.

Module 2: QUANTUM THEORY OF CHEMICAL BONDING	**9 hours**
Chemical bonding: Covalent bonding, valence bond and molecular orbital approaches, LCAO-MO treatment of H2+. Bonding and antibonding orbitals. Qualitative extension to H_2. Comparison of LCAO-MO and VB treatments of H_2 (only wavefunctions, detailed solution not required) and their limitations. Refinements of the two approaches (Configuration Interaction for MO, ionic terms in VB). Qualitative description of LCAO-MO treatment of homonuclear and heteronuclear diatomic molecules (HF, LiH). Localized and non-localized molecular orbitals treatment of triatomic (BeH_2, H_2O) molecules. Qualitative MO theory and its application to AH_2 type molecules.	
Module 3: MOLECULAR AND ELECTRONIC SPECTROSCOPY	**14 hours**
Interaction of electromagnetic radiation with molecules and various types of spectra; Born Oppenheimer approximation. Rotation spectroscopy: Selection rules, intensities of spectral lines, determination of bond lengths of diatomic and linear triatomic molecules, isotopic substitution. Vibrational spectroscopy: Classical equation of vibration, computation of force constant, amplitude of diatomic molecular vibrations, anharmonicity, Morse potential, dissociation energies, fundamental frequencies, overtones, hot bands, degrees of freedom for polyatomic molecules, modes of vibration, concept of group frequencies. Vibration-rotation spectroscopy: diatomic vibrating rotator, P, Q, R branches. Raman spectroscopy: Qualitative treatment of Rotational Raman effect; Effect of nuclear spin, Vibrational Raman spectra, Stokes and anti-Stokes lines; their intensity difference, rule of mutual exclusion. Electronic spectroscopy: Franck-Condon principle, electronic transitions, singlet and triplet states, fluorescence and phosphorescence, dissociation and predissociation, calculation of electronic transitions of polyenes using free electron model.	
Module 4: MAGNETIC RESONANCE SPECTROSCOPY	**7 hours**
Nuclear Magnetic Resonance (NMR) spectroscopy: Principles of NMR spectroscopy, Larmor precession, chemical shift and low resolution spectra, different scales, spin-spin coupling and high-resolution spectra, interpretation of PMR spectra of organic molecules. Electron Spin Resonance (ESR) spectroscopy: Its principle, hyperfine structure, ESR of simple radicals.	
Total Lecture hours	**45 hours**

BCH23307P **Total Lab Hours:30 Hours**

LABORATORY EXPERIMENTS

UV/Visible spectroscopy

1. Study the 200-500 nm absorbance spectra of $KMnO_4$ and $K_2Cr_2O_7$ (in 0.1 M H_2SO_4) and determine the λmax values. Calculate the energies of the two transitions in different units (J molecule^{-1}, kJ mol^{-1}, cm^{-1}, eV).
2. Study the pH-dependence of the UV-Vis spectrum (200-500 nm) of $K_2Cr_2O_7$.
3. Record the 200-350 nm UV spectra of the given compounds (acetone, acetaldehyde, 2- propanol, acetic acid) in water. Comment on the effect of structure on the UV spectra of organic compounds.

Colourimetry

1. Verify Lambert-Beer's law and determine the concentration of $CuSO_4$/$KMnO_4$/$K_2Cr_2O_7$ in a solution of unknown concentration.
2. Determine the concentrations of $KMnO_4$ and $K_2Cr_2O_7$ in a mixture.
3. Study the kinetics of iodination of propanone in acidic medium.

4. Determine the dissociation constant of an indicator (phenolphthalein). 5. Study the kinetics of interaction of crystal violet/ phenolphthalein with sodium hydroxide	
Textbook(s)	
1.	Quantum Chemistry by R. K. Prasad, New Age International Publishers (1985).
2.	Introductory Quantum Chemistry by A. K. Chandra, Tata McGraw-Hill (2001).
3.	Fundamentals of Molecular Spectroscopy by C. N. Banwell, & E. M. McCash, 4th Ed. Tata McGraw-Hill: New Delhi (2006).
4.	Introduction to Spectroscopy D.L. Pavia, G. M. Lampman, G. S. Kriz, 4th Ed., Brooks/Cole Cengage Learning (2015).
Reference Books	
1.	Fundamentals of Quantum Chemistry by J. E. House, 2nd Ed. Elsevier: USA (2004).
2.	Quantum Chemistry by N. Levine, Prentice Hall of India Pvt. Ltd. New Delhi (1994)
3.	Organic Spectroscopy by W. Kemp, 3rd Edition, Palgrave Macmillan, 2011.
4	Senior Practical Physical Chemistry by B. D. Khosla, V. C. Garg, & A. Gulati, R. Chand & Co.: New Delhi (2011).
5	Experiments in Physical Chemistry by, C. W. Garland, J. W. Nibler & D. P. Shoemaker, 8th Ed.; McGraw-Hill: New York (2003).

BCH23322T Elective	**Food Chemistry**	**L**	**T**	**P**	**C**
		3	**0**	**2**	**4**

Pre-requisite: Knowledge of Basic Science

Course Objectives:

1.To make students aware of basics of food science.
2.To provide knowledge about food additives and storage and preservation.
3. To make students aware of the food chemistry of fats, oils and protein.

Course Outcome:

After successful completion of the course, the students will be able
CO1: To understand the basics of food chemistry.
CO2: To apply the principles and techniques for analysis of food.
CO3: Analyze the food composition, additives and techniques to find solutions.
CO4: To Evaluate different parameters of food science.

Module 1: INTRODUCTION TO FOOD SCIENCE — **12 hours**

Basic food groups, Functions of food, food guide pyramid, food in relation to health, composition of wheat, rice. Composition of milk and milk products, milk proteins, Factor affecting composition of milk, food and nutritive value, Principle of determination of fat content, minerals in milk, preservatives in milk, Estimation of added water in milk.

Module 2: FOOD ADDITIVES, ADULTERANTS AND CONTAMINANTS — **15 hours**

Different types of Food Additives and their functions, Food preservatives, Artificial sweeteners, Artificial Flavours, monosodium glutamate.
Introduction to adulteration, incidental additives or contaminants, adulterants in some common food items like coffee powder, chili powder, turmeric powder, coriander powder, asafetida and pulses.
Artificial food colorants - Coal tar dyes and non-permitted colours and metallic salts.

Module 3: FATS AND OILS — **7 hours**

Essential oils and sources, some oils with characteristic fatty acids, Hydrogenation of oil, rancidity, unsaponifiable matter in animal fat, comparison of vegetable oil with special reference to blood cholesterol level.

Module 4: FOOD SPOILAGE AND PRESERVATION — **7 hours**

Nature of water and water availability, crystal growth and nucleation, water activity and food spoilage, shelf life and spoilage under different conditions, Microorganism in food (mold, yeast, bacteria): preservation and food processing-Traditional and Modern Methods- Heat Treatment, Fermentation, Pickling, Smoking, Drying, Curing, Freezing, Pasteurization, Ultra Heat Treatment.

Module 5: PROTEIN — **4 hours**

Protein, classification, non-enzymatic browning, chemical changes during storage and processing.

Practical
BCH23322P

List of Laboratory Experiments:(credit-1) 30 hours

1. Detection of adulterants in different food items
   (a) Milk
   (b) Turmeric
   (c) Cane sugar
   (d) Common salt
   (e) Mustard oil
   (f) Ghee and Butter
   (g) Coffee
   (h) Cereals and pulses
2. Qualitative test for carbohydrates, amino acids, proteins.
3. Isolation of casein and lactose from milk.
4. Extraction of caffeine from tea leaves.

Textbook(s)	
1	B. Srilakshmi, "Food science, Seventh Edition".
2	S. Manay, "Food: Facts and Principles
3	S. Sehgal, "A Laboratory Manual of Food Analysis".
4	Food Science – Srilakshmi, New Age international (P) Limited, New Delhi
Reference Books	
1	J.M. de Man, "Principles of Food Chemistry"
2	H.D. Belitz, W. Grosch and P. Schieberle, "Food Chemistry".
3	Food Facts and Principles Many N. S. & Shadakshasawamy M. New Age International Publishers.
4	Comprehensive Practical Organic Chemistry Qualitative Analysis, V K Ahluwalia, Sunita Dhingra.

BCH23323T	**GREEN CHEMISTRY**	**L**	**T**	**P**	**C**
		3	**0**	**2**	**4**

Pre-requisite: Knowledge of chemistry at (10+2) level

Course Objectives:

1. To provide knowledge of green chemistry principles and applications.
2. To provide fundamental insight into the designing a green chemical synthesis.
3. To make students understand the green synthesis pathways.
4. To provide fundamental knowledge of future trends of green chemistry and sustainability.
5. To provide students concepts and skills of green chemistry experiments.

Course Outcome:

After successful completion of the course, the students will be able

CO1: To explain the concepts of green chemistry.

CO2: To apply the fundamental knowledge of green chemistry principles in designing and synthesis of chemical reactions.

CO3: To elaborate the principles, chemical synthesis, sustainability, and SDGs through the lens of green chemistry.

CO4: To apply the concepts of green chemistry for performing different laboratory experiments of green chemistry.

Module 1: INTRODUCTION TO GREEN CHEMISTRY	**5 hours**

Meaning of Green Chemistry, Need for Green Chemistry, Goals of Green Chemistry. Limitations/ Obstacles in the pursuit of the goals of Green Chemistry.

Module 2: PRINCIPLES OF GREEN CHEMISTRY AND DESIGNING A CHEMICAL SYNTHESIS	**20 hours**

Twelve principles of Green Chemistry with their explanations and examples; Designing a Green Synthesis using these principles; Prevention of Waste/ byproducts; maximum incorporation of the materials used in the process into the final products (Atom Economy); prevention/ minimization of hazardous/ toxic products; designing safer chemicals – different basic approaches to do so; selection of appropriate auxiliary substances (solvents, separation agents), green solvents, solventless processes, immobilized solvents and ionic liquids; energy requirements for reactions - use of microwaves, ultrasonic energy; selection of starting materials; avoidance of unnecessary derivatization – careful use of blocking/protecting groups; use of catalytic reagents (wherever possible) in preference to stoichiometric reagents; designing of biodegradable products; prevention of chemical accidents; strengthening/ development of analytical techniques to prevent and minimize the generation of hazardous substances in chemical processes.

Module 3: EXAMPLES OF GREEN SYNTHESIS/ REACTIONS	**10 hours**

1. Green Synthesis of the following compounds: adipic acid, catechol, BHT, methylmethacrylate, urethane, citral, ibuprofen, paracetamol, furfural.
2. Microwave assisted reactions in water: Oxidation of toluene, alcohols.

Microwave assisted reactions in organic solvents: Esterification, Fries rearrangement, Diels-Alder Reaction.
Microwave assisted solid state reactions: Deacetylation, Deprotection.
Saponification of esters, Alkylation of reactive methylene compounds, reductions, benzimidazoles.

Module 4: FUTURE TRENDS IN GREEN CHEMISTRY	**10 hours**

Oxidation reagents and catalysts; Biomimetic, multifunctional reagents; Solventless reactions; Combinatorial green chemistry, Real world cases in green chemistry, Green chemistry for sustainable development. MDG, SDG and Green Chemistry, Role of chemists in achieving sustainable development.

Total Lecture hours	**45 hours**

BCH23323P

Green Chemistry Laboratory **(30 hours)**

List of Laboratory Experiments

1. Safer starting materials
   The Vitamin C clock reaction using Vitamin C tablets, tincture of iodine, hydrogen peroxide and liquid laundry starch.
   a. Effect of concentration on clock reaction
   b. Effect of temperature on clock reaction. (if possible)
2. Using renewable resources
   Preparation of biodiesel from vegetable oil.
3. Avoiding waste
   Principle of atom economy.
   Use of molecular model kit to stimulate the reaction to investigate how the atom economy can illustrate Green Chemistry.
   Preparation of propene by two methods can be studied
   (I) Triethylamine ion + OH- → propene + trimethyl propene + water
   (II) 1-propanol propene + water
   The other types of reactions, like addition, elimination, substitution and rearrangement should also be studied for the calculation of atom economy.
4. Use of enzymes as catalysts
   Benzoin condensation using Thiamine Hydrochloride as a catalyst instead of cyanide

Alternative Green solvents

5. (I) Diels Alder reaction in water
   (II) Reaction between furan and maleic acid in water and at room temperature rather than in benzene and reflux.
6. Extraction of D-limonene from orange peel using liquid CO2 prepared form dry ice.
7. Mechanochemical solvent free synthesis of azomethines
8. Co-crystal controlled solid state synthesis (C3S3) of N-organ phthalimide using phthalic anhydride and 3-aminobenzoic acid.

Alternative sources of energy

9. Solvent free, microwave assisted one pot synthesis of phthalocyanine complex of copper (II).

10. Photoreduction of benzophenone to benzopinacol in the presence of sunlight.	
Textbook(s)	
1.	V.K. Ahluwalia & M. Kidwai: New Trends in Green Chemistry, Anamaya Publishers (2005).
2.	P.T. Anastas & J.K. Warner: Oxford Green Chemistry- Theory and Practice, University Press (1998).
3.	A.S. Matlack: Introduction to Green Chemistry, Marcel Dekker (2001).
Reference Books	
1.	M.C. Cann & M.E. Connely: Real-World cases in Green Chemistry, American Chemical Society, Washington (2000).
2.	M.A. Ryan & M. Tinnesand, Introduction to Green Chemistry, American Chemical Society, Washington (2002
3	Kirchoff, M. & Ryan, M.A. Greener approaches to undergraduate chemistry experiment. American Chemical Society, Washington DC (2002).
4	Sharma, R.K.; Sidhwani, I.T. & Chaudhari, M.K. Green Chemistry Experiment: A monograph, I.K International Publishing House Pvt Ltd. New Delhi. BangaloreCISBN 978-93-81141-55-7 (2013).

	PHYSICAL CHEMISTRY – IV	L	T	P	C
		3	0	2	4

Pre-requisite: Knowledge of chemistry at (10+2) level

Course Objectives:

1. To introduce the student with the basic concepts of equilibrium thermodynamics.
2. To introduce students with statistical thermodynamics and its various concepts.
3. To give an insight into surface chemistry and catalysis.
4. To make students familiar with the concepts and applications of smart and nanomaterials.

Course Outcome:

After successful completion of the course, the students will be able

CO1: To explain the fundamentals laws, rules and theories related to equilibrium and statistical thermodynamics, smart materials, and surfaces in chemistry.

CO2: To apply the concepts of thermodynamics, surface chemistry concepts and smart materials in various applications.

CO3: To elaborate different processes in thermodynamics, catalysis and smart and nano material systems.

CO4: To apply the concepts of physical chemistry for performing different laboratory experiments of physical chemistry.

Module 1: EQUILIBRIUM THERMODYNAMICS — **12 hours**

Fugacity, Determination of fugacity. Ideal solution and non-ideal solutions, Activity, activity coefficient, Determination of activity coefficient, Excess function for non-ideal solutions. Partial molar quantities: chemical potential, Determination of partial molar volume, Thermodynamics of mixing. Third law of thermodynamics, its experimental verification, Applications of third, Determination of absolute entropy.

Module 2: STATISTICAL THERMODYNAMICS — **15 hours**

Statistical mechanics of systems independent particles: Maxwell Boltzmann distribution, entropy and probability. Calculation of thermodynamic properties for independent particles, - molecular partition functions- evaluation of translational, rotational and vibrational and nuclear partition functions.

Thermodynamic properties of monatomic and diatomic gases (Suckur-Tetrode equation)- calculation of partition functions, thermodynamic function, principles of equipartition, heat capacities (Einstein model and Debye modification), residual entropy, equilibrium constant.

Module 3: SURFACE CHEMISTRY AND CATALYSIS — **10 hours**

Adsorption and free energy changes at interfaces-Solid-gas interface-Langmuir, BET isotherms-Surface area determination-soluble and insoluble film-Solid - liquid interfaces Gibbs adsorption isotherm-contact angle and wetting-applications of adsorption. Role of surface in catalysis-semiconductor catalysis-n and p-type surfaces. Specific and general acid base catalysis: Bronsted catalysis law-Hammett acidity functions. Enzyme catalysis: Michaelis Menten Law- Influence of pH and temperature on enzyme catalysis. Heterogeneous catalysis: Kinetics of bimolecular surface reactions-Langmuir-Hinshelwood mechanism, Langmuir Rideal mechanism and Rideal-Eley mechanism, Industrial applications of catalysts, Green catalysts

Module 4: SPECIAL TOPICS IN PHYSICAL CHEMISTRY — **8 hours**

Smart Materials-Introduction, design of intelligent materials, thermoresponsive, pH sensitive, light sensitive materials, smart polymers, shape memory alloys.

Nanomaterials-Concepts, 0D, 1D, 2D and 3D nanostructures, Fullerene, Carbon Nanotubes, Aerosols, Zeolites, Quantum dots, Carbon Dots, Applications in electronics, environment and energy, space and defense, medicine and health, textile and cosmetics.

Total Lecture hours **45 hours**

Physical Chemistry IV Laboratory **(30 hours)**

List of Laboratory Experiments

1. Purification by column chromatography
2. Characterization by Gas Chromatography
3. Adsorption of dye on activated carbon and analysis of result by different adsorption models.
4. Determination of adsorption kinetics of dye on activated carbon.
5. Preparation of Biochar (from Tea leaves, Bamboo etc.) and Study on dye degradation
6. Determination of turbidity, electrical conductivity and pH of given samples.
7. Preparation and characterization of nanoparticles by DLS etc.
8. Extraction of oil by using Soxhlet apparatus.
9. Determination of physico-chemical (Acid value, Saponification value, Iodine value) properties of oil.
10. Study of Saponification of oil
11. Preparation of Hydrogel and Characterization,
12. Study of adsorption kinetics of hydrogels.

** Other related experiments may also be introduced

Text Book(s)

1.	Levine I. R., Physical chemistry 6 th Edition, Mcgraw Hill Education, 2011.
2.	Atkins P., Paula J., Physical Chemistry, 9th Edition, Oxford University Press, Oxford 2010.
3.	McQuarrie D. A., Simon J. D., Physical Chemistry: A Molecular Approach, Viva Student Edition, 1st Edition, 2011.

Reference Books

1.	Thermodynamics: Statistical Thermodynamics and Kinetics by Thomas Engel and Philip Reid, Pearson
2.	McQuarrie, D. A. Statistical Mechanics, Viva Books Pvt. Ltd.: New Delhi (2003).
3.	Physical Chemistry: Thomas Engel and Philip Reid
4	Bagchi B. Statistical Mechanics for Chemistry and Material Science, CRC Press (2018).
5.	Landau L. D. and Lifshitz E. M., Statistical Mechanics, Part I, Butterworth- Heinemann, 3rd ed. (2005).
6.	Berry R. S., Rice S. A. and Ross J., Physical Chemistry, 2nd Edition, Oxford University Press, Oxford 2007.
7.	Puri B. R.; Sharma L. R., Pathania M. S., Principles of Physical Chemistry; 47th Ed, Vishal Publishing, New Delhi (2017).

	RESEARCH METHODOLOGY	L	T	P	C
		4	0	0	4

Pre-requisite: Knowledge of chemistry at (10+2) level

Course Objectives:

1. To introduce the students with the basic concepts of literature survey.
2. To give an insight into scientific research and writing scientific papers.
3. To familiarize students about chemical safety and handling of chemicals
4. To give an insight into data analysis methods in research.

Course Outcome:

After successful completion of the course, the students will be able
CO1: To explain the basic research methodology tools such literature survey, writing scientific papers, data analysis, chemical handling and safety.
CO2: To apply the knowledge of of data analysis, chemical safety and methods of scientific writing in research.
CO3: To discuss on literature survey, writing scientific papers, data analysis, chemical handling and safety.

MODULE 1: Literature Survey — **16 hours**

Print: Sources of information: Primary, secondary, tertiary sources; Journals: Journal abbreviations, abstracts, current titles, reviews, monographs, dictionaries, text-books, current contents, Introduction to Chemical Abstracts and Beilstein, Subject Index, Substance Index, Author Index, Formula Index, and other Indices with examples.
Digital: Web resources, E-journals, Journal access, TOC alerts, Hot articles, Citation index, Impact factor, H-index, i-10 index, other Scientometric indexes, ORCID, E-consortium, UGC infonet, E-books, Preprint servers, Search engines, Scirus, Google Scholar, Chem Industry, Wiki-Databases, Chem Spider, Science Direct, SciFinder, Scopus.
Information Technology and Library Resources: The Internet and World Wide Web. Internet resources for chemistry. Finding and citing published information.

MODULE 2: Methods of Scientific Research and Writing Scientific Papers — **16 hours**

Reporting practical and project work. Writing literature surveys and reviews. Organizing a poster display. Giving an oral presentation. Writing scientific papers – justification for scientific contributions, bibliography, description of methods, conclusions, the need for illustration, style, publications of scientific work. Ethics in research. Avoiding plagiarism.

MODULE 3: Chemical Safety and Handling of Chemicals — **13 hours**

Safe working procedure and protective environment, protective apparel, emergency procedure and first aid, laboratory ventilation. Safe storage and use of hazardous chemicals, procedure for working with substances that pose hazards, flammable or explosive hazards, procedures for working with gases at pressures above or below atmospheric – safe storage and disposal of waste chemicals, recovery, recycling and reuse of laboratory chemicals, procedure for laboratory disposal of explosives, identification, verification and segregation of laboratory waste, disposal of chemicals in the sanitary sewer system, incineration and transportation of hazardous chemicals.

MODULE 4: Data Analysis — **15 hours**

The Investigative Approach: Making and Recording Measurements. SI Units and their use. Scientific method and design of experiments.
Analysis and Presentation of Data: Descriptive statistics. Choosing and using statistical tests. Chemometrics. Analysis of variance (ANOVA), Correlation and regression, Curve fitting, fitting of linear equations, simple linear cases, weighted linear case, analysis of residuals, General polynomial fitting, linearizing transformations, exponential function fit, *r* and its abuse. Basic aspects of multiple linear regression analysis.

Total Lecture hours	**60 hours**
Text - Books	
1	Dean, J. R., Jones, A. M., Holmes, D., Reed, R., Weyers, J. & Jones, A. (2011) Practical skills in chemistry. 2nd Ed. Prentice-Hall, Harlow.
2	Hibbert, D. B. & Gooding, J. J. (2006) Data analysis for chemistry. Oxford University Press.
3	Topping, J. (1984) Errors of observation and their treatment. Fourth Ed., Chapman Hall, London.
4	Research methodology for Chemistry, Neha Rani Kumar, Tarun Kumari, Kalyani Publishers, 2022.
Reference Books	
1.	Harris, D. C. Quantitative chemical analysis. 6th Ed., Freeman (2007) Chapters 3-5.
2	Levie, R. de, How to use Excel in analytical chemistry and in general scientific data analysis. Cambridge Univ. Press (2001) 487 pages.
3	Chemical safety matters – IUPAC – IPCS, Cambridge University Press, 1992.
4	OSU safety manual 1.01.

	MEDICINAL CHEMISTRY	L	T	P	C
		3	0	2	4

Pre-requisite: Knowledge of chemistry at B.Sc. level

Course Objectives:

5. To make students aware of the historical background of drug.
6. To give knowledge about the mechanism and theoretical aspects of drug action.
7. To provide knowledge about Antibiotics.
8. To make students familiar with different types of drugs like antimalarials, diuretics, antivirals and anticancer drugs.

Course Outcome:

After successful completion of the course, the students will be able

CO1: To explain the historical development and theoretical aspects of different modern drugs, pro-drugs, and their uses.

CO2: To apply medicinal chemistry principles in defining the structure, activity, and mechanisms of different drugs.

CO3: To elaborate QSAR, SAR and mechanism of action of different drugs such as sulphonamides, antibiotics, antimalarials, Antitubercular and Anticancer drugs.

CO4: To apply the concepts of medicinal chemistry for performing different laboratory experiments of medicinal chemistry.

Module 1: Introduction & History of Drug Development — **8 hours**

Definition of drug and prodrugs, need of drugs, germ theory of diseases, history and chemistry of Aspirin, comparison to other analgesics, History and chemistry of Thalidomide, History and chemistry of sulphadrugs & their mode of action, about antibacterial agents.
Generic, name brand and OTC Drugs, Herbal drugs.

Module 2: Mechanism and Theoretical Aspects of Drug Action — **10 hours**

General mechanisms of action of antibacterial agents, SAR of sulfonamides, Sulfonamide analogues, analogues with reduced toxicity, applications of sulfonamides.

About receptors and the two-state model of receptor theory, drug-receptor interaction and Clark's Occupancy, Need of quantification of drug action, definition of chemotherapeutic index & therapeutic index, factors affecting bioactivity of drugs, pharmacokinetics and pharmacodynamics, QSAR.

Drug design, physio-chemical parameters used in QSAR such as Partition Co-efficient, Hammet's electronic parameter, Tafts steric parameter and Hansch analysis. Docking techniques, Combinatorial Chemistry.

Module 3: Antibiotics - A Major Group of Drugs — **12 hours**

Definition of antibiotics, their sources and classification, causes & concerns of bacterial resistance to antibiotics, Definition and need of broad-spectrum antibiotics.

History leading to the discovery of penicillins (β-lactam antibiotics) – natural & semi-synthetic penicillins, structure activity relationship & chemical modification.

Aminoglycoside antibiotics, their sources and uses, streptomycin, gentamycin, kanamycin, neomycin.

Tetracyclines-introduction and mechanism of action

Module 4: Antimalarials, Antitubercular and Anticancer Drugs — **15 hours**

Classification of human malaria and plasmodia responsible for human malaria, discovery of quinine and its SAR, importance of quinine as a lead to discovery of other low-cost antimalarials, artemisinin and its derivatives.
Antitubercular Drugs – Introduction, history, classification, symptoms of TB, TB treatment, First line and second line Antitubercular Drugs, mechanism of action of Isoniazid.
Anticancer Drugs-Introduction and uses of vinca alkaloids, Taxol.

Total Lecture hours **45 hours**

List of Laboratory Experiments **(30 hours)**

1.To perform phytochemical screening of unknown compound.
2.To perform the assay of paracetamol powder.
3.To perform assay of isoniazid.
4.To prepare chlorobutanol from acetone and chloroform.
5.To prepare sulfanilamide from aniline
6.To prepare hexamine from formaldehyde
7.To isolate caffeine from Tea
8.To isolate piperine from black peeper
9.To synthesize and characterize Dibenzal acetone from Benzaldehyde.
10.To characterize and prepare the calibration curve of a drug by using UV spectrophotometry.
11.To prepare a hydrogel and encapsulate drug.
12. To synthesize and characterize Benzilic acid from Benzil.

** Other related experiments may also be introduced

Text Book(s)

1. G. Thomas, Medicinal Chemistry: An Introduction, 2nd Edition. John Wiley & Sons, 2007
2. G. L. Patrick, An Introduction to Medicinal Chemistry, 5th Edition. , Oxford University Press, 2013.

Reference Books

1. A. Gringauz, Introduction to Medicinal Chemistry, Wiley India Pvt Ltd, 2010.
2. Medicinal Chemistry, D. Sriram and P. Yogeeswari, Pearson Education. (Dorling Kindersley India).
3. Medicinal Chemistry, Ashutosh Kar, New Age International (P) Limited.

MINOR ELECTIVE

	SUSTAINABLE CHEMISTRY	L	T	P	C
		3	0	2	4

Pre-requisite: Knowledge of Basic Science

Course Objectives:

The course is being offered with the following objectives:

1. To develop a fundamental understanding of the concepts, principles, and significance of sustainable and green chemistry.
2. To explain and apply the principles of green chemistry in designing safer, environmentally benign chemical processes and sustainable industrial practices.
3. To understand and promote the efficient use of renewable resources, waste minimization, circular economy concepts, and sustainable waste management strategies.
4. To appreciate and evaluate the role of chemistry in addressing environmental challenges, promoting sustainable technologies, and achieving the Sustainable Development Goals (SDGs).
5. To develop practical skills in green synthesis, natural product extraction, and water quality analysis using sustainable laboratory techniques while promoting environmental awareness and safe laboratory practices.

Course Outcome:

After successful completion of the course, the students will be able to:

CO1 : Explain the fundamental concepts and principles of sustainable chemistry and green chemistry. **(Understand)**

CO2: Apply the principles of green chemistry to design safer, environmentally friendly chemical processes and practices. **(Apply)**

CO3: Analyze the role of renewable resources, waste management, circular economy, sustainable energy, and pollution control strategies in achieving environmental sustainability. **(Analyze)**

CO4: Evaluate the contribution of chemistry in environmental protection, sustainable industrial development, and the achievement of the Sustainable Development Goals (SDGs). **(Evaluate)**

CO5 : Perform green synthesis, natural product extraction, and basic water quality analysis using standard laboratory techniques while demonstrating the principles of sustainable chemistry, environmental responsibility, and safe laboratory practices. **(Apply)**

Module 1: Introduction to Sustainable Chemistry	**9 hours**

Sustainable Development and Sustainable Development Goals (SDGs), Need for sustainable chemistry, Green chemistry and sustainable chemistry, Twelve Principles of Green Chemistry, Benefits of sustainable chemistry, Examples of green chemical processes

Module 2: Green Chemical Processes	**9 hours**

Green solvents and water as a solvent, Catalysis and biocatalysis, Microwave-assisted synthesis, Photochemical reactions (basic idea), Energy-efficient chemical processes, Applications of green chemistry in chemical industries

Module 3: Renewable Resources and Waste Management	**9 hours**

Renewable and non-renewable resources, Biomass and biofuels, Biodegradable and biodegradable alternatives to plastics, Recycling and reuse of materials, Electronic waste (E-waste), Circular economy, Waste minimization and resource conservation

Module 4: Sustainable Energy and Environmental Protection	**9 hours**
Solar energy, Hydrogen as a clean fuel, Fuel cells (basic concepts), Green batteries, Air pollution and its control, Water pollution and its control, Carbon footprint and climate change (basic concepts)	
Module 5: Applications of Sustainable Chemistry	**9 hours**
Sustainable agriculture and green fertilizers, Green pharmaceuticals, Green nanotechnology (basic idea), Sustainable household chemicals, Environmental laws and chemical safety (basic concepts), Case studies: - Bhopal Gas Disaster, Biodegradable plastics, Plastic waste management, Sustainable packaging	
Total Lecture hours	**45 hours**

LABORATORY EXPERIMENTS (Total Lab Hours: 30)

1. Extraction of natural indicators from plant materials.
2. Extraction of essential oils using steam distillation.
3. Synthesis of soap from waste cooking oil.
4. Preparation of Biodiesel from vegetable oil.
5. Preparation of biodegradable polymer (starch-based plastic).
6. Extraction of Natural Dyes from Plant Materials
7. Determination of pH of Natural Water Samples
8. Measurement of Electrical Conductivity (EC) of water samples
9. Measurement of Total Dissolved Solids (TDS) of water samples
10. Determination of Alkalinity of Water
11. Estimation of Dissolved Oxygen (DO) in water.

Text Book(s)

1.	Paul T. Anastas and John C. Warner, Green Chemistry: Theory and Practice, Oxford University Press, New York.
2.	Mike Lancaster, Green Chemistry: An Introductory Text, Royal Society of Chemistry (RSC Publishing), Cambridge, UK.
3.	Stanley E. Manahan, Environmental Chemistry, CRC Press, Taylor & Francis Group.
4.	B.K. Sharma, Environmental Chemistry, Krishna Prakashan Media (P) Ltd., Meerut.
5.	V.K. Ahluwalia, Green Chemistry, Narosa Publishing House Pvt. Ltd., New Delhi.
6.	James H. Clark and Duncan Macquarrie, Handbook of Green Chemistry and Technology, Blackwell Science Ltd. (now Wiley-Blackwell).

Reference Books

1.	Albert Matlack, Introduction to Green Chemistry, CRC Press, Taylor & Francis Group.
2.	Indu Tucker Sidhwani & Rakesh K. Sharma, An Introductory Text on Green Chemistry, Wiley India Pvt. Ltd.
3.	Vera M. Kolb, Green Organic Chemistry and Its Interdisciplinary Applications, CRC Press, Taylor & Francis Group.

Minor Elective

	Chemistry of Polymers	L	T	P	C
		3	0	2	4

Pre-requisite: Knowledge of chemistry at (10+2) level

Course Objectives:

The course is being offered with the following objectives:

1. To provide basic concept of polymer chemistry, mechanisms and techniques of polymerization.
2. To offer concept of polymer processing techniques.
3. To deliver in depth knowledge of polymer analysis and characterization.
4. To provide knowledge of commodity and engineering industrial polymers.

Course Outcome:

After successful completion of the course, the students will be able to

CO1: Explain about basic chemistry, mechanisms, techniques, processing, properties, and analysis of polymers.

CO2: Apply the understanding of polymer chemistry for different polymer synthesis, their characterization, processing, and applications.

CO3: Elaborate the methods of synthesis, properties, behaviors and applications of industrially important polymers.

CO4: To apply the concepts of polymer chemistry for performing different laboratory experiments of polymer chemistry.

Module 1: Concepts of High Polymer Systems, Rheology and Morphology — **10 hours**

Overview of raw materials for polymers, gas cracker, naphtha cracker, synthesis of some industrially important monomers. Techniques of polymerization, advantages and limitations of different techniques, special features of polymerization, polymerization reactors.

Molecular weight distribution and control of molecular weight.

Structure-property relationships in polymers, Glass transition temperature of polymers, molecular basis of Tg.

Polymer Rheology, Theories of viscoelastic behavior of polymers,

Mechanical models: Maxwell model, Kelvin-Voigt model, Burgers Model.

Polymer crystallization, Polymer Single Crystals, Spherulites

Module 2: Polymer Processing — **10 hours**

Plastic Molding methods, Compression molding, Transfer molding, Injection molding, Blow molding, Reaction injection molding, Extrusion, Single screw and twin-screw extrusion, Calendaring, Rotational molding, Thermoforming, Rubber processing in two-roll mill, Internal mixer.

Module 4: Testing, Analysis, and Characterization of Polymers — **10 hours**

Determination of molecular weight and molecular weight distribution, GPC, light scattering, end group analysis method, Analysis involving spectroscopy, X-ray diffraction analysis – Thermogravimetric Analysis (TGA), Differential thermal analysis (DTA), Differential Scanning Calorimetry (DSC), Microscopic (Optical and Electronic) techniques.

Testing of Mechanical strength, Tensile strength, Flexural and Compressive strength, Toughness, Elastic and plastic deformation, stress-strain relationship, Testing of Abrasion, Adhesion testing, testing of Endurance, Fatigue, Hardness, Tear, Resilience, Izod and Charpy Impact tests, Ageing resistance, Environmental stress cracking resistance, testing for biodegradability.

Module 5: Synthesis and Properties of Industrially Important Polymers — **15 hours**

Commodity, Engineering and Speciality Plastics.

Synthesis, Structure-property relation and applications of

Commodity Plastics: Polyethylene (LDPE, HDPE, LLDPE), Polypropylene, Polystyrene,

HIPS, Poly(vinyl chloride) etc., methods of their synthesis and properties.
Engineering plastics: Poly(acrylonitrile), Polyamides, Polyesters, Polyurethanes, poly(tetrafluoroethylene), etc. and their properties.
Industrial thermosetting resins: phenolic resins, amino-resins, alkyds, unsaturated polyesters, polyurethanes, epoxy resins etc.
Biobased and bio-degradable polymers. Polymers in 3D printing.
Plastic waste management-current scenario, recycling and upcycling strategies.
Integrated waste management for sustainable development.

Total Lecture hours	**45 hours**
List of Laboratory Experiments	**30 hours**

(min eight experiments chosen from below)
1. To prepare hexamine from formaldehyde
2. Microwave-stimulated synthesis of ethylbenzene and styrene.
3. Synthesis of Polyaniline.
4. Preparation of epoxy and other resins.
5. Determination of molecular weight of a polymer by SEC/GPC/Viscometry method.
6. Preparation of a test sample by processing through Injection moulding.
7. Determination of mechanical property of a polymer and study of stress-strain behaviour.
8.Characterization of a given sample by using thermal analysis techniques.
9. Study of non-Newtonian polymer solutions by Brookfield viscometer
10. Characterization of a given polymer sample by using XRD techniques.
11. Design and 3D Printing by using polymers.
12. Study of Rheological behavior of polymers
***any other related experiments

Text Book(s)

1.	F.W. Billmeyer, Jr.(1984) “Text Book of Polymer Science” 3rd Edition, Willey – Interscience, New York.
2.	P. Ghosh, Polymer Science and Technology: Plastics, Rubbers, Blends and Composites, Third Edition, McGraw Hill Education Private Limited (India), 2011
3.	J. A. Brydson, Plastics Materials, 4th edn., Butterworths, London, 1982
4.	1. Odian, G. Principles of Polymerization (Wiley, 2004).

Reference Books/Journals

1.	Charrier, J. (1991) Polymeric Materials and Processing: Plastics,Elastomers and Composites. München: Carl Hanser Verlag.
2	Polymer Rheology and Processing, A.A. Collyer, Leszek A. Utracki; Springer, 1990.
3	R.F. Speyer, Thermal Analysis of Materials, Marcel Decker, 1994.
4	Yang Leng: Materials Characterization-Introduction to Microscopic and Spectroscopic Methods, John Wiley & Sons (Asia) Pte Ltd., 2008.
5	Journal of Chemical Education, ACS Publications

Minor Elective

	INDUSTRIAL CHEMICALS AND ENVIRONMENT	L	T	P	C
		3	0	2	4

Pre-requisite: Knowledge of Basic Science

Course Objectives:

The course is being offered with the following objectives:

1. To introduce the fundamental concepts of industrial chemistry, industrial raw materials, manufacturing processes, material and energy balance, and industrial safety practices.
2. To develop an understanding of the manufacturing processes, properties, applications, and environmental aspects of major industrial chemicals, fertilizers, cement, glass, polymers, petroleum products, and pharmaceuticals.
3. To familiarize students with the petroleum, petrochemical, pharmaceutical, food, and cosmetic industries, including quality control measures, good manufacturing practices (GMP), and industrial applications.
4. To create awareness of industrial pollution, waste management, pollution control technologies, environmental impact assessment (EIA), and sustainable industrial practices for environmental protection and sustainable development.

Course Outcome:

After successful completion of the course, the students will be able to:

CO1: Explain the scope of industrial chemistry, industrial raw materials, unit operations, unit processes, material and energy balance concepts, and essential industrial safety practices. **(Understand)**

CO2: Apply the principles of industrial chemical manufacturing to describe the production processes of major industrial chemicals, fertilizers, cement, glass, polymers, petroleum products, and pharmaceuticals. **(Apply)**

CO3: Analyze the processing, refining, quality control, and industrial applications of petroleum, petrochemicals, pharmaceutical products, food additives, and cosmetic products, relating them to industrial practices. **(Analyze)**

CO4: Evaluate the environmental impacts of industrial activities by assessing pollution sources, waste management strategies, pollution control technologies, environmental impact assessment (EIA), carbon footprint, and sustainable industrial practices. **(Evaluate)**

CO5: Apply industrial chemistry principles and laboratory techniques to perform experiments and interpret results. (Apply)

Module 1: Introduction to Industrial Chemistry	**12 hours**

Introduction - Definition and scope of industrial chemistry, Industrial Raw Materials - Mineral resources, Petroleum, Natural gas, Coal, Water, Renewable and non-renewable resources, Industrial Processes - Unit operations and unit processes, Batch and continuous processes, Flow diagrams, Material balance (basic concept), Energy balance (basic concept), Industrial Safety - Chemical hazards, Fire and explosion hazards, Safety symbols and labels, Personal Protective Equipment (PPE), Safe handling and storage of chemicals.

Module 2: Manufacture of Industrial Chemicals	**12 hours**

Heavy Chemicals - Manufacture of sulphuric acid (Contact Process), Manufacture of ammonia (Haber Process), Manufacture of nitric acid (Ostwald Process), Manufacture of sodium carbonate (Solvay Process), Fertilizer Industry - Nitrogenous fertilizers, Phosphatic fertilizers,

Potassic fertilizers, Compound fertilizers, Cement and Glass Industries - Raw materials, Manufacturing process, Types and applications, Environmental issues, Polymer Industry - Manufacture of polyethylene, PVC, Polystyrene, Biodegradable plastics (basic idea).	
Module 3: Petroleum, Petrochemicals and Pharmaceutical Industries	**11 hours**
Petroleum Industry - Composition of crude oil, Fractional distillation, Petroleum refining, Cracking, Reforming, Petrochemical products, Fuels – LPG, CNG, Biofuels, Hydrogen fuel, Fuel quality, Pharmaceutical Industry - Bulk drugs, Active Pharmaceutical Ingredients (APIs), Good Manufacturing Practices (GMP), Quality control, Food and Cosmetic Industries - Food additives, Preservatives.	
Module 4: Industrial Pollution and Environmental Impact	**10 hours**
Industrial Pollution - Sources of industrial pollution, Air pollution, Water pollution, Soil pollution, Industrial Waste - Solid waste, Liquid waste, Hazardous waste, Pollution Control - Air pollution control devices, Wastewater treatment, Solid waste management, Recycling and resource recovery, Environmental Impact - Environmental Impact Assessment (EIA), Carbon footprint, Greenhouse gases, Global warming.	
Total Lecture hours	**45 hours**

LABORATORY EXPERIMENTS (Total Lab Hours: 30)

1. Determination of acidity of commercial vinegar.
2. Determination of alkalinity of washing soda.
3. Estimation of chloride in water by argentometric method.
4. Determination of total dissolved solids (TDS) in water.
5. Determination of pH of drinking and industrial water samples.
6. Determination of dissolved oxygen (DO) in water.
7. Determination of turbidity of water samples.
8. Determination of Saponification Value of Oil
9. Determination of Acid Value of an Industrial Oil
10. Preparation of eco-friendly liquid soap.
11. Extraction of essential oil from orange/lemon peel by steam distillation.
12. Extraction of natural dyes from flowers, spinach, turmeric, or onion peel.
13. Estimation of Vitamin C in fruit juices by iodometric titration.

Text Book(s)

1.	B. K. Sharma, Industrial Chemistry, Goel Publishing House, Meerut.
2.	B. K. Sharma, Environmental Chemistry, Krishna Prakashan Media Pvt. Ltd.
3.	Shashi Chawla, A Textbook of Engineering Chemistry, Dhanpat Rai Publications.
4.	V. K. Ahluwalia, Environmental Chemistry, Ane Books India.

Reference Books

1.	M. Gopala Rao and Marshall Sittig, *Outlines of Chemical Technology,* Khanna Publishers, New Delhi
2.	George T. Austin, *Chemical Process Industries,* McGraw-Hill Education
3.	Stanley E. Manahan, *Environmental Chemistry,* CRC Press (Taylor & Francis Group)

	Chemistry of Food	L	T	P	C
		3	0	2	4

Pre-requisite: Knowledge of Basic Science

Course Objectives:

1.To make students aware of basics of food science.
2.To provide knowledge about food additives and storage and preservation.
3.To make students aware of the different components of food.

Course Outcome:

After successful completion of the course, the students will be able to

CO1: understand the basics of food chemistry.
CO2: apply the principles and techniques for analysis of food.
CO3: analyze food composition, additives and techniques to find solutions.
CO4: Apply experimental methods to evaluate different parameters of food.

Module 1: INTRODUCTION TO FOOD SCIENCE — **12 hours**

Basic food groups, Functions of food, food guide pyramid, food in relation to health, composition of wheat, rice. Composition of milk and milk products, milk proteins, Factor affecting composition of milk, food and nutritive value.

Module 2: FOOD ADDITIVES, ADULTERANTS AND CONTAMINANTS — **12 hours**

Different types of Food Additives and their functions, Food preservatives, Artificial sweeteners, Artificial Flavours, monosodium glutamate.
Introduction to adulteration, incidental additives or contaminants, adulterants in some common food items like coffee powder, chili powder, turmeric powder, coriander powder, and pulses.
Artificial food colorants - Coal tar dyes and non-permitted colours and metallic salts.

Module 3: FATS AND OILS — **8 hours**

Essential oils and sources, some oils with characteristic fatty acids, Hydrogenation of oil, rancidity, unsaponifiable matter in animal fat, comparison of vegetable oil with special reference to blood cholesterol level.

Module 4: VITAMINS AND MINERALS — **9 hours**

Vitamins: Introduction, sources, classification: water soluble and water insoluble vitamins, essential vitamins, physiological function, deficiencies, causes of variation and loss in foods, vitamins like compounds, and effect of food processing. Minerals: Introduction, sources, classification: major minerals and trace elements, physiological function, deficiencies, factors affecting mineral content of food, fortification and enrichment of foods with minerals.

Module 5: Natural Food Pigments — **4 hours**

Introduction and classification, Types of food pigments (chlorophyll, carotenoids, anthocyanins and flavonoids, beet pigments, caramel)

List of Laboratory Experiments: **30 hours**

1. Detection of adulterants in different food items
   (a) Milk
   (b) Turmeric
   (c) Cane sugar
   (d) Common salt
   (e) Mustard oil
   (f) Ghee and Butter

(g) Coffee
(h) Cereals and pulses

2. Qualitative test for carbohydrates, amino acids, proteins.
3. Isolation of casein and lactose from milk.
4. Extraction of caffeine from tea leaves.

Textbook(s)	
1	B. Srilakshmi, "Food science, Seventh Edition".
2	S. Manay, "Food: Facts and Principles
3	S. Sehgal, "A Laboratory Manual of Food Analysis".
4	Food Science – Srilakshmi, New Age international (P) Limited, New Delhi
Reference Books	
1	J.M. de Man, "Principles of Food Chemistry"
2	H.D. Belitz, W. Grosch and P. Schieberle, "Food Chemistry".
3	Food Facts and Principles Many N. S. & Shadakshasawamy M. New Age International Publishers.
4	Comprehensive Practical Organic Chemistry Qualitative Analysis, V K Ahluwalia, Sunita Dhingra.

	ORGANIC CHEMISTRY – IV	L	T	P	C
		3	0	2	4

Pre-requisite: B. Sc knowledge in Chemistry

Course Objectives:

1. To provide knowledge of the generation and application of different reaction intermediates in organic synthesis.
2. To give a comprehensive idea of various oxidizing agents used in organic transformations.
3. To discuss different reduction reactions.
4. To make students familiar with kinetics of reaction mechanism.
5. To make students familiar with laboratory techniques.

Course Outcome:

After successful completion of the course, the students will be able to

CO1-understand the chemistry of reaction intermediates and reactivity, oxidation, reduction and kinetics of reaction mechanism.

CO2-apply the knowledge gained to identify suitable reagents and reactive intermediates for various reactions as well as kinetics of reaction mechanism.

CO3- analyze the reactivity of reaction intermediates along with the different approaches to oxidation, reduction and kinetics of reaction mechanism to draw conclusions.

CO4- evaluate the reagents, intermediates and reaction pathways to defend conclusions.

CO5-To apply laboratory techniques and analytical methods to find conclusions.

Module 1: REACTION MECHANISMS & INTERMEDIATES: STRUCTURE & REACTIVITY – II	**12 hours**

Carbenes and Nitrenes: Structure of carbenes, generation of carbenes, addition and insertion reactions, rearrangement reactions of carbenes such as Wolff rearrangement, generation and reactions of ylids, structure of nitrene, generation and reactions of nitrene and related electron deficient nitrogen intermediates, Curtius, Hoffmann, Schmidt, Beckmann rearrangement, Tebbeolefination reactions.

Radicals: Generation of radical intermediates and its (a) addition to alkenes, alkynes (inter &intramolecular) for C-C bond formation and Baldwin's rules (b) fragmentation and rearrangements.

Module 2: OXIDATION REACTIONS	**12hours**

Oxidation: Metal and non-metal-based oxidations of alcohols to carbonyls (Chromium, manganese, aluminium, silver, DMSO and hypervalent iodine). Oxidation of phenols: Fremy's salt, alkenes to epoxides: via halohydrin, peroxides/per acids based, Sharpless asymmetric epoxidation; alkenes to diols (Manganese, osmium-based reagents), Prevost reaction and Woodward modification; oxidation of alkyl or alkenyl fragments: selenium dioxide, ketones to ester/lactones: Baeyer-Villiger oxidation.

Module 3: REDUCTION REACTIONS	**12 hours**

Reduction: Catalytic hydrogenation (Heterogeneous: Palladium/ Platinum/ Rhodium/ Nickel etc. Homogeneous: Wilkinson catalyst); metal-liquid ammonia processes: Birch reduction, Pinacol formation etc.; stereo selection and mechanism of the following reagents: Lithium aluminium hydride, L-selectride, K-selectride, sodium borohydride, DIBAL, sodium cyanoborohydride, alkyl borane, non-metallic reducing agents: diimide.

Module 4: Kinetics and Energetics of Reaction Mechanism	**9 hours**
TS theory of reaction rates: kinetics & thermodynamics requirements. Hammond postulate, Curtin-Hammett Principle; kinetic and thermodynamic control. Linear free energy relationships (LFER): Hammett equation.	
Total Lecture hours	**45 hours**

List of Laboratory Experiments **30 hours**

1. Chromatography Experiments-
   (i) Separation of a mixture of three amino acids by paper chromatography.
   (ii) Purification of binary mixtures by Thin Layer Chromatography (TLC).
2. Experiments on Natural products:
   (i) Extraction of natural products - Caffeine, Lycopene, Citral, carotenoids
3. Synthesis
   (i) 2,4-dinitrophenylhydrazone from 2, 4 dinitrophenylhydrazine
   (ii) Cinnamic acid from Benzaldehyde and malonic acid.
   (iii) Preparation of dye
   (iv) Benzilic acid from benzil
4. Preparation of organic compounds involving the following representative reactions
   (i)Oxidation
   (ii) Reduction

*Other related experiments may be introduced

Text Book(s)

1.	Cary F. A., Sundberg R. I., Advanced Organic Chemistry, Part A and B, 5th Edition,Springer, 2009.
2.	Smith M. B., Organic Synthesis, 4th Ed., Academic Press, Cambridge, Massachusetts,2016.
3.	Carruthers W. and Coldham I., Modern Methods of Organic Synthesis, First South AsianEdition, 2005, Cambridge University Press.
4.	Greeves N., Clayden J.,Warren S., Organic Chemistry, 2nd Ed., Oxford University Press,New Delhi, 2012.
5.	Anslyn E. V., Dougherty D. A., Modern Physical Organic Chemistry, University Science Books, 2005.
6.	Furniss B. S., Hannaford A. J., Smith P. W. G., Vogel's Textbook of Practical Organic
7	Ahluwalia V. K., Dhingra S., Comprehensive Practical Organic Chemistry, University Press
	Reference Books
1.	Smith M. B., March J., March's Advanced Organic Chemistry: Reactions, Mechanisms and Structure, 7th Ed., Wiley India, New Delhi, 2015.
2.	Carruthers W., Modern Methods of Organic Synthesis, 4th Ed., Cambridge University Press, New Delhi, 2005.
3.	Zweifel G. S., Nantz M. H., Somfai P., Modern Organic Synthesis: An Introduction, 2nd Ed., Wiley-Blackwell, New York, 2017.

4.	Morrison R. T., Boyd R. N., Bhattacharjee S. K., Organic Chemistry, 7th Edition, Pearson Education India, 2010.
5.	Solomons T. W. G., Fryhle C. B., Snyder S. A., Organic Chemistry, 12th Edition, Wiley, 2017.
6.	Harmata M., Strategies and Tactics in Organic Synthesis, Volume 4, Academic Press, 2004.
7.	Lowry T. H., Richardson K. S., Mechanism and Theory in Organic Chemistry, 3rd Edition, Pearson, 1997.

	INORGANIC CHEMISTRY - V	L	T	P	C
		3	0	2	4

Pre-requisite: Knowledge of Basic Science

Course Objectives:

The course is being offered with the following objectives:

1. To develop a comprehensive understanding of the mechanisms of inorganic reactions, including substitution and redox reactions, stability concepts, and factors influencing the reactivity of coordination compounds.
2. To provide knowledge of the structure, bonding, synthesis, and properties of boranes, organoboron compounds, inorganic polymers, crown ethers, cryptands, metal chalcogenides, and other advanced inorganic materials.
3. To familiarize students with the chemistry of lanthanides and actinides, including their electronic structure, periodic trends, extraction methods, coordination chemistry, and technological applications.
4. To impart a thorough understanding of the synthesis, bonding, reactivity, and catalytic applications of organometallic compounds, with emphasis on industrially important catalytic processes and modern synthetic methodologies.
5. To develop practical skills in qualitative and quantitative inorganic analysis, synthesis of coordination compounds, and volumetric estimation techniques using standard laboratory procedures while fostering accuracy, scientific reasoning, and safe laboratory practices.

Course Outcome:

After successful completion of the course, the students will be able to:

CO1: Explain the concepts of kinetic and thermodynamic stability, substitution and redox reaction mechanisms, stability constants, and the factors governing the reactivity of coordination compounds. **(Understand)**

CO2: Apply Wade's rules, electron counting methods, and bonding theories to interpret the structure, properties, and reactivity of boranes, organoboron compounds, inorganic polymers, crown ethers, cryptands, and other descriptive inorganic compounds. **(Apply)**

CO3: Analyze the electronic configuration, periodic trends, magnetic and spectral properties, extraction methods, and coordination chemistry of lanthanides and actinides. **(Analyze)**

CO4: Evaluate the synthesis, bonding, reactivity, and catalytic applications of organometallic compounds, including metal carbonyls, metallocenes, and transition metal-catalyzed industrial processes such as hydrogenation, hydroformylation, the Monsanto process, Wacker process, olefin metathesis, and Suzuki coupling reaction. **(Evaluate)**

CO5: Apply qualitative and quantitative analytical techniques and synthesize coordination compounds to identify, estimate, and characterize inorganic substances with accuracy while demonstrating safe and ethical laboratory practices. **(Apply**)

Module 1: MECHANISM OF INORGANIC REACTIONS	**10 hours**

Kinetic and thermodynamic stability, Lability and inertness, Stability Constants, Mechanistic pathways of Substitution reactions in octahedral and square planer complexes, Trans effect and its application to the synthesis of metal complexes, Inner sphere and outer sphere mechanisms of Redox Reactions.

Module 2: DESCRIPTIVE INORGANIC CHEMISTRY	**17 hours**
Structure and bonding in polyhedral boranes, carboranes and heterocarboranes, electron count in polyhedral boranes – styx numbering, Wade's rules – polyhedral skeletal electron pair theory (PSEPT), synthesis of polyhedral boranes. The hydroboration reaction, organoboranes such as boronic acids, tetrahydridoborates, boron nitride, borazines and borazines. Reactivity of lithium aluminium hydride; alkyl aluminium compounds; chemistry of Al, Ga, In and Tl in +1 and +2 oxidation states.Fullerenes and fullerides, nonmolecular compounds of carbon, clays and zeolites; organo compounds of Si, Ge, Sn and Pb; phosphates, metaloxo compounds, calixarenes, cryptands and crown ethers in complexation chemistry, metal chalcogenides. Properties of inorganic polymers, polysilanes (Si–Si bonds), polysiloxanes (Si–O bonds, or silicones), polysilazanes (Si–N bonds).	
Module 3: LANTHANIDES AND ACTINIDES	**8 hours**
Electronic configuration, lanthanide/ actinide contraction and consequences, magnetic and spectral properties, various physical and chemical properties, stability of lanthanide/actinide complexes, occurrence and extraction of lanthanides and actinides.	
Module 4: ORGANOMETALLIC CHEMISTRY	**10 hours**
Synthesis, structure, bonding and reactivity of mono and polynuclear metal carbonyls. Substituted metal carbonyls. Types of M-C bonds, Calculation of M-C bonds in complexes, synthesis and reactivity of metal alkyls, carbenes, alkenes, alkynes, and arene complexes; metallocenes and bent metallocenes. Reactions of organometallic complexes: substitution, oxidative addition, reductive elimination, insertion and deinsertion; catalysis: hydrogenation, hydroformylation.	
Total Lecture hours	**45 hours**

LABORATORY EXPERIMENTS (Total Lab Hours : 30)

1. Qualitative analysis of tertiary mixture, alloy, ore.
2. Quantitative analysis (binary mixture, alloy, ore) - Ca-Mg ore, Cu-Zn alloy, Pb-Sn alloy, Ni in an alloy, steel etc.
3. Synthesis of co-ordination compounds
(i) Potassium trioxalato ferrate(III) trihydrate, $K_3[Fe(C_2O_4)_3].3H_2O$
(ii) Cis- and trans-dichloro bis (ethylene diamine) cobalt (III) chloride $[Co(en)_2Cl_2]Cl$
(iii) Potassium dioxalato cuprate (II) dihydrate $K_2[Cu(C_2O_4)_2(H_2O)_2]$
(iv)Synthesis of Pentaamminechloro cobaltic(III) chloride $[Co(NH_3)_5Cl]Cl_2$
(v) Synthesis of Pentaammine nitro cobaltic(III) chloride $[Co(NH_3)_5NO_2]Cl_2$
(vi) Synthesis of Pentaammine nitrito cobaltic(III) chloride $[Co(NH_3)_5ONO]Cl_2$
4. Determination of concentration of components in a mixture
(i) Estimation of FeII and FeIII in a mixture.
(ii) Estimation of Na_2CO_3 and $NaHCO_3$ in a mixture.

Text Book(s)

1.	Lee, J.D. Concise Inorganic Chemistry ELBS, 1991
2.	P. W. Atkins, T. Overton, J. Rourke, M. Weller, F. Armstrong; Shriver & Atkins' Inorganic Chemistry, 5th Ed. Oxford University Press, 2010.
3.	J. E. Huheey, E. A. Keiter and R. L. Keiter; Inorganic Chemistry: Principles of Structure and Reactivity, 4th Ed. Pearson Education, 2006

Reference Books

1.	F. A. Cotton, G. Wilkinson, C. A. Murillo and M. Bochmann; Advanced Inorganic Chemistry, 6th ed. Wiley, 1999
2.	Fundamental Concepts of Inorganic Chemistry, Vols. 1-7, by A.K. Das and M. Das, CBS Publishers and Distributors, 2015

3.	G. L. Miessler, D Tarr; Inorganic Chemistry. 3rd Ed., Pearson Education, 2004.
4.	C. Elschenbroich, A. Salzer, Organometallics: A Concise Introduction, 2 nd Ed. Wiley VCH, 1995.
5.	R. H. Crabtree, Organometallic Chemistry of the Transition Metals 2nd Ed., John Wiley, 1993.

	PHYSICAL CHEMISTRY – V	L	T	P	C
		3	0	2	4

Pre-requisite: Knowledge of chemistry at (10+2) level

Course Objectives:

1. To introduce the student with the basic concepts of chemical kinetics.
2. To give an insight into molecular reaction dynamics.
3. To introduce the students with the basic concepts of polymer chemistry.
4. To make students familiar with data analysis.

Course Outcome:

After successful completion of the course, the students will be able

CO1: To explain the fundamentals laws, rules and theories related chemical kinetics, molecular reaction dynamic, electrical interface, polymerization kinetics and data analysis.

CO2: To apply theories of chemical kinetics, molecular reaction dynamics, polymers, sampling, and data analysis in various systems.

CO3: To elaborate different processes and mechanisms in chemical kinetics, molecular reaction dynamics, corrosion and polymers.

CO4: To apply the concepts of physical chemistry for performing different laboratory experiments in physical chemistry.

Module 1: MOLECULAR REACTION DYNAMICS — **12 hours**

Collisions of real molecules- trajectory calculations, Laser techniques, reactions in molecular beam, reaction dynamics, estimation of activation energy and calculation of potential energy surface- the transition state theory (TST) of bimolecular gaseous reactions. Comparison between transition state theory and hard sphere collision theory. Diffusion controlled reactions; kinetics of reactions in solution diffusion controlled and chemically controlled reactions.

Module 2: THEORIES OF UNIMOLECULAR REACTIONS — **7 hours**

Theory of unimolecular reactions Lindemann theory and its drawbacks, Hinselwood modification, RRK theory, slaters treatment, RRKM theory.

Module 3: THEORIES OF ELECTRICAL INTERFACE — **10 hours**

Electrocapillary phenomena- Lippmann equation, electron transfer at interfaces, polarizable and non-polarizable and nonpolarizable interfaces, Butler-Volmer equation, Tafel plot.
Electrode Processes, Mechanism of electrode reactions, mechanism of hydrogen evolution and oxygen evolution reactions. Corrosion of Metals – mixed potential mechanism – different types of corrosion – methods protection of metals from corrosion.

Module 4: CHEMICAL KINETICS — **10 hours**

Mechanisms of complex reactions, Steady state approximation, kinetics of straight-chain reaction, branching-chain reactions, enzyme catalyzed reactions, reactions in solutions, diffusion-controlled reactions in solutions, influence of ionic strength in reaction rates, kinetics of fast reactions, potential energy surfaces. Kinetics of polymerization reaction, molecular weight determination, copolymerization, average dimension of polymer molecules, size exclusion Chromatography and gel permeation chromatography.

Module 5: SAMPLING AND DATA ANALYSIS — **6 hours**

Sampling of solid, liquid and gaseous samples, mean and standard deviation, absolute and relative errors, linear regression, covariance and correlation coefficient, t-test and f-test.

Total Lecture Hours — **45 hours**

List of Laboratory Experiments **(30 hours)**

Experiments include Purification of chemicals, calibration of analytical instruments through Analysis of error, primary and secondary data, accuracy and precision, averaging of data etc.,

Handling of basic instruments, e.g., potentiometer, conductivity meter, spectrophotometer, etc., through eight experiments chosen from below.

Synthesis and Analysis:

1. Determination of alkalinity of water sample
2. Determination of average molecular weight of a polymer by viscometry method.
3. Study the kinetics of hydrolysis of methyl acetate and determine the energy of activation.
4. Study of the autocatalytic reaction between oxalic acid and KMnO4 and determination of the order of the reaction.
5. Study of the kinetics of reaction between iodine and acetone in acidic medium by half-life period method and determination of the order with respect to iodine and acetone.
6. Investigation of the inversion of cane sugar in presence of acid and hence determination of the activation energy of the reaction.

Instrumental methods

7. Characterization of a given sample by using spectroscopic techniques.
8. Characterization of a given sample by using thermal analysis techniques.
9. To study the kinetics of polymerization of styrene by dilatometric method.
10. Study of non-Newtonian polymer solutions by Brookfield viscometer
11. To prepare a graphical representation of a given data set.
12. To test data set by using one way ANOVA technique.

** Other related experiments may also be introduced

Text Book(s)

1.	Levine I. R., Physical chemistry 6 th Edition, Mcgraw Hill Education, 2011.
2.	Atkins P., Paula J., Physical Chemistry, 9th Edition, Oxford University Press, Oxford 2010.
3.	McQuarrie D. A., Simon J. D., Physical Chemistry: A Molecular Approach, Viva Student Edition, 1st Edition, 2011.
4.	V. R. Gowarikar, N. V. Viwanathan, J. Sreedhar, Polymer Science, 1st Edition, New age International Publishers, 1986.

Reference Books

1.	Physical Chemistry: Thomas Engel and Philip Reid
2.	Bagchi B. Statistical Mechanics for Chemistry and Material Science, CRC Press (2018).
3.	Landau L. D. and Lifshitz E. M., Statistical Mechanics, Part I, Butterworth- Heinemann, 3rd ed. (2005).
4.	Berry R. S., Rice S. A. and Ross J., Physical Chemistry, 2nd Edition, Oxford University Press, Oxford 2007.
5.	Puri B. R.; Sharma L. R., Pathania M. S., Principles of Physical Chemistry; 47th Ed, Vishal Publishing, New Delhi (2017).
6	Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry 8th Ed., McGraw-Hill: New York (2003).
7	Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H. Freeman & Co., New York (2003).

	Reactivity, Organic Transformations and Kinetics	L	T	P	C
		4	0	0	4

Pre-requisite: B. Sc knowledge in Chemistry

Course Objectives:

6. To provide knowledge of the generation and application of different reaction intermediates in organic synthesis.
7. To give a comprehensive idea of various oxidizing agents used in organic transformations.
8. To discuss different reduction reactions.
9. To make students familiar with kinetics of reaction mechanism.

Course Outcome:

After successful completion of the course, the students will be able to

CO1-understand the chemistry of reaction intermediates and reactivity, oxidation, reduction and kinetics of reaction mechanism.

CO2-apply the knowledge gained to identify suitable reagents and reactive intermediates for various reactions as well as kinetics of reaction mechanism.

CO3- analyze the reactivity of reaction intermediates along with the different approaches to oxidation, reduction and kinetics of reaction mechanism to draw conclusions.

CO4- evaluate the reagents, intermediates and reaction pathways to defend conclusions.

Module 1: REACTION MECHANISMS & INTERMEDIATES: STRUCTURE & REACTIVITY – II — **15 hours**

Carbenes and Nitrenes: Structure of carbenes, generation of carbenes, addition and insertion reactions, rearrangement reactions of carbenes such as Wolff rearrangement, generation and reactions of ylids, structure of nitrene, generation and reactions of nitrene and related electron deficient nitrogen intermediates, Curtius, Hoffmann, Schmidt, Beckmann rearrangement, Tebbeolefination reactions.

Radicals: Generation of radical intermediates and its (a) addition to alkenes, alkynes (inter &intramolecular) for C-C bond formation and Baldwin's rules (b) fragmentation and rearrangements.

Module 2: OXIDATION REACTIONS — **15hours**

Oxidation: Metal and non-metal-based oxidations of alcohols to carbonyls (Chromium, manganese, aluminium, silver, DMSO and hypervalent iodine). Oxidation of phenols: Fremy's salt, alkenes to epoxides: via halohydrin, peroxides/per acids based, Sharpless asymmetric epoxidation; alkenes to diols (Manganese, osmium-based reagents), Prevost reaction and Woodward modification; oxidation of alkyl or alkenyl fragments: selenium dioxide, ketones to ester/lactones: Baeyer-Villiger oxidation.

Module 3: REDUCTION REACTIONS — **15 hours**

Reduction: Catalytic hydrogenation (Heterogeneous: Palladium/ Platinum/ Rhodium/ Nickel etc. Homogeneous: Wilkinson catalyst); metal-liquid ammonia processes: Birch reduction, Pinacol formation etc.; stereo selection and mechanism of the following reagents: Lithium aluminium hydride, L-selectride, K-selectride, sodium borohydride, D I B A L , sodium cyanoborohydride, alkyl borane, non-metallic reducing agents: diimide.

Module 4: Kinetics and Energetics of Reaction Mechanism — **15 hours**

TS theory of reaction rates: kinetics & thermodynamics requirements. Hammond postulate, Curtin-Hammett Principle; kinetic and thermodynamic control. Linear free energy relationships (LFER): Hammett equation, Taft equation, kinetic isotope effects in organic reactions. Effects of conformation on reactivity: anomeric effect, stereoelectronic effects, neighbouring group participation.	
Total Lecture hours	**60 hours**
Text Book(s)	
1.	Cary F. A., Sundberg R. I., Advanced Organic Chemistry, Part A and B, 5th Edition,Springer, 2009.
2.	Smith M. B., Organic Synthesis, 4th Ed., Academic Press, Cambridge, Massachusetts,2016.
3.	Carruthers W. and Coldham I., Modern Methods of Organic Synthesis, First South AsianEdition, 2005, Cambridge University Press.
4.	Greeves N., Clayden J.,Warren S., Organic Chemistry, 2nd Ed., Oxford University Press,New Delhi, 2012.
5.	Anslyn E. V., Dougherty D. A., Modern Physical Organic Chemistry, University Science Books, 2005.
	Reference Books
1.	Smith M. B., March J., March's Advanced Organic Chemistry: Reactions, Mechanisms and Structure, 7th Ed., Wiley India, New Delhi, 2015.
2.	Carruthers W., Modern Methods of Organic Synthesis, 4th Ed., Cambridge University Press, New Delhi, 2005.
3.	Zweifel G. S., Nantz M. H., Somfai P., Modern Organic Synthesis: An Introduction, 2nd Ed., Wiley-Blackwell, New York, 2017.
4.	Morrison R. T., Boyd R. N., Bhattacharjee S. K., Organic Chemistry, 7th Edition, Pearson Education India, 2010.
5.	Solomons T. W. G., Fryhle C. B., Snyder S. A., Organic Chemistry, 12th Edition, Wiley, 2017.
6.	Harmata M., Strategies and Tactics in Organic Synthesis, Volume 4, Academic Press, 2004.
7.	Lowry T. H., Richardson K. S., Mechanism and Theory in Organic Chemistry, 3rd Edition, Pearson, 1997.

Elective	INDUSTRIAL CHEMICALS AND ENVIRONMENT	L	T	P	C
		3	1	0	4

Pre-requisite: Knowledge of Basic Science

Course Objectives:

The course is being offered with the following objectives:

1. To introduce the fundamental concepts of industrial chemistry, industrial raw materials, manufacturing processes, material and energy balance, and industrial safety practices.
2. To develop an understanding of the manufacturing processes, properties, applications, and environmental aspects of major industrial chemicals, fertilizers, cement, glass, polymers, petroleum products, and pharmaceuticals.
3. To familiarize students with the petroleum, petrochemical, pharmaceutical, food, and cosmetic industries, including quality control measures, good manufacturing practices (GMP), and industrial applications.
4. To create awareness of industrial pollution, waste management, pollution control technologies, environmental impact assessment (EIA), and sustainable industrial practices for environmental protection and sustainable development.

Course Outcome:

After successful completion of the course, the students will be able to:

CO1: Explain the scope of industrial chemistry, industrial raw materials, unit operations, unit processes, material and energy balance concepts, and essential industrial safety practices. **(Understand)**

CO2: Apply the principles of industrial chemical manufacturing to describe the production processes of major industrial chemicals, fertilizers, cement, glass, polymers, petroleum products, and pharmaceuticals. **(Apply)**

CO3: Analyze the processing, refining, quality control, and industrial applications of petroleum, petrochemicals, pharmaceutical products, food additives, and cosmetic products, relating them to industrial practices. **(Analyze)**

CO4: Evaluate the environmental impacts of industrial activities by assessing pollution sources, waste management strategies, pollution control technologies, environmental impact assessment (EIA), carbon footprint, and sustainable industrial practices. **(Evaluate)**

Module 1: Introduction to Industrial Chemistry	**12 hours**

Introduction - Definition and scope of industrial chemistry, Industrial Raw Materials - Mineral resources, Petroleum, Natural gas, Coal, Water, Renewable and non-renewable resources, Industrial Processes - Unit operations and unit processes, Batch and continuous processes, Flow diagrams, Material balance (basic concept), Energy balance (basic concept), Industrial Safety - Chemical hazards, Fire and explosion hazards, Safety symbols and labels, Personal Protective Equipment (PPE), Safe handling and storage of chemicals.

Module 2: Manufacture of Industrial Chemicals	**12 hours**

Heavy Chemicals - Manufacture of sulphuric acid (Contact Process), Manufacture of ammonia (Haber Process), Manufacture of nitric acid (Ostwald Process), Manufacture of sodium carbonate (Solvay Process), Fertilizer Industry - Nitrogenous fertilizers, Phosphatic fertilizers, Potassic fertilizers, Compound fertilizers, Cement and Glass Industries - Raw materials,

Manufacturing process, Types and applications, Environmental issues, Polymer Industry - Manufacture of polyethylene, PVC, Polystyrene, Biodegradable plastics (basic idea).	
Module 3: Petroleum, Petrochemicals and Pharmaceutical Industries	**11 hours**
Petroleum Industry - Composition of crude oil, Fractional distillation, Petroleum refining, Cracking, Reforming, Petrochemical products, Fuels – LPG, CNG, Biofuels, Hydrogen fuel, Fuel quality, Pharmaceutical Industry - Bulk drugs, Active Pharmaceutical Ingredients (APIs), Good Manufacturing Practices (GMP), Quality control, Food and Cosmetic Industries - Food additives, Preservatives.	
Module 4: Industrial Pollution and Environmental Impact	**10 hours**
Industrial Pollution - Sources of industrial pollution, Air pollution, Water pollution, Soil pollution, Industrial Waste - Solid waste, Liquid waste, Hazardous waste, Pollution Control - Air pollution control devices, Wastewater treatment, Solid waste management, Recycling and resource recovery, Environmental Impact - Environmental Impact Assessment (EIA), Carbon footprint, Greenhouse gases, Global warming.	
Total Lecture hours	**45 hours**

Tutorial Activities (15 hours)

(i) Problem-solving exercises
(ii) Process flow diagram interpretation
(iii) Industrial case studies
(iv) Group discussions
(v) Student seminars and presentations
(vi) Assignment discussion
(vii) Analysis of industrial accidents
(viii) Environmental impact assessment exercises
(ix) Review of industrial safety data sheets (SDS)
(x) Quiz and doubt-clearing sessions

Text Book(s)

1.	B. K. Sharma, Industrial Chemistry, Goel Publishing House, Meerut.
2.	B. K. Sharma, Environmental Chemistry, Krishna Prakashan Media Pvt. Ltd.
3.	Shashi Chawla, A Textbook of Engineering Chemistry, Dhanpat Rai Publications.
4.	V. K. Ahluwalia, Environmental Chemistry, Ane Books India.
Reference Books	
1.	M. Gopala Rao and Marshall Sittig, *Outlines of Chemical Technology,* Khanna Publishers, New Delhi
2.	George T. Austin, *Chemical Process Industries,* McGraw-Hill Education
3.	Stanley E. Manahan, *Environmental Chemistry,* CRC Press (Taylor & Francis Group)

Elective	CHEMISTRY OF ADVANCED MATERIALS	L	T	P	C
		3	1	0	4

Pre-requisite: Knowledge of chemistry at B.Sc. level

Course Objectives:

The course aims to enable students to:

1. Understand the chemistry governing advanced functional materials.
2. Correlate crystal structure with material properties.
3. Explain various synthesis routes for advanced materials.
4. Understand characterization techniques used in materials research.
5. Explore applications of advanced materials in energy, environment, catalysis and healthcare.
6. Perform synthesis and characterization of selected functional materials.

Course Outcome:

After successful completion of the course, the students will be able to

CO1: Explain the relationship between structure, bonding and properties of advanced materials.(*Understand*)

CO2: Compare different synthesis methods and select appropriate routes for material preparation. (*Apply*)

CO3: Interpret characterization data obtained from common analytical techniques. (*Analyze*)

CO4: Describe the chemistry and applications of nanomaterials, energy materials and smart materials. (*Evaluate*)

CO5: Analyze characterization data to determine the structural, optical, thermal, and surface properties of functional materials. (*Analyze*)

Module 1: FUNDAMENTALS OF ADVANCED MATERIALS — **8 hours**

Classification of materials: Metals, Ceramics, Polymers, Composites, Nanomaterials, Biomaterials, Structure–property relationship, Crystal defects, Grain boundaries, Phase diagrams (basic concepts).

Module 2: CHARACTERIZATION AND FUNCTIONAL MATERIALS — **20 hours**

Characterization techniques: Powder X-ray diffraction, FTIR spectroscopy, Raman spectroscopy (basic principles),UV-Visible diffuse reflectance spectroscopy**,** SEM **,** TEM**,** BET surface area analysis, Thermal analysis (TGA/DSC), Interpretation of simple characterization data.

Tutorial:

1. Particle size estimation using XRD (Scherrer equation).
2. Phase identification using JCPDS database.
3. Interpretation of FTIR spectra of synthesized materials.
4. UV–Visible band gap determination using Tauc plot.
5. Thermal stability analysis using TGA data.
6. BET surface area calculation from provided adsorption data.

Module 3: ADVANCED FUNCTIONAL MATERIALS AND APPLICATIONS — **20 hours**

Energy materials: Lithium-ion batteries, Sodium-ion batteries, Supercapacitors, Fuel cell materials, Hydrogen storage materials, Photocatalytic materials. **Smart and sustainable materials:** Shape memory alloys, Piezoelectric materials, Magnetostrictive materials, Conducting polymers, Self-healing materials, Biodegradable polymers. **Composite materials:** Polymer, metal and ceramic matrix composites; clay-polymer composites; carbon composites; bioceramics. **Environmental and sustainable**

materials: Photocatalysts, water purification materials, LEDs/OLEDs, circular economy, green materials and environmental remediation.	
Module 4: NANOMATERIALS	**12 hours**
Size-dependent properties, Quantum confinement, Carbon nanomaterials, Graphene, Carbon nanotubes (SWNT, MWNT CNT), Fullerenes, Metal oxide nanoparticles, Surface functionalization, Applications in catalysis, sensors and medicine. **Crystal chemistry:** Packing in solids, Coordination polyhedral, Spinel, Perovskite, Garnet structures, Ionic conductivity, Defect chemistry. **Materials synthesis:** Solid-state reaction, Sol–gel method, Hydrothermal synthesis, Co-precipitation, Combustion synthesis, Chemical vapour deposition (overview), Green synthesis of nanomaterials.	
Total Lecture hours	**60 hours**
Recommended Textbooks	
1.	**Anthony R. West** – *Solid State Chemistry and Its Applications*
2.	**William D. Callister** – *Materials Science and Engineering*
3.	**Donald R. Askeland** – *The Science and Engineering of Materials*
4.	**C. N. R. Rao, A. Müller & A. K. Cheetham** – *The Chemistry of Nanomaterials: Synthesis, Properties and Applications* (Wiley-VCH).
5.	**Guozhong Cao & Ying Wang** – *Nanostructures and Nanomaterials: Synthesis, Properties and Applications* (World Scientific).
Reference Books	
1.	**C. Brinker & G. Scherer** – *Sol–Gel Science: The Physics and Chemistry of Sol–Gel Processing* (Academic Press). *(The standard reference for silica sol–gel chemistry.)*
2.	**T. A. Skotheim & J. R. Reynolds** – *Handbook of Conducting Polymers* (CRC Press). *(The classic reference for polyaniline synthesis.)*
3.	**Marsh & Rodríguez-Reinoso** – *Activated Carbon* (Elsevier). *(The definitive reference on activated carbon preparation and characterization.)*

SEC

BCH26160T(SEC)	FUNDAMENTALS OF ANALYTICAL METHODS	L	T	P	C
		3	0	0	3

Prerequisite: Knowledge of Chemistry at 10th standard level

Course Objectives:

1. To introduce students to the fundamentals of analytical chemistry and laboratory practices.
2. To develop knowledge of qualitative and quantitative analysis.
3. To provide analytical understanding of food, soil, water, and cosmetic samples.
4. To familiarize students with modern analytical instruments and their applications.

Course Outcome:

After successful completion of the course, the students will be able

CO1 : To remember concepts of basic analytical chemistry and interpret analytical data.

CO2 : To understand basic principles and techniques of analytical chemistry.

CO3 : To apply the concepts and perform qualitative and quantitative analysis of common samples.

CO4 : To analyze food, soil, water, and cosmetic samples using standard methods.

Module 1: Fundamentals of Analytical Chemistry — 12 hours

Definition, scope and importance of analytical chemistry. Types of analysis: qualitative and quantitative. Errors in chemical analysis: Accuracy, precision. Digital data handling: tabulation of data, use of spreadsheets/software for calculations, graphical representation. Sample preparation. Laboratory Safety and Good Laboratory Practices.

Hands-on: Preparation and standardization of solutions (primary and secondary standards). Estimation of hardness of water by EDTA method.

Module 2: Analytical Chemistry of Food — 12 hours

Different types of Food Additives and their functions, Food preservatives, Artificial sweeteners, Artificial Flavours, monosodium glutamate. Introduction to adulteration, incidental additives or contaminants, adulterants in some common food items like coffee powder, chili powder, turmeric powder, coriander powder, asafetida and pulses. BIS and FSSAI standards, food-safety regulations, labelling requirements, permissible limits, and regulatory awareness related to food quality and adulteration.

Hands-on: Detection of food adulterants in Milk, Turmeric, Cane sugar, Common salt, Mustard oil, Ghee and Butter, Coffee, Cereals and pulses.

Module 3: Soil and Water Analysis — 10 hours

Soil sampling and preparation. Determination of soil acidity. Water quality parameters: acidity, hardness, alkalinity. Drinking water standards and environmental significance. Quality assurance and quality control (QA/QC) in soil and water analysis (calibration of instruments, use of standards and blanks, replicate analysis, validation of results, and proper

documentation). **Hands-on:** Estimation of chloride, nitrate and iron in water.	
Module 4: Analysis of Cosmetics and Household Products	11 hours
Introduction to cosmetic chemistry and regulations: classification and formulation. Raw materials used in soaps, shampoos, creams, talcum powders, detergents, and disinfectants. Role of surfactants, emulsifiers, preservatives, fragrances, colourants, thickeners, and active ingredients. Quality parameters: moisture content, total fatty matter, insoluble matter, alkalinity/acidity, stability, and safety. Differences between soaps and synthetic detergents. **Hands-on:** Determination of pH in shampoos and creams. Determination of Insoluble (Solid) Matter in Soap. Preparation of Soap by Saponification. Determination of constituents of talcum powder: Magnesium oxide, Calcium oxide, Zinc oxide and Calcium carbonate.	
Total hours	**45 hours**
Textbook(s)	
1. Skoog, West, Holler & Crouch – Fundamentals of Analytical Chemistry.	
2. Vogel – Textbook of Quantitative Chemical Analysis.	
3. William C. Lipps (Editor), Ellen Burton Braun-Howland (Editor), Terry E. Baxter (Editor)– Standard Methods for the Examination of Water and Wastewater.	
Reference Books	
1. Chemical Food Analysis: A Practical Manual by Bruce R. D'Arcy & Geoff Hawes	
2. Ranganna – Handbook of Analysis and Quality Control for Fruit and Vegetable Products.	