Details of Minor Generic Elective (GE) Courses offered by Department of Chemistry

Course	Name of the course	Credits	Hrs	Semester
CHEMISTRY-GE-1	Atomic Structure and Chemical Bonding	4	60	I
CHEMISTRY-GE-2	Color Chemistry	4	60	I
CHEMISTRY-GE-3	Bioinorganic Chemistry	4	60	II
CHEMISTRY-GE-4	Chemistry of Food nutrients	4	60	II
CHEMISTRY-GE-5	Basic Concepts of Organic Chemistry	4	60	III
CHEMISTRY-GE-6	Chemistry and Environment	4	60	III
CHEMISTRY-GE-7	States of Matter (Solid, Liquid and Gaseous State)	4	60	IV
CHEMISTRY-GE-8	Chemistry and Energy	4	60	IV
CHEMISTRY-GE-9	Chemical Technology and Society	4	60	V
CHEMISTRY-GE-10	Chemistry of Cosmetics & Perfumes	4	60	VI

CHEMISTRY- GE-1

Course Title: Atomic Structure and Chemical Bonding

Total Credits: 04

Total Lectures:60

Objectives: The course reviews the structure of the atom, which is a necessary pre-requisite in understanding the nature of chemical bonding in compounds. It provides basic knowledge about ionic and covalent bonding. The constitution of the course strongly aids in the paramount learningof the fundamental concepts about atomic structure, chemical bonding and their applications.

Learning Outcomes:

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

- Solve the conceptual questions using the knowledge gained by studying the quantum mechanical model of the atom, quantum numbers, electronic configuration, radial and angular distribution curves, and shapes of s, p, and d orbitals
- Understand the concept of lattice energy and solvation energy.
- Draw the plausible structures and geometries of molecules using radius ratio rules, VSEPRtheory and MO diagrams (homo- & hetero-nuclear diatomic molecules).

Unit 1: Basics of Chemical Bonding **(Lectures :15)**

This unit introduces the fundamental concepts of atomic structure and chemical bonding. It includes the basic understanding of atomic models such as the Bohr Model and the development of Quantum Mechanics. Students will study quantum numbers and the rules governing the filling of electrons in orbitals, including the Aufbau Principle, Pauli Exclusion Principle, and Hund's Rule. The unit also covers electronic configurations of elements, shapes and orientations of s, p, and d orbitals, relative energies of orbitals, and the concepts of shielding and penetration. Additionally, the stability associated with half-filled and completely filled orbitals is explained through the concept of exchange energy.

Unit 2: Ionic Bonding and Energetics **(Lectures 12)**

This unit focuses on the formation and properties of ionic bonds. It explains the general characteristics of ionic compounds and the energetics involved in their formation. Important concepts such as Lattice Energy and the Born-Haber Cycle are discussed to understand the stability of ionic solids. The role of solvation and hydration energy in determining solubility is also covered. Furthermore, the unit explains polarization effects, polarizing power, and polarizability, along with Fajans' Rules to describe covalent character in ionic compounds.

Unit 3: Covalent Bonding and Molecular Geometry **(Lectures 13)**

This unit deals with covalent bonding using the Valence Bond (VB) approach and molecular geometry. It introduces the concept of sigma and pi bonds and explains hybridization involving sp, sp^2, sp^3, dsp^2, sp^3d, and sp^3d^2 orbitals. The VSEPR Theory is used to predict the shapes of molecules and ions such as H_2O, NH_3, PCl_5, SF_6, ClF_3, and SF_4. The effect of lone pairs on molecular geometry and deviations from ideal shapes are also discussed, providing a comprehensive understanding of molecular structure.

Unit 4: Molecular Orbital Theory **(Lectures 15)**

This unit provides a detailed understanding of bonding using the Molecular Orbital Theory. It explains the Linear Combination of Atomic Orbitals (LCAO) method and the formation of bonding, antibonding, and nonbonding molecular orbitals. The unit covers the interaction of atomic orbitals (s–s, s–p, and p–p overlaps) and the construction of molecular orbital energy diagrams. It includes the study of homonuclear diatomic molecules such as H_2, B_2, C_2, N_2, O_2, and F_2, along with heteronuclear molecules like CO, NO, and NO^+. Concepts of bond order, magnetic properties, and comparison with valence bond theory are also included.

Unit 5: Bond Parameters and Molecular Properties **(Lectures 5)**

This unit explains various bond parameters such as bond length, bond angle, and bond energy, and the factors affecting them. It also introduces the concept of Dipole Moment and its application in determining molecular polarity and percentage ionic character. Additionally, the unit briefly covers intermolecular forces including hydrogen bonding and van der Waals interactions, highlighting their importance in determining physical properties of substances.

References:

1. Lee, J.D.; (2010), **Concise Inorganic Chemistry**, Wiley India.
2. Huheey, J.E.; Keiter, E.A.; Keiter; R. L.; Medhi, O.K. (2009), **Inorganic Chemistry-Principles of Structure and Reactivity**, Pearson Education.
3. Douglas, B.E.; McDaniel, D.H.; Alexander, J.J. (1994), **Concepts and Models of Inorganic Chemistry**, John Wiley & Sons.
4. Atkins, P.W.; Overton, T.L.; Rourke, J.P.; Weller, M.T.; Armstrong, F.A. (2010), **Shriverand Atkins Inorganic Chemistry**, 5th Edition, Oxford University Press.

Additional Resources:

1. Wulfsberg, G (2002), **Inorganic Chemistry**, Viva Books Private Limited.
2. Miessler, G.L.; Fischer P.J.; Tarr, D. A. (2014), **Inorganic Chemistry**, 5th Edition, Pearson.

CHEMISTRY- GE-2
Course Title: Color Chemistry
Total Credits: 04
Total Lectures: Theory- 60 Hrs

Objectives: The purpose of the course is to introduce students to important chemical materials such as colours, dyes, pigments, etc. The students would learn how fibres and related polymers are produced from natural sources and in synthetic forms. In addition, the applications of colours, dyes, pigments, fibres and polymers in the environment will be examined. New challenges and economic importance of chemical materials in an emerging economy will also be discussed.

Learning Outcomes:

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

- Explain the concept of colour, pigments, dyes and related materials
- Identify each of the colours, dyes and pigments; their properties and uses.
- Explain the relationship and difference between colours, pigment and dyes
- Illustrate how fibers and related polymers are produced
- Define the concept of dyeing and pigment technology in relation to specific materials
- Describe new challenges in the emerging world of chemical and material technology
- Demonstrate the basic mechanism and processes involved in dyeing and pigment.

Unit 1: Colour, Pigments and Dye **(15 Lectures)**

Introduction to colour and its origin, visible spectrum, colour perception, chromophore and auxochrome, concept of fastness of colour. Types of colours and their basic features. Introduction to pigments: definition, properties and uses. Classification of pigments: organic pigments, inorganic pigments and metallic pigments. Examples and applications of important pigments such as titanium dioxide, zinc oxide, iron oxide and ultramarine blue. Difference between pigments and dyes. Relationship between pigments and dyes. Applications of dyes and pigments in textile, paint, paper, plastic and cosmetic industries

Unit 2: Classification of Dyes and Fibres **(15 Lectures)**

Definition and classification of dyes based on source and application. Acid dyes, basic dyes, direct dyes, reactive dyes, vat dyes, disperse dyes and azo dyes. Classification of fibres: natural fibres, artificial fibres and synthetic fibres. Natural fibres: cotton, wool and silk—basic structure and properties. Introduction to natural dyes and their sources. Simple dyeing processes using natural dyes. Role of mordants in dyeing. Factors affecting dyeing of fibres.

Unit 3: Synthetic Dyes and Fibres **(15 Lectures)**

Introduction to synthetic fibres and their importance. Polymer fibres and fibre-forming polymers. Polyesters: preparation, properties and uses. Polyamide fibres: nylon and its applications. Polyurethanes and their uses. Cellulose fibres and regenerated cellulose. Polyacrylonitrile and acrylic fibres. Aramids and their special applications. Poly (methyl methacrylate) and polycarbonate: properties and uses. Basic idea of modern synthetic fibres used in daily life.

Unit 4: Dyeing Mechanisms and Textile Processing **(15 Lectures)**

Basic principles of textile dyeing. Steps involved in textile dyeing process. Pretreatment of fabrics: washing, bleaching and finishing. Mechanism of dye–fibre interaction. Methods of dyeing for natural and synthetic fibres. Introduction to Beam Dyeing Machine, Hank Dyeing Machine, Jig Dyeing Machine and Jet Dyeing Machine. Simple finishing operations after dyeing. Environmental pollution caused by dye industries. Basic methods for treatment of dye effluents and importance of eco-friendly dyeing.

References:

Theory:

1. Zollinger, H., 2003. *Color chemistry: syntheses, properties, and applications of organic dyes and pigments*. John Wiley & Sons.
2. Shore, J., 2002. Colorants and Auxiliaries, Volume 1-Colorants. *Hampshire: Society of Dyers and Colourists, 1*.
3. Horiishi, N., Kathrein, H., Krieg, S., Pfaff, G., Pitzer, U., Ronda, C., Schwab, E., Besold, R. and Buxbaum, G., 2005. Specialty pigments. *Industrial Inorganic Pigments*, pp.195-295.
4. Herbst, W. and Hunger, K., 2006. *Industrial organic pigments: production, properties, applications*. John Wiley & Sons.
5. Venkataraman, K. ed., 2012. *The Chemistry of Synthetic Dyes V4* (Vol. 4). Elsevier.
6. Waring, D.R. and Hallas, G. eds., 2013. *The chemistry and application of dyes*. Springer Science & Business Media.

CHEMISTRY- GE-3

Course Title: Bioinorganic chemistry

Total Credits: 04

Total Lectures: 60

Objectives: The purpose of the course is to introduce students to bioinorganic chemistry, currentlya frontier area of chemistry providing an interface between organic chemistry, inorganic chemistryand biology. The student would learn about the importance of inorganic chemical species,especially metals, in biological systems, through discussions on topics such as the sodium- potassium pump, the applications of iron in physiology, including iron transport and storage system, role of magnesium in energy production and chlorophyll, toxicity of heavy metal ions andtheir antidotes.

Learning Outcomes:

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

- Classify metal ions in biological systems as essential, non-essential, trace & toxic.
- Diagrammatically explain the working of the sodium-potassium pump in organisms andthe factors affecting it
- Understand the role of metal ions such as Mg, Ca and Fe in biological systems.
- Understand the toxicity of heavy metal ions (Hg, Pb, Cd and As) in the physiological system
- Explain the use of chelating agents in medicine

Unit 1: Introduction to Bioinorganic Chemistry **(15 Hours)**

Definition, scope and importance of bioinorganic chemistry. Relationship between inorganic chemistry and biological systems. Occurrence of metal ions in living organisms. Classification of metal ions on the basis of biological action: essential, non-essential, trace and toxic elements. Biological importance of transition and non-transition metal ions. Classification of metallobiomolecules: metalloenzymes, metal-activated enzymes, transport proteins, storage proteins and non-protein biomolecules. Examples of biologically important metalloproteins. Basic concept of cell membrane and membrane transport. Passive and active transport. Brief introduction to ion channels, ion pumps and carrier proteins. Biological significance of membrane transport

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Unit 2: Role of s-block Elements in Biological Systems **(15 Hours)**

Biological importance of s-block elements. Role of sodium (Na^+) and potassium (K^+) ions in living systems. Maintenance of osmotic pressure and nerve impulse transmission. Sodium-potassium pump (Na^+/K^+ pump): structure, working and significance. Role of magnesium (Mg^{2+}) ions in biological systems. Importance of Mg^{2+} in ATP-dependent reactions and energy production. Role of Mg^{2+} in chlorophyll and photosynthesis. Biological role of calcium (Ca^{2+}) ions. Calcium pump and regulation of calcium ions.

Unit 3: Role of Iron in Biological Systems **(15 Hours)**

Biological importance of iron. Structure and functions of haemoglobin and myoglobin. Role of iron in oxygen transport and oxygen storage.Comparison between haemoglobin and myoglobin. Oxygen dissociation and oxygen saturation curves of haemoglobin and myoglobin.Perutz mechanism of oxygen binding in haemoglobin. Cooperative effect and its significance. Bohr effect and its biological importance. Effect of carbon monoxide poisoning on haemoglobin. Storage and transport of iron in humans. Role of ferritin and transferrin in iron metabolism.

Unit 4: Toxicity of Heavy Metal Ions **(15 Hours)**

Introduction to toxic metal ions and heavy metal poisoning. Sources of heavy metal contamination in the environment. Toxicity of mercury (Hg), lead (Pb), cadmium (Cd) and arsenic (As). Biochemical reasons for toxicity of heavy metals. Effect of heavy metals on enzymes and biological functions. Symptoms and health hazards caused by heavy metal poisoning. Bioaccumulation and biomagnification of toxic metals. Methods of prevention and control of heavy metal toxicity. Chelation therapy and common antidotes for heavy metal poisoning. Environmental and health significance of toxic metal monitoring.

References:

1. Huheey, J.E.; Keiter, E.A., Keiter; R. L.; Medhi, O.K. (2009), **Inorganic Chemistry-Principles of Structure and Reactivity**, Pearson Education.
2. Shriver, D.D.; Atkins, P.; Langford, C.H. (1994), **Inorganic Chemistry** 2nd Ed., Oxford University Press.
3. Cotton, F.A.; Wilkinson, G.; Gaus, P.L. **Basic Inorganic Chemistry**, 3rd Edition,Wiley India.
4. Crichton, R.R. (2008), **Biological Inorganic Chemistry: An Introduction**. Amsterdam,Elsevier.
5. Kaim, W., B. Schwederski and A. Klein. (2014), **Bioinorganic Chemistry: Inorganic Elements in the Chemistry of Life: An Introduction and Guide.** 2nd Edition, Wiley.

Additional Resources:

Lippard, S.J.; Berg, J.M. (1994), Principles of Bioinorganic Chemistry, Panima Publishing Company.

1. Greenwood, N.N.; Earnshaw, A. (1997), **Chemistry of the Elements**, 2nd Edition, Elsevier

CHEMISTRY- GE-4
COURSE TITLE: CHEMISTRY OF FOOD NUTRIENTS
Total Credits: 04
Total Lectures: 60

Course Objectives

To provide fundamental knowledge of carbohydrates, lipids, proteins, vitamins, and minerals and their importance in food chemistry and human nutrition.

1. To develop understanding of the structure, classification, properties, and functional roles of major food constituents and their significance in health and diet.
2. To explain the chemical changes occurring in food components during processing, storage, cooking, and preservation, and their effects on food quality and nutrition.
3. To create awareness about nutritional balance, deficiency disorders, food safety, and the role of essential nutrients in maintaining human health.

Learning Outcomes

1. Students will be able to classify carbohydrates, lipids, proteins, vitamins, and minerals and explain their structure, sources, and biological importance.
2. Students will be able to analyze the chemical properties of fats and oils, protein denaturation, and the effect of processing on vitamins and minerals.
3. Students will be able to identify the nutritional significance of major food constituents and relate them to balanced diet and deficiency diseases.
4. Students will be able to understand food quality, preservation, and health-related aspects associated with food chemistry and nutrition.

Unit 1: Carbohydrates **(15 Lectures)**

Introduction to carbohydrates and their importance in food chemistry. Sources and functions of carbohydrates in living systems. Classification of carbohydrates: monosaccharides, oligosaccharides and polysaccharides. Monosaccharides: glucose, fructose and galactose. Oligosaccharides: sucrose, lactose and maltose. Polysaccharides: starch, cellulose and glycogen. Structure, properties and food importance of polysaccharides. Pectin and its role in food preservation and jelly formation. Gums and mucilage: occurrence and uses in food industry. Dietary fibre and its nutritional significance. Artificial sweeteners: introduction, examples and uses (saccharin, aspartame, sucralose).

Unit 2: Lipids **(15 Lectures)**

Introduction to lipids and their importance in food chemistry. Sources and functions of lipids in the human body. Classification of lipids: fatty acids, phospholipids, fats and oils, waxes. Saturated and unsaturated fatty acids. Common fatty acids present in fats and oils. Essential fatty acids: Omega-3 and Omega-6 fatty acids and their health benefits. Trans fats and their harmful effects. Chemical properties of fats and oils: Reichert–Meissl value, Polenske value, iodine value, peroxide value and saponification value. Changes in fats and oils: rancidity, lipolysis, flavour reversion and auto-oxidation. Prevention of rancidity and preservation of edible oils.

Unit 3: Proteins **(15 Lectures)**

Introduction to proteins and their significance in food chemistry. Sources and functions of proteins in the body. Classification of proteins: simple, conjugated and derived proteins. Amino acids: structure, classification and essential amino acids. Peptide bond and formation of proteins. Levels of protein structure: primary, secondary and tertiary structure. Brief idea of quaternary structure. Denaturation of proteins and its causes. Effect of heat, pH and chemicals on proteins. Functional properties of proteins in food systems. Nutritional importance of proteins and protein deficiency disorders.

Unit 4: Vitamins and Minerals **(15 Lectures)**

Introduction to vitamins and their role in human nutrition. Classification of vitamins: fat-soluble vitamins (A, D, E, K) and water-soluble vitamins (B-complex and C). Sources, functions and deficiency diseases of major vitamins. Effect of cooking and food processing on vitamins. Introduction to minerals and their nutritional importance. Classification of minerals: macrominerals and microminerals. Macrominerals: calcium (Ca), phosphorus (P), magnesium (Mg) and their functions. Microminerals: iron (Fe), iodine (I), cobalt (Co), zinc (Zn), copper (Cu), selenium (Se) and chromium (Cr). Sources and deficiency disorders of important minerals.

Reference Books:

1. DeMan, J.M., Finley, J.W., Hurst, W.J., Lee, C.Y., 2018. *Principles of Food Chemistry*, 4th Edition, Springer.
2. Msagati, T.A.M., 2013. *Chemistry of Food Additives and Preservatives*, Wiley-Blackwell.
3. Fennema, O.R., 2017. *Food Chemistry*, 5th Edition, CRC Press.
4. Attokaran, M., 2017, *Natural Food Flavors and Colorants*, 2nd Ed., Wiley-Blackwell.
5. Potter, N.N., Hotchkiss, J.H., 1995. *Food Science*, 5th Ed., Chapman & Hall.
6. Brannen, D., Davidsin, P.M., Salminen, T. Thorngate III, J.H., 2002, *Food Additives*, 2nd Edition, CRC Press.
7. Coultate, T., 2016. *Food: The Chemistry of its Components*, 6th Edn., Royal Society of Chemistry.
8. Belitz, H. D.; Grosch, W., 2009. *Food Chemistry*, Springer.

CHEMISTRY- GE-5
Course Title: Basic Concepts of Organic Chemistry
Total Credits: 04
Total Lectures: 60

Course Objectives

1. To develop a clear understanding of fundamental concepts of organic chemistry including electronic effects, reactive intermediates, acidity, basicity, and aromaticity.
2. To provide knowledge of stereochemistry, stereoisomerism, and molecular configuration for understanding the three-dimensional behavior of organic molecules.
3. To explain the mechanisms of important organic reactions such as substitution, addition, elimination, and electrophilic aromatic substitution along with their stereochemical aspects.
4. To strengthen problem-solving and analytical skills for predicting reaction pathways, product formation, and reactivity patterns in organic compounds.

Learning Outcomes

1. Students will be able to explain electronic effects, stability of intermediates, aromaticity, and the role of electrophiles and nucleophiles in organic reactions.
2. Students will be able to identify and assign stereochemical configurations using projection formulae, CIP rules, and different stereochemical notations.
3. Students will be able to describe and compare reaction mechanisms such as SN1, SN2, E1, E2, electrophilic addition, and electrophilic aromatic substitution reactions.
4. Students will be able to predict the outcome of organic reactions and apply mechanistic concepts to solve problems related to structure, stability, and reactivity.

Unit 1: Basic Concepts of Organic Chemistry (15 Hours)

Introduction to organic chemistry and electronic displacements: inductive effect, electromeric effect, resonance, mesomeric effect and hyperconjugation with applications.
Dipole moment, acidity and basicity of organic compounds.
Homolytic and heterolytic bond fission with suitable examples.
Formation, shape and relative stability of carbocations, carbanions and free radicals.
Electrophiles and nucleophiles.

Unit 2: Stereochemistry (15 Hours)

Stereoisomerism: optical activity and optical isomerism, asymmetry, chirality, enantiomers and diastereomers.
Specific rotation and optical purity.
Configuration and projection formulae: Newman, Sawhorse and Fischer projections with interconversion.
Chirality in molecules with one and two stereocentres, meso compounds.
CIP rules, erythro/threo, D/L and R/S designations.
Geometrical isomerism: cis–trans, syn–anti and E/Z notations.

Unit 3: Aliphatic Organic Reactions (15 Hours)

Introduction to substitution, addition, elimination, rearrangement, oxidation and reduction reactions.
Free radical substitution reactions: halogenation and relative reactivity vs selectivity.
Mechanisms of E1 and E2 reactions, Saytzeff and Hoffmann elimination, Cope elimination.
Electrophilic addition reactions of alkenes and alkynes: Markovnikov and anti-Markovnikov addition, syn and anti addition, hydroboration–oxidation, ozonolysis and hydroxylation.
Nucleophilic substitution reactions: SN1 and SN2 mechanisms with stereochemical aspects and effect of solvent.
Nucleophilic substitution versus elimination reactions.

Unit 4: Aromaticity and Aromatic Reactions (15 Hours)

Concept of aromaticity, antiaromaticity and non-aromaticity.
Hückel's rule and aromatic character of benzene and other cyclic compounds.
Examples of aromatic, antiaromatic and non-aromatic compounds.
Electrophilic aromatic substitution reactions: halogenation, nitration, sulphonation, Friedel–Crafts alkylation and Friedel–Crafts acylation.
Mechanisms of electrophilic aromatic substitution reactions.
Generation of electrophiles in aromatic substitution reactions.
Directing effects of substituent groups: activating and deactivating groups.
Ortho, meta and para orientation in monosubstituted benzene derivatives.

References:

1. Sykes, P. (2005), **A Guide Book to Mechanism in Organic Chemistry**, Orient Longman.
2. Eliel, E. L. (2000), **Stereochemistry of Carbon Compounds**, Tata McGraw Hill.
3. Morrison, R. N.; Boyd, R. N., Bhattacharjee, S.K. (2010), **Organic Chemistry**, 7^{th} Edition, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
4. Mehta B.; Mehta M. (2015), **Organic Chemistry**, PHI Learning Private Limited
5. Bahl, A; Bahl, B. S. (2012), **Advanced Organic Chemistry**, S. Chand.

CHEMISTRY- GE-6
COURSE TITLE: CHEMISTRY AND ENVIRONMENT
Total Credits: 04
Total Lectures: 60

Course Objectives

- To develop understanding of the fundamental concepts of environmental chemistry, atmospheric composition, and the behavior of contaminants in the environment.
- To study various types of pollution such as air, water, and soil pollution, their sources, effects, analysis, and control measures.
- To provide knowledge of greenhouse effect, global warming, climate change, and their impact on the environment along with remedial strategies.
- To introduce the principles of toxicology, toxicity of heavy metals and organic toxicants, and their effects on human health and ecosystems.

Learning Outcomes

- Students will be able to explain environmental processes, atmospheric chemistry, and the movement and degradation of pollutants in nature.
- Students will be able to identify major sources of air, water, and soil pollution and apply suitable analytical and control methods for pollution management.
- Students will be able to understand the causes and consequences of greenhouse effect, global warming, and climate change, and suggest sustainable solutions.
- Students will be able to evaluate the toxic effects of hazardous substances, including heavy metals and organic pollutants, and understand their environmental and health impacts.

Unit 1: Environment **Lectures: 15**

Introduction to Environmental Chemistry and its scope, composition and layers of atmosphere of Earth, structure and functions of atmosphere, biogeochemical cycles: carbon, nitrogen, oxygen and sulphur cycles, contaminant behavior in the environment, sources, classification and transport of contaminants, contaminants and their natural pathways of degradation and their abatement, organic pollutants: sources, types and environmental impact, pollution from combustion systems, coal combustion and its environmental effects, photochemical smog: formation, composition and control measures, indoor air pollution: sources, effects and prevention.

Unit 2: Pollution **Lectures: 20**

Air pollution: carbon monoxide, oxides of nitrogen, sulphur dioxide, volatile organic compounds (VOCs), particulate matter, analysis of air pollutants such as CO, SOx, NOx and particulate matter, monitoring and control of air pollution, water pollution: ground and subsurface water contamination, water quality parameters: BOD, DO, COD and chlorine demand, analytical methods for measuring BOD, DO, COD and chlorine demand, water purification and treatment methods, soil pollution and contamination with toxic inorganic compounds, ion exchange reactions in soil and soil fertility, nuclear waste management, sewage treatment and solid waste management, cause-effect relationship between pollutants and community health problems, health effects of criteria pollutants.

Unit 3: Green House Effect **Lectures: 12**

Green house effect and global warming – introduction, how the green house effect is produced, major sources of green house gases, emissions of CO_2 and other green house gases, impact of green house effect on global climate, ozone layer depletion and its environmental significance, acid rain: causes, effects and control, control and remedial measures of green house effect, global warming as a serious threat, climate change mitigation and sustainable development.

Unit 4: Toxicology **Lectures: 13**

Definition of toxicology and its scope, history of toxicology, dose-response relationship, absorption, distribution and excretion of toxic materials, metabolism of toxic substances, bioaccumulation and biomagnification, toxicity of metal ions: Pb, Hg, Al, Ni, As, organic toxicants such as halogenated hydrocarbons, pesticides and solvents, chemical carcinogens and mutagens, toxicological effects on human health and environment, safety measures and preventive approaches in handling toxic substances.

References:

1. Manahan, Stanley E., 2001. *Fundamentals of Environmental Chemistry,* Boca Raton: CRC Press LLC.
2. Sonja Krause, Herbert M. Clark, James P. Ferris, Robert L., 2002. *Strong Chemistry of the Environment*, Elsevier Science & Technology Books.
3. Eugene R. Weiner, 2000. *Applications of Environmental Chemistry*, CRC Press, LLC
4. Clair N. Sawyer, Perry L. McCarty, Gene F. Parkin Chemistry for environmental engineering and science (5th edition) McGrawHill Professional
5. Sawyer, C.N., McCarty, P.L. and Parkin, G.F., 2003. *Chemistry for environmental engineering and science*. McGraw-Hill.
6. Bidlack, W.R., 2002. Casarett & Doull's toxicology: the basic science of poisons.
7. Maiti, S.K., 2003. *Handbook of methods in environmental studies* (Vol. 2, pp. 110-121). Jaipur: ABD publishers.
8. De Anil, K., 2003. *Environmental chemistry*. New Age International.

CHEMISTRY- GE-7
COURSE TITLE: STATES OF MATTER
Total Credits: 04
Total Lectures: 60

Course Objectives

1. To develop a clear understanding of the fundamental principles governing the gaseous, liquid, and solid states of matter and their physical properties.
2. To explain the behavior of ideal and real gases through gas laws, kinetic theory, van der Waals equation, and liquefaction processes.
3. To provide knowledge of intermolecular forces, viscosity, vapour pressure, surface tension, and phase behavior in liquids, along with their practical significance.
4. To introduce crystal structures, X-ray diffraction, packing of solids, crystal defects, and the electrical and magnetic properties of solids.

Learning Outcomes

1. Students will be able to apply gas laws, kinetic theory, and real gas equations to solve numerical problems related to gaseous systems.
2. Students will be able to explain the physical behavior of liquids in terms of intermolecular forces, viscosity, surface tension, vapour pressure, and liquid crystal properties.
3. Students will be able to classify solids based on structure and bonding, and interpret crystal lattices, unit cells, and close-packed arrangements.
4. Students will be able to analyze crystal defects and distinguish between different electrical and magnetic properties of solids with practical examples.

Unit I: Gaseous State **(20 Lectures)**

Gas laws: Boyle's law, Charles' law, Avogadro's law and their applications; Ideal gas equation; Dalton's law of partial pressures. Kinetic theory of gases: Postulates and derivation of gas pressure; molecular interpretation of temperature and pressure. Maxwell–Boltzmann distribution of molecular velocities: Most probable velocity, average velocity and root mean square velocity; relationship among different molecular velocities.

Unit II: Behaviour of Real Gases **(10 Lectures)**

Deviation of real gases from ideal behavior; Compressibility factor and its significance. van der Waals equation of state and its applications; Critical constants and their significance. Liquefaction of gases: Joule–Thomson effect, inversion temperature and Linde's process. Numerical problems based on gas laws and real gas equations.

Unit III: Liquid State **(10 Lectures)**

Nature of liquid state; Intermolecular forces in liquids: dipole–dipole interactions, hydrogen bonding and London dispersion forces. Surface phenomena: Surface tension, factors affecting surface tension, capillary action and its applications; Effect of temperature and impurities on surface tension.

Unit IV: Viscosity and Vapour Pressure **(10 Lectures)**

Viscosity of liquids: Coefficient of viscosity, Poiseuille's equation and factors affecting viscosity. Vapour pressure and its variation with temperature; Boiling point and phase equilibrium. Clausius–Clapeyron equation and its application in the determination of enthalpy of vaporization. Liquid crystals: Types of liquid crystals—nematic, smectic and cholesteric phases; Applications in display technologies and biological systems.

Unit V: Solid State **(10 Lectures)**

Classification of solids: Crystalline and amorphous solids. Types of crystalline solids: Ionic, covalent, metallic and molecular solids. Crystal lattice and unit cell; Bravais lattices; Crystal planes and Miller indices.

Unit VI: X-ray Diffraction and Defects in Solids **(10 Lectures)**

X-ray diffraction and crystal structure determination; Bragg's law. Close packing of particles in solids: Hexagonal close packing (hcp) and cubic close packing (ccp); Packing efficiency; Tetrahedral and octahedral voids. Defects in solids: Schottky defect and Frenkel defect and their effect on properties. Electrical and magnetic properties of solids: Conductors, semiconductors and insulators; Diamagnetism, paramagnetism and ferromagnetism.

Reference Books:

1. Atkins, P. and de Paula, J. **Atkins' Physical Chemistry**, 12th Edition, Oxford University Press, 2023.
2. Glasstone, S. **Textbook of Physical Chemistry**, 2nd Edition, Macmillan, 1948.
3. Raj, G. **Advanced Physical Chemistry**, 35th Revised Edition, Goel Publishing House, 2019.
4. Kapoor, K. L. **A Textbook of Physical Chemistry: Volume 1 (States of Matter and Ions in Solution)**, 6th Edition, McGraw Hill Education, 2015.
5. Puri, B. R., Sharma, L. R. and Pathania, M. S. **Principles of Physical Chemistry**, 47th Edition, Vishal Publishing Co., 2017.
6. Mahan, B. H. **University Chemistry**, 3rd Edition, Narosa Publishing House, 2000.
7. Ladd, M. **Introduction to Physical Chemistry**, 3rd Edition, Cambridge University Press, 1998.
8. Tabor, D. **Gases, Liquids and Solids**, 3rd Edition, Cambridge University Press, 1991.

CHEMISTRY- GE-8
COURSE TITLE: CHEMISTRY AND ENERGY
Total Credits: 04
Total Lectures: 60

Unit I: Introduction to Conventional Energy and Solid Fuels **(10 Hours)**
Fuels: Definition, classification and properties of fuels; Calorific value and its significance; Determination of calorific value by Bomb calorimeter; Dulong's formula for calorific value. Storage and handling of fuels; Principles of combustion; Combustion of coal, oil and gaseous fuels. Solid fuels: Coal—origin and classification; Analysis of coal: Proximate and Ultimate analysis. Metallurgical coke: Carbonization of coal; Manufacture of metallurgical coke by Otto-Hoffmann by-product oven; Combustion calculations.

Unit II: Liquid Fuels **(8 Hours)**
Origin and composition of petroleum; Refining of petroleum; Cracking and reforming processes. Synthetic petrol and non-petroleum fuels. Knocking and anti-knocking agents; Octane rating and Cetane rating. Diesel engine fuels, Kerosene and LPG.

Unit III: Gaseous Fuels **(8 Hours)**
Gaseous fuels: Natural gas, Coal mine gas, Producer gas, Water gas and Coal gas. Gases derived from waste and biomass: Wood gas. Gases from industrial processes: Blast furnace gas and refinery gases. Gasification of coal and oil; Purification of gaseous fuels.

Unit IV: Nuclear Energy **(8 Hours)**
Nuclear energy: Nuclear reactions and their significance. Nuclear reactors: Design and construction of nuclear reactors. Fuel materials: Uranium, Zirconium, Thorium and Beryllium. Types of nuclear wastes and their disposal. Biological effects of radiation; Reactor safety and security; International conventions on radiation hazard prevention and safety aspects.

Unit V: Alternative and Non-Conventional Sources of Energy with Solar Energy (10 Hours)
Limitations of fossil fuels; Role and potential of renewable and non-renewable energy sources. Energy consumption as a measure of national development; Prospects of renewable energy resources. Solar energy: Environmental impact of solar power; Solar constant; Extraterrestrial and terrestrial solar radiation. Solar radiation on tilted surfaces; Instruments for measuring solar radiation and sunshine; Solar radiation data and solar ponds. Solar applications: Solar heating and cooling techniques, Solar distillation and Solar drying.

Unit VI: Wind Energy and Biomass **(8 Hours)**
Principle of wind energy conversion; Basic components of wind energy conversion systems; Windmill components. Wind patterns; Types of wind turbines; Kinetic energy of wind; Betz coefficient. Biomass energy: Principles of bio-conversion; Biogas

generation plants—classification, advantages and disadvantages. Constructional details of biogas plants; Anaerobic and aerobic digestion; Types of biogas digesters; Fuel properties of biogas and economic aspects.

Unit VII: Geothermal Energy **(8 Hours)**

Geothermal energy: Estimation and nature of geothermal energy. Geothermal sources and resources: Hydrothermal, Geopressured, Hot dry rock and Magma resources. Advantages, disadvantages and applications of geothermal energy.

Recommended Books:

1. Richard A. Dawe, 2001. *Modern Petroleum Technology*, Vol 1, Upstream, Ed. by, IP, 6th edition, John Wiley & Sons Ltd.
2. Sarkar S.K., 1990. *Fuels and combustion*, 2nd edition, Orient Longman Ltd.
3. Griswold, J., 1946. *Fuels, combustion, and furnaces*. McGraw-hill book company.
4. Thomas J.Cannoly, 1978. *Fundamentals of Nuclear Engineering*. John Wiley.
5. Collier J.G., and Hewitt G.F. 1987. *Introduction to Nuclear Power*, Hemisphere Publishing, New York,
6. Rai, G.D. and Rai, C.D., 1992. *Non-conventional energy sources*. Khanna.
7. Ramesh, R. and Kumar, K.U., 2004. Renewable Energy Technologies.
8. Solanki, C.S., 2008. *Renewable energy technologies: A practical guide for beginners*. PHI Learning Pvt. Ltd.

CHEMISTRY- GE-9
COURSE TITLE: CHEMICAL TECHNOLOGY AND SOCIETY
Total Credits: 04
Total Lectures: 60

Course Objectives

This course is designed to:

- Bridge the gap between chemistry, chemical technology, and societal applications
- Provide fundamental understanding of industrial chemical processes and technologies
- Develop awareness of sustainable and clean technologies
- Enable students to critically analyze chemical issues impacting society
- Promote scientific literacy for informed decision-making

Learning Outcomes

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

- Understand the relationship between basic chemistry and chemical engineering principles
- Explain key unit operations and industrial processes
- Identify and describe chemical technologies used in industries
- Evaluate the role of chemistry in energy, environment, and materials
- Analyze societal challenges using chemical knowledge
- Propose sustainable and scientific solutions to real-world problems

Unit I: Fundamentals of Chemical Technology **(12 Hours)**

Introduction to chemical technology and industrial chemistry. Role of chemistry in industrial development and economy (basic idea with examples) Concept of unit operations and unit processes (simple industrial examples) Basic idea of material and energy balance (no detailed numericals) Flow charts and block diagrams (introductory level)Industrial safety: Common hazards, safety symbols, basic precautions. Introduction to industrial pollution (air, water) and its control

Unit II: Separation Techniques in Chemical Industry **(12 Hours)**

Basic principles and simple applications of: Distillation (simple and fractional), Solvent extraction (solid–liquid and liquid–liquid), Absorption and adsorption (introductory idea), Membrane separation: Reverse osmosis and ultrafiltration (basic concept only). Applications in: Petroleum refining (basic idea of fractionation), Food industry (oil refining, sugar purification), Pharmaceutical industry (purification of drugs)

Unit III: Industrial Equipment and Scale-Up **(12 Hours)**

Introduction to common industrial equipment (working principle only): Reactors (batch and continuous), Distillation columns (basic idea), Heat exchangers (simple concept), Pumps and compressors (basic working), Mixers, grinders, and extruders, Concept of scale-up:From laboratory to industry (basic understanding), Common challenges: Mixing, heat generation, reaction control (qualitative only)

Unit IV: Clean and Sustainable Chemical Technology **(12 Hours)**

Basic principles of green chemistry (with simple examples), Clean and eco-friendly technologies, Waste minimization and recycling, Concept of circular economy (introductory level). Biodegradable materials and plastics, Waste-to-wealth concept (e.g., plastic/PET recycling), Basic idea of environmental regulations.

Unit V: Chemistry in Society **(12 Hours)**

Energy resources: Fossil fuels (uses and environmental issues), Renewable energy (solar, biomass, hydrogen – basic idea), Nuclear energy (introductory concept). Materials and polymers: Plastics and their uses, Environmental issues related to plastics. Chemical processes in daily life: Combustion (fuels), Corrosion (rusting and prevention), Basic idea of drugs and medicines. Role of chemistry in: Healthcare, Agriculture (fertilizers and pesticides), Environmental protection (water purification, pollution control)

Reference books:

1. Benvenuto, M. A. (2019). *Industrial Chemistry*. Berlin: De Gruyter.
2. Heaton, C. A. (1996). *An Introduction to Industrial Chemistry* (3rd ed.). Dordrecht: Springer.
3. Rao, B. K. B. (2012). *Chemical Technology: From Principles to Products*. New Delhi: Oxford University Press.
4. Tinkler, K. J., & Masters, G. M. (2019). *Applied Chemistry* (2nd ed.). Boston: Cengage Learning.
5. Kent, J. A. (Ed.). (2013). *Handbook of Industrial Chemistry and Biotechnology* (12th ed.). New York: Springer.
6. Wiley-VCH (Ed.). (2012). *Ullmann's Encyclopedia of Industrial Chemistry*. Weinheim: Wiley-VCH.
7. Anastas, P. T., & Warner, J. C. (1998). *Green Chemistry: Theory and Practice*. New York: Oxford University Press.
8. Jain, P., Raghav, S., & Jangir, A. K. (Eds.). (2025). *Towards green chemical processes: Strategies and innovations*. Cham: Springer.
9. Bajpai, P. (2026). *Green chemistry and sustainability in pulp and paper industry* (2nd ed.). Cham: Springer.
10. Jiménez-González, C., & Constable, D. J. C. (2025). *Green and sustainable chemistry and engineering: A practical design approach* (2nd ed.). Hoboken: Wiley.
11. Ameta, S. C., & Ameta, R. (Eds.). (2024). *Green chemistry: Fundamentals and applications* (2nd ed.). Boca Raton: Apple Academic Press.
12. Benvenuto, M. A. (2024). *Industrial organic chemistry*. Berlin: De Gruyter.
13. Benvenuto, M. A. (2024). *Industrial inorganic chemistry*. Berlin: De Gruyter.
14. Liu, Z., & Kraus, G. (Eds.). (2023). *Green chemistry and green materials from plant oils and natural acids*. Cambridge: Royal Society of Chemistry.
15. Lancaster, M. (2020). *Green chemistry: An introductory text* (3rd ed.). Cambridge: Royal Society of Chemistry.

CHEMISTRY- GE-10
COURSE TITLE: CHEMISTRY OF COSMETICS & PERFUMES
Total Credits: 04
Total Lectures: 60

Course Objectives

- To understand the chemical composition of cosmetics and perfumes
- To study raw materials, formulation, and evaluation
- To provide knowledge of fragrance chemistry and essential oils
- To develop awareness about safety, regulations, and environmental aspects

Course Learning Outcomes

After completion, students will be able to:

1. Explain the chemistry of cosmetic ingredients and formulations
2. Understand skin and hair care product chemistry
3. Describe fragrance chemistry and perfume formulation
4. Evaluate safety, toxicity, and regulatory aspects
5. Apply knowledge for small-scale cosmetic preparation

UNIT I: Basics of Cosmetic Chemistry **(10 Hours)**

Definition, classification, and history of cosmetics, Structure and chemistry of skin and hair, Functions of cosmetics,Raw materials used in cosmetics: Water, oils, waxes, emulsifiers, preservatives, antioxidants,Concept of pH and stability in formulations

UNIT II: Skin Care Products **(15 Hours)**

Creams and lotions: types (oil-in-water, water-in-oil emulsions), Moisturizers and cold creams, Sunscreens: UV filters (organic and inorganic), Face powders and foundations. Lipsticks: formulation, role of pigments, waxes, and oils, Bleaching agents and depilatories.

UNIT III: Hair Care and Oral Care Products **(10 Hours)**

Shampoos: types and formulation (surfactants, conditioners), Hair dyes: temporary, semi-permanent, permanent (oxidation dyes), Hair styling products (gels, sprays), Toothpaste and mouthwash: abrasives, fluorides, antiseptics.

UNIT IV: Perfume Chemistry **(15 Hours)**

Introduction to perfumery, Classification of fragrances, Floral, woody, oriental, fresh Essential oils: Extraction methods (steam distillation, solvent extraction) Chemistry of odor: Functional groups responsible for fragrance Perfume formulation: Top notes, middle notes, base notes Fixatives and stabilizers.

UNIT V: Safety, Toxicology & Regulations **(10 Hours)**

Toxic effects of cosmetic ingredients, Allergens and skin sensitivity, Role of preservatives and antimicrobial agents, Regulatory bodies: BIS, FDA, EU guidelines, Labeling and quality control

Suggested Readings

1. Poucher's Perfumes, Cosmetics and Soaps
   Edited by Hilda Butler 10th Edition, Springer / Kluwer Academic Publishers, 2000.
2. Handbook of Cosmetic Science and Technology André O. Barel; Marc Paye; Howard I. Maibach 4th Edition, CRC Press, 2014.
3. Harry's Cosmeticology J. B. Wilkinson; R. J. Moore 8th Edition, Chemical Publishing

Company, 2012.
4. Cosmetics: Formulation, Manufacturing and Quality Control P. P. Sharma 4th Edition, Vandana Publications, New Delhi, 2014.
5. Beginning Cosmetic Chemistry Randy Schueller; Perry Romanowski 3rd Edition, Allured Publishing Corporation, 2009.
6. Chemistry and Technology of the Cosmetics and Toiletries Industry David F. Williams; Wilhelm Schmitt Springer, 1996.
7. Perfume: The Art and Science of Scent Tony Pybus; Charles Sell Royal Society of Chemistry, 2006.

B.Sc. Chemistry Honours/Honours with Research (NEP)

FOUR-YEAR FULL-TIME PROGRAMME

Programme Specific Outcomes (PSOs)

PSO 1 Understand the fundamental concepts, principles and processes underlying the academic field of chemistry, its different subfields (analytical, inorganic, organic and physical), and its linkages with related disciplinary areas/subjects.

PSO 2 Demonstrate the procedural knowledge that creates different types of professionals in the field of chemistry and related fields such as pharmaceuticals, chemical industry, teaching, research, environmental monitoring, product quality, consumer goods industry, food products, and other related industries etc.

PSO 3 Employ critical thinking and the scientific method to design, carry out, record and analyze the results of chemical experiments and get an awareness of the impact of chemistry on the environment and the society.

PSO 4 Use chemical techniques relevant to academia and industry, generic skills and global competencies, including knowledge and skills that enable students to undertake further studies in the field of chemistry or a related field and work in the chemical and non-chemical industry sectors.

PSO 5 Undertake hands on lab work and practical activities which develop problem solving abilities required for successful career in pharmaceuticals, chemical industry, teaching, research, environmental monitoring, product quality, consumer goods industry, food products, and other related industries etc.

PSO 6 Understand safety of chemicals, transfer and measurement of chemicals, preparation of solution and find out the green route for chemical reaction for sustainable development.

PSO 7 Create an awareness of the impact of chemistry on the environment, society and development outside the scientific community.

Course structure and credit framework of
B.Sc. Chemistry Honours/Honours with Research (NEP)

FOUR-YEAR FULL-TIME PROGRAMME

(w.e.f. Academic session 2026-27)

21 APRIL, 2026

Semester	Course code	Course Title	Course Type	Internal Marks	External Marks	Total Marks	Credits	Total hrs
I	B020151T	Inorganic Chemistry – I	MJDSC-1	25	75	100	3	45
	B020152T	Physical Chemistry – I	MJDSC-2	25	75	100	3	45
	B020153T	Organic Chemistry – I	MJDSC-3	25	75	100	3	45
		Practical-I	MJDSC-4	-	100	100	3	90
	V1001006	From pool of courses/Basic Analytical Chemistry	Offered SEC-1	40	60	100	2	30
	P0001020	From pool of courses/ Cement technology	Offered VAC	-	100	100	2	30
		From pool of courses/ Atomic Structure and Chemical Bonding or Color Chemistry (Offered to other UG programs)	Offered MNGEC-1	25	75	100	4	60
		From pool of courses	AEC	25	75	100	2	30
			Total Credits				22	
II	B020251T	Organic Chemistry – II	MJDSC-5	25	75	100	3	45
	B020252T	Physical Chemistry – II	MJDSC-6	25	75	100	3	45
	B020253T	Inorganic Chemistry – II	MJDSC-7	25	75	100	3	45
		Practical-II	MJDSC-8	-	100	100	3	90
	V2001006	From pool of courses/Pesticide Chemistry	Offered SEC-2	40	60	100	2	30
		From Swayam portal	VAC				2	
		From pool of courses/ Bioinorganic Chemistry or Chemistry of Food	Offered MNGEC-2	25	75	100	4	60

Semester	Course code	Course Title	Course Type	Internal Marks	External Marks	Total Marks	Credits	Total hrs
		Nutrients (Offered to other UG programs)						
		From pool of courses	AEC	25	75	100	2	30
			Total Credits				22	
			Total Credits I & II sem				44	
III	B020351T	Inorganic Chemistry - III	MJDSC-9	25	75	100	3	45
	B020352T	Organic Chemistry - III	MJDSC-10	25	75	100	3	45
	B020353T	Physical Chemistry - III	MJDSC-11	25	75	100	3	45
		Practical-III	MJDSC-12	-	100	100	3	90
	B020354T/	Application of Computers in Chemistry or Novel Inorganic Solids	MJDSE-1* or MJDSE-2*	25	75	100	4	60
	V3001003	From pool of courses/Green Chemistry and Disaster Management	Offered SEC-3	40	60	100	2	30
		From pool of courses/ Basic concepts of organic Chemistry or Chemistry and Environment or (Offered to other UG programs)	Offered MNGEC-3	25	75	100	4	60
		From pool of courses	AEC	25	75	100	2	30
			Total Credits				20	
IV	B020451T	Inorganic Chemistry - IV	MJDSC-13	25	75	100	3	45
	B020452T	Organic Chemistry - IV	MJDSC-14	25	75	100	3	45

	B020453T	Physical Chemistry - IV	MJDSC-15	25	75	100	3	45
		Practical-IV	MJDSC-16	-	100	100	3	90
	B020454T	Analytical methods or Industrial Chemicals & Environment	MJDSE-3* or MJDSE-4*	25	75	100	4	60
	V4001003	From pool of courses/Fuel Chemistry	Offered SEC-4	40	60	100	2	30
	P0004004	From Swayam Portal/ HANDS ON TRANING -UV-VIS SPECTROSCOPY	Offered VAC				2	
		From pool of courses/ States of Matter or Chemistry and Energy (Offered to other UG programs)	Offered MNGEC-4	25	75	100	4	60
		From pool of courses	AEC	25	75	100	2	30
			Total Credits				22	
			Total Credits III & IV sem				42	
			Total Credits I and II year				86	

*There is a choice between MJDSE and MNGEC in III and IV semesters as per curriculum of B.Sc. (H) NEP.

Semester	Course code	Course Title	Course Type	Internal Marks	External Marks	Total Marks	Credits	Total hrs
V		Organic Chemistry – V	MJDSC-17	25	75	100	4	60
		Inorganic Chemistry – V	MJDSC-18	25	75	100	4	60
		Practical – V	MJDSC-19	-	100	100	4	120
		Inorganic Materials of Industrial importance or Molecular	MJDSE-5 or MJDSE-6	25	75	100	4	60

		modelling and drug design						
		From pool of courses/Chemical Technology & Society (Offered to other UG programs)	Offered MNGEC-5	25	75	100	4	60
			Total Credits				20	
VI		Advanced Physical Chemistry	MJDSC-20	25	75	100	4	60
		Polynuclear hydrocarbons, Photochemistry & Pericyclic reactions	MJDSC-21	25	75	100	4	60
		Practical – VI	MJDSC-22	-	100	100	4	120
		Industrial and Analytical Chemistry or Green Chemistry	MJDSE-7 or MJDSE-8	25	75	100	4	60
		From pool of courses/Chemistry of Cosmetics and Perfumes (Offered to other UG programs)	Offered MNGEC-6	25	75	100	4	60
			Total Credits				20	
			Total Credits I and II year				86	
			Total Credits I, II and III year				126	

The credit framework is as per approved University guidelines for UG Honours NEP programmes.

SEMESTER I

DSC-1
INORGANIC CHEMISTRY-I
Atomic Structure & Chemical Bonding
(Credits: 03)
(Theory – 45 hrs)

Course Objectives: The course reviews the structure of the atom, which is a necessary pre-requisite in understanding the nature of chemical bonding in compounds. It provides basic knowledge about ionic and covalent bonding, and explains that chemical bonding is best regarded as a continuum between the two cases. It discusses the periodicity in properties with reference to the s and p block, which is necessary in understanding their group chemistry.

Learning Outcomes:

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

- Explain the fundamental concepts of atomic structure including quantum mechanics, Schrödinger wave equation, quantum numbers, wave functions, and electronic configuration of atoms.
- Interpret periodic trends such as atomic and ionic radii, ionization enthalpy, electron gain enthalpy, and electronegativity using concepts like effective nuclear charge, shielding effect, and Slater's rules.
- Analyze ionic bonding using radius ratio rules, Born-Landé equation, Born-Haber cycle, and Fajan's rules, and explain the factors influencing lattice energy and covalent character in ionic compounds.
- Describe covalent bonding through VSEPR theory, valence bond theory, hybridization, Bent's rule, and molecular orbital theory, and predict molecular geometry, bond properties, and stability of simple molecules and ions.

Unit I: Atomic Structure **(14 hrs)**

Recapitulation of Bohr's theory, its limitations and atomic spectrum of hydrogen atom. Wave mechanics: de Broglie equation, Heisenberg's uncertainty principle and its significance, Schrödinger's wave equation, significance of Ψ and Ψ^2. Quantum numbers and their significance. Normalized and orthogonal wave functions. Sign of wave functions. Radial and angular wave functions for hydrogen atom. Radial and angular distribution curves. Shapes of s, p, d and f orbitals. Pauli's exclusion principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations.

Unit II: Periodicity of Elements **(6 hrs)**

Brief discussion of the following properties of the elements, with reference to s & p- Effective nuclear charge, shielding (screening effect), ionization energy, Slater rules, variation of effective nuclear charge in periodic table.

a. Atomic and Ionic radii.

b. Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization energy Electron gain enthalpy

c. Electronegativity, Pauling's/Allred Rochow's scales. Variation of electronegativity with bond order, partial charge, hybridization, group electronegativity.

Unit III: Ionic bond **(12 hrs)**

General characteristics, types of ions, size effects, radius ratio rule and its limitations. Packing of ions in crystals. Born-Landé equation with derivation Born-Haber cycle and its applications. Covalent character in ionic compounds, polarizing power and polarizability. Fajan's rules and consequences of polarization.

Unit IV: Covalent bond **(13 hrs)**

Valence shell electron pair repulsion (VSEPR) theory, shapes of simple molecules and ions containing lone pairs and bond pairs of electrons: H_2O, NH_3, PCl_3, PCl_5, SF_6, ClF_3, I_3, BrF_2^+, PCl_6^-, ICl_2^-, ICl_4^-, and SO_4^{2-}. Valence Bond theory (Heitler-London approach). Hybridization, equivalent and nonequivalent hybrid orbitals, Bent's rule. Ionic character in covalent compounds: Percentage ionic character from dipole moment and electronegativity difference. Molecular orbital diagrams of homo & hetero diatomic molecules and their ions N_2, O_2, C_2, B_2, F_2, CO, NO.

Reference Books:

1. Lee, J.D. (2019) Concise Inorganic Chemistry, Pearson Education.
2. Huheey, J.E., Kieter, E.A., Kieter, R.L., Medhi, O.K., (2021) Inorganic Chemistry, Principles of Structure and Reactivity, Pearson Education.
3. Douglas, B.E. and Mc Daniel, D.H., (2011) Concepts & Models of Inorganic Chemistry, Oxford University Press.
4. Shriver, D.D., & P. Atkins, (2016) Inorganic Chemistrty 2nd Ed, Oxford University Press.
5. Day, M.C. and Selbin, J. (2012) Theoretical Inorganic Chemistry, ACS Publications.

DSC-2
PHYSICAL CHEMISTRY-I
Gaseous and Liquid state
(Credits: 03)
(Theory -45 hrs)

Course Objectives

- To develop an understanding of the kinetic theory of gases and the behavior of ideal gases, including molecular velocities, collision properties, and gas laws.
- To explain the concept of viscosity in gases and liquids, its molecular origin, and the factors affecting viscosity, surface tension, and related liquid properties.
- To study the behavior of real gases using compressibility factor, deviations from ideal behavior, and van der Waals equation of state.
- To provide knowledge of the physical properties of liquids such as vapour pressure, boiling point, capillary action, and surface tension, along with their practical determination methods.

Learning Outcomes

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

- Apply the kinetic theory of gases to explain molecular motion, Maxwell's distribution of velocities, collision frequency, mean free path, and related gas properties.
- Analyze the coefficient of viscosity in gases and liquids, and explain the effects of temperature, pressure, molecular interactions, and solute addition on viscosity.
- Interpret the behavior of real gases using compressibility factor, van der Waals equation, and molecular interaction concepts, and distinguish between ideal and non-ideal gas behavior.
- Evaluate important liquid state properties such as vapour pressure, surface tension, capillary action, and boiling point, and perform calculations related to their experimental determination.

Unit 1: Gaseous state **(10 hrs)**

Kinetic theory of gases- postulates and derivation of kinetic gas equation, Maxwell distribution of molecular velocities and its use in evaluating average, root mean square and most probable velocities and average kinetic energy. Definition, expression, applications and temperature and pressure dependence of each one of the following properties of ideal gases: Collision frequency, Collision diameter, Mean free path.

Unit 2: Coefficient of viscosity **(10 hrs)**

Coefficient of viscosity, definition, units and origin of viscosity of gases, relation between mean free path and coefficient of viscosity, temperature and pressure dependence of viscosity of a gas, calculation of molecular diameter from viscosity Barometric distribution law, its derivation and applications, effect of height, temperature and molecular mass of the gas on barometric distribution.

Unit 3: Behaviour of real gases **(10 hrs)**

Behaviour of real gases- Compressibility factor, Z, Variation of compressibility factor with pressure at constant temperature (plot of Z vs P) for different gases (H_2, CO_2, CH_4 and NH_3), Cause of deviations from ideal gas behaviour and explanation of the observed behaviour of real gases in the light of molecular interactions van der Waals equation of state & Limitations.

Unit4: Liquid state **(15 hrs)**

Nature of liquid state, qualitative treatment of the structure of the liquid state Physical properties of liquids-vapour pressure, its origin and definition, Vapour pressure of liquids and intermolecular forces, and boiling point Surface tension, Capillary action in relation to cohesive and adhesive forces, determination of surface tension by (i) using stalagmometer (drop number and drop mass method both) and (ii) capillary rise method, role of surface tension in the cleansing action of detergents Coefficient of viscosity and its origin in liquids. Interpretation of viscosity data of pure liquids (water, ethanol, ether and glycerol) in the light of molecular interactions, Effects of addition of sodium chloride, ethanol and polymer on the viscosity of water, relative viscosity, specific viscosity of liquids and gases.

Reference Books:

1.Atkins, P.W.; Paula, J.de. (2018), Atkin's Physical Chemistry Ed., 10th Edition, Oxford University Press.
2. Ball, D. W. (2017), Physical Chemistry, 2nd Edition, Cengage Learning, India.
3. Castellan, G. W. (2012), Physical Chemistry, 4th Edition, Narosa.
4. Kapoor, K.L. (2019), A Textbook of Physical Chemistry, Vol 1, 6th Edition, McGraw Hill Education

DSC-3
ORGANIC CHEMISTRY- I
Basic Concepts, Aliphatic & Aromatic Hydrocarbons
(Credits: 03)
(Theory -45 hrs)

Objectives:

The core course Organic Chemistry-I is designed in a manner that it forms a cardinal part of the learning of organic chemistry for the subsequent semesters. The course is infused with the recapitulation of fundamental concepts of organic chemistry and the introduction of the concept of visualizing the organic molecules in a three-dimensional space. To establish the applications of these concepts, the functional groups-alkanes, alkenes, alkynes, benzene are introduced. The constitution of the course strongly aids in the paramount learning of the concepts and their applications.

Learning Outcomes: On completion of the course, the student will be able to:

• Understand and explain the electronic displacements and reactive intermediates and their applications in basic concepts.
• Formulate the mechanistic route of organic reactions by recalling and correlating the fundamental concepts.
• Identify and comprehend mechanism for free radical substitution, electrophilic addition, nucleophilic substitution and elimination reactions.
• Understand the fundamental concepts of stereochemistry.
• Understand and suitably use the chemistry of hydrocarbons

Unit I: Basic Concepts of Organic Chemistry **(8 hrs)**

Electronic displacements and their applications: inductive, electromeric, resonance and mesomeric effects and hyperconjugation. Dipole moment, acidity and basicity. Homolytic and heterolytic fissions with suitable examples. Types, shape and relative stability of carbocations, carbanions, carbenes and free radicals. Electrophiles & nucleophiles, and introduction to types of organic reactions: addition, elimination and substitution reactions.

Unit II: Stereochemistry **(18 hrs)**

Stereoisomerism: Optical activity and optical isomerism, asymmetry, chirality, enantiomers, diastereomers. specific rotation; Configuration and projection formulae: Newman, Sawhorse, Fischer and their interconversion. Chirality in molecules with one and two stereocentres; meso configuration. Relative and absolute configuration: D/L and R/S designations (CIP rules). Geometrical isomerism: cis-trans, syn-anti and E/Z notations. Conformational Isomerism: Alkanes (Conformations, relative stability and energy diagrams of Ethane, Propane and butane). Relative stability of cycloalkanes (Baeyer strain theory), Cyclohexane conformations and Conformations of monosubstituted cyclohexanes.

Unit III: Aliphatic Hydrocarbons **(10 hrs)**

Alkanes: Preparation, Halogenation of alkanes, Concept of relative reactivity v/s selectivity. Alkenes and Alkynes: Methods of preparation of alkenes using Mechanisms of E1, E2, E1cb reactions, Electrophilic additions, mechanism with suitable examples, (Markownikoff/Anti-markownikoff addition), syn and anti-addition; addition of H_2, X_2, oxymercuration-demercuration, hydroboration-oxidation, ozonolysis, hydroxylation, reaction with NBS, Reactions of alkynes; acidity, Alkylation of terminal alkynes, electrophilic addition: hydration to form carbonyl compounds.

Unit IV: Aromatic Hydrocarbons **(09 hrs)**

Concept of Aromaticity and anti-aromaticity; Electrophilic aromatic substitution: halogenation, nitration, sulphonation, Friedel Crafts alkylation/acylation with their mechanism. Directing effects of groups in electrophilic substitution.

Reference Books:

1. Morrison, R. N. & Boyd, R. N. (2010) Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Finar, I. L.(2022) Organic Chemistry (Volume 1), Dorling Kindersley (India)Pvt.Ltd.(PearsonEducation).
3. Finar, I. L.(2022) Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (PearsonEducation).
4. Eliel, E. L. &Wilen, S. H. (2008) Stereochemistry of Organic Compounds; Wiley: London.
5. Kalsi, P.S.(2010) Stereochemistry: Conformation and Mechanism, New age International.

DSC-4
PRACTICAL -I
(Credits: 03)
(45 labs of 2 hrs each=90 hrs)

Course Objectives

- To develop practical skills in volumetric analysis, physicochemical measurements, and separation techniques used in chemical laboratories
- To provide hands-on experience in titrimetric analysis, surface tension, viscosity, thermal measurements, and chromatographic methods
- To enhance understanding of laboratory techniques, calibration of apparatus, purification methods, and qualitative analysis of organic compounds

Learning Outcomes

Upon successful learning, students will be able to:

- Prepare standard solutions and perform acid-base and redox titrations with accuracy and precision
- Apply principles of surface tension, viscosity, gas laws, and thermal measurements in laboratory experiments
- Perform recrystallization, determine melting and boiling points, and calibrate basic laboratory instruments
- Separate and identify compounds using chromatography and detect extra elements such as nitrogen, sulphur, and halogens in organic compounds

1. **Titrimetric Analysis**

a) Calibration and use of apparatus
b) Preparation of solutions of different Molarity/Normality

2. **Acid- Base Titrations**

Principles of Acid-base titrants to be discussed.

a. Estimation of oxalic acid using standardized NaOH solution
b) Estimation of sodium carbonate using standardized HCl.
c) Estimation of carbonate and hydroxide present together in a mixture.
d) Estimation of carbonate and bicarbonate present together in a mixture.

3. **Redox Titration**

Principles of oxidation-reduction titrants (electrode potentials) to be discussed.

a) Estimation of oxalic acid using standardized $KMnO_4$ solution
b) Estimation of oxalic acid and sodium oxalate in a given mixture

4. **Gases.** To verify the Charles law using Charles law apparatus.
5. **Surface tension measurements using stalagmometer**

a) Determine the surface tension of a liquid by drop number method.
b) Determine the surface tension of a liquid by drop weight method.
c) Study the variation of surface tension with different concentration of detergent solutions. Determine CMC.
d) Study the effect of the addition of solutes on the surface tension of water at room temperature and explain the observations in terms of molecular interactions: (i) sugar (ii) ethanol (iii) sodium chloride
e) Study the variation of surface tension with different concentration of sodium chloride solutions.

6. **Viscosity measurement using Ostwald's viscometer**

a) Determination of co-efficient of viscosity of two unknown aqueous solution.

b) Study the variation of viscosity with different concentration of sugar solutions.

c) Study the effect of the addition of solutes such as (i) polymer (ii) ethanol (iii) sodium chloride on the viscosity of water at room temperature and explain the observations in terms of molecular interactions

d) Study the variation of viscosity of water with the amounts of a solute and calculate the intrinsic viscosity at room temperature.

e) Determine the viscosity average molecular mass of the polymer (PVA) using viscosity measurements

7. Calibration of a thermometer and determination of the melting points of the organic compounds using Kjeldahl method.
8. Concept of recrystallisation using alcohol/water/alcohol-water systems (Any two).
9. Determination of boiling point of liquid compounds (boiling point lower than and more than 100 °C by distillation, capillary method
10. Separation of a mixture of two amino acids/sugars by radial/ascending paper chromatography.
11. Separation of a mixture of o-and p-nitrophenol or o-and p-aminophenol by thin layer chromatography (TLC).
12. Detection of other elements like N, S & halogen.

Reference Books:

- Vogel, A.I. A (1980). Textbook of Quantitative Inorganic Analysis,
- Khosla, B.D.; Garg, V.C.; Gulati, A. (2015), Senior Practical Physical Chemistry, R. Chand & Co, New Delhi.
- Kapoor, K.L. (2020), A Textbook of Physical Chemistry, Vol.7, 1st Edition, McGraw Hill Education.
- Garland, C. W.; Nibler, J. W.; Shoemaker, D. P. (2012), Experiments in Physical Chemistry, 8th Edition, McGraw-Hill, New York.
- Mann, F.G., Saunders, B.C. (2012), Practical Organic Chemistry, 4th Edition, Pearson Education.
- Ahluwalia, V.K., Dhingra, S. (2022), Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press.
- Furniss, B.S., Hannaford, A.J., Smith, P.W.G.; Tatchell, A.R (2004), Vogel's Textbook of Practical Organic Chemistry, Pearson.
- Leonard, J., Lygo, B., Procter, G. (2013) Advanced Practical Organic Chemistry, 3rd Edition, CRC Press.
- Pasricha, S., Chaudhary, A. (2021), Practical Organic Chemistry: Volume–I, I K International Publishing house Pvt. Ltd, New Delhi

SEC-1
BASIC ANALYTICAL CHEMISTRY
(Credits: 02)
Lectures: 30

Course Objectives:
To inculcate the basic understanding of Analytical chemistry and its interdisciplinary applications among the students.

Learning outcomes:
Upon successful learning, students will be able to:

- Gather knowledge of basic and applied areas of Analytical Chemistry as well as how to present experimental data.
- Understand the composition of soil and measurement of important parameters of soil.
- Measurement of important water quality parameters and adulterants in food items.
- To understand the basic concept of different types of two-dimensional chromatography and its application.
- To develop concept about analysis of cosmetics and metal ions in various samples using classical and instrumental method of quantitative analysis.

UNIT 1 Introduction **(Lectures: 8)**
Introduction to Analytical Chemistry and its interdisciplinary nature. Concept of sampling. Importance of accuracy, precision and sources of error in analytical measurements.

Unit 2 Concept of Indicators **(Lectures: 6)**
Indicator in chemistry, Acid base indicators, Redox indicators, Adsorption indicators, Radioactive indicators. Methyl orange, Methyl red, Litmus, Phenolphthalein.

UNIT 3 Analysis of soil **(Lectures: 8)**
Composition of soil, Concept of pH its measurement, Complexometric titrations, Chelation, Chelating agents, use of indicators

UNIT 4 Analysis of water **(Lectures: 8)**
Definition of pure water, sources responsible for contaminating water, water sampling methods, water purification methods. Part - I. Determination of pH, acidity and alkalinity of a water sample. Part - II Determination of dissolved oxygen (DO) of a water sample.

Suggested Applications (Any one):
a. To study the use of phenolphthalein in trap cases.
c. To carry out analysis of gasoline.

Suggested Instrumental demonstrations:
a. Estimation of macro nutrients: Potassium, Calcium, Magnesium in soil samples by flame photometry.
b. Spectrophotometric determination of Iron in Vitamin /Dietary Tablets.
c. Determination of pH of soil samples.
d. Estimation of Calcium and Magnesium ions as Calcium carbonate by complexometric titration.

Reference Books:

1. Willard, H. H. (2015). Instrumental Methods of Analysis, CBS Publishers.
2. Skoog, D.A. and Leary, J.J., (2003). Instrumental Methods of Analysis, Saunders College Publications, New York,

3. Skoog, D.A.; West, D.M. and Holler, F.J. (2010). Fundamentals of Analytical Chemistry 6th Ed., Saunders College Publishing, Fort Worth.
4. Harris, D. C. (2007). Quantitative Chemical Analysis 7th Ed., W. H. Freeman and Co., NewYork
5. Dean, J. A. (2018). Analytical Chemistry Handbook, McGraw Hill.
6. Day, R. A. and Underwood, A. L. (2021). Quantitative Analysis, Prentice Hall of India.
7. Cooper, T.G. (1977). (Ed.) The Tools of Biochemistry, John Wiley and Sons, N.Y.
8. Svehla, G., (1996). Vogel's Qualitative Inorganic Analysis 7thEd., Prentice Hall.

VAC-I
Cement Technology
Credits:02
(Lectures:30)

Course objectives:

- To impart basic understanding of cement technology.
- To provide knowledge of cement manufacturing processes and mechanisms involved.
- To train students regarding basic testing of cement.
- To equip students with professional skills required to work in cement industry.

Learning outcomes:

- Understand the theoretical and practical background of cement technology
- Demonstrate knowledge of cement testing methods
- Develop skills to work in related industries.

(Lectures:08)

UNIT-1 Raw Materials
Limestone, silica, alumina, alkalis, shells and chalk or marl combined with shale, clay, slate, blast furnace, slag and iron ore, colouring elements. Functions of ingredients.

(Lectures:06)

UNIT-2 Types of Cements and their Applications
Ordinary Portland cement (OPC), Portland pozzolana cement (PPC), Rapid-hardening cement, extra-rapid-hardening cement, Quick-setting cement, Low-heat cement, sulfate-resisting cement, blast furnace slag cement.

(Lectures:04)

UNIT-3 Manufacturing of Cement and setting
Cement manufacturing process, blasting, mixing, grinding & burning, hydration: types & mechanisms, hardening

(Lectures:08)

UNIT-4 Testing of Cement
Specifications and grading; Chemical composition, Fineness, consistency, strength, specific gravity, soundness, air content, compressive strength, early age strength development, increased heat of hydration, lower heat of hydration, particle size, setting time, tensile strength. VICAT apparatus.

Experiments: 4 sessions of two hrs each (any four)

i) Determination of fineness of cement
ii) Determination of initial and final setting time
iii) Chemical composition test
iv) Determination of heat of hydration
v) Determination of soundness of cement
vi) Determination of specific gravity
vii) Determination of compressive strength of concrete

Reference Books:

1. Chatterjee A.K., 2020. Cement production technology Taylor and Francis, CRC Press
2. Sahu S.P., 2020. The secret of cement laboratory, Notion Press.
3. Omar, R., 2020. Fundamental of Instrumentation and Process Control: Cement Technology, Notion Press.

SEMESTER II

DSC-5

ORGANIC CHEMISTRY -II

Haloalkanes, Haloarenes, Alcohols, Phenols, ethers and epoxides

(Credits: 03)

(Theory -45 hrs)

Course Objectives

1. To understand the preparation, properties, and reaction mechanisms of haloalkanes and haloarenes, with emphasis on nucleophilic substitution and elimination reactions.
2. To explain the chemistry of alcohols and phenols, including their preparation, physical and chemical properties, oxidation, rearrangements, and important name reactions.
3. To study the preparation and reactions of ethers and epoxides, with special focus on cleavage reactions and ring opening mechanisms under acidic and basic conditions.
4. To develop the ability to analyze organic reaction mechanisms, stereochemical aspects, and factors affecting reactivity and selectivity in substitution, elimination, and rearrangement reactions.

Learning Outcomes

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

1. Describe the preparation and reactivity of haloalkanes and haloarenes, and differentiate between SN1, SN2, SNi, SNAr, and benzyne mechanisms with stereochemical considerations.
2. Explain the reactions of alcohols and phenols, including oxidation, esterification, rearrangements, and electrophilic substitution reactions, and predict the effect of structure on reactivity.
3. Analyze the preparation and cleavage of ethers and epoxides, and compare acid-catalyzed and base-catalyzed mechanisms of ether cleavage and epoxide ring opening.
4. Apply mechanistic reasoning to interpret substitution, elimination, rearrangement, and ring-opening reactions, and predict the products of organic transformations.

Unit - 1: Haloalkanes **(12 Lectures)**

Alkyl halides: Methods of preparation and properties, nucleophilic substitution reactions – SN_1, SN_2 and SN_i mechanisms with stereochemical aspects and effect of solvent; nucleophilic substitution v/s elimination.

Unit - 2: Aryl halides **(09 Lectures)**

Preparation (including preparation from diazonium salts) and properties, nucleophilic aromatic substitution; SN_{Ar}, Benzyne mechanism. Relative reactivity of alkyl, allyl, benzyl, vinyl and aryl halides towards nucleophilic substitution reactions.

Unit - 3: Alcohols & Phenols **(15 Lectures)**

Alcohols: Relative reactivity of 1°, 2°, 3° alcohols, reactions of alcohols with sodium, HX (Lucas test), esterification, oxidation (with PCC, alkaline $KMnO_4$, acidic dichromate, conc. HNO_3). Oppenauer oxidation; Pinacol-Pinacolone rearrangement. Phenols: Preparation using Cumene hydroperoxide, Acidity and factors affecting it, Kolbe's–Schmidt reactions, Riemer-Tiemann reaction, Houben–Hoesch condensation, Schotten–Baumann reaction, Fries and Claisen rearrangements and their mechanism.

Unit-4: Ethers & Epoxides **(09 Lectures)**

Preparation of ethers by Williamson's ether synthesis and dehydration of alcohols. Physical and chemical properties of ethers. Cleavage of ethers with hydrogen halides (HI and HBr). Mechanism of acid-catalyzed cleavage of symmetrical and unsymmetrical ethers.

Methods of preparation of epoxides from alkenes and halohydrins. Ring strain in epoxides and its effect on reactivity. Acid-catalyzed ring opening of epoxides and mechanism. Base-catalyzed ring opening of epoxides with nucleophiles and mechanism. Difference between acid-catalyzed and base-catalyzed cleavage of epoxides with suitable examples.

Essential/recommended readings

1. Morrison, R. N., Boyd, R. N., Bhattacharjee, S.K. (2010), Organic Chemistry, 7th Edition, Dorling Kindersley (India) Pvt. Ltd., Pearson Education.
2. Finar, I.L. (2002), Organic Chemistry, Volume 1, 6th Edition, Dorling Kindersley (India) Pvt. Ltd., Pearson Education.
3. Ahluwalia, V.K.; Bhagat, P.; Aggarwal, R.; Chandra, R. (2005), Intermediate for Organic Synthesis, I.K. International.
4. Solomons, T.W.G., Fryhle, C.B., Snyder, S.A. (2017), Organic Chemistry, 12th Edition, Wiley.

Suggestive readings

1. Carey, F.A., Sundberg, R. J. (2008), Advanced Organic Chemistry: Part B: Reaction and Synthesis, Springer.
2. Bruice, P.Y. (2020), Organic Chemistry, 3 rd Edition, Pearson.
3. Patrick, G. (2012), BIOS Instant Notes in Organic Chemistry, Viva Books.
4. Parashar, R.K., Ahluwalia, V.K. (2018), Organic Reaction Mechanism, 4th Edition, Narosa Publishing House.

DSC-6

PHYSICAL CHEMISTRY –II

Chemical Thermodynamics and its Applications

(Credits: 03)

(Theory – 45 hrs)

Learning Objectives

The Learning Objectives of this course are as follows:

• To make students understand thermodynamic concepts, terminology, properties of thermodynamic systems, laws of thermodynamics and their correlation with other branches of physical chemistry and make them able to apply thermodynamic concepts to the system of variable compositions, equilibrium and colligative properties.

Learning outcomes

On completion of the course, the student will be able to:

• Explain and apply the three laws of thermodynamics, concept of State and Path functions, extensive and intensive properties to solve critical problems.

• Derive the expressions of ΔU, ΔH, ΔS, ΔG, ΔA for an ideal gas under different conditions and use them for solving real world problems.

• Explain the concept of partial molar properties.

UNIT – 1: Basic Concepts of Chemical Thermodynamics **(6 Lectures)**

Intensive and extensive variables; state and path functions; isolated, closed and open systems. Mathematical treatment - Exact and inexact differential, Partial derivatives, Euler's reciprocity rule, cyclic rule.

UNIT – 2: First law and Thermodynamics **(15 Lectures)**

Concept of heat, Q, work, W, internal energy, U, and statement of first law; enthalpy, H, relation between heat capacities, Joule Thompson Porous Plug experiment, Nature of Joule Thompson coefficient, calculations of Q, W, ΔU and ΔH for reversible, irreversible and free expansion of gases (ideal and van der Waals) under isothermal and adiabatic conditions. Enthalpy of reactions: standard states; enthalpy of neutralization, enthalpy of hydration, enthalpy of formation and enthalpy of combustion and its applications, bond dissociation energy and bond enthalpy; effect of temperature (Kirchhoff's equations) on enthalpy of reactions.

UNIT – 3: Second Law and Thermodynamics **(15 Lectures)**

Concept of entropy; statement of the second law of thermodynamics, Carnot cycle.Calculation of entropy change for reversible and irreversible processes (for ideal gases). Free Energy Functions: Gibbs and Helmholtz energy; variation of S, G, A with T, V, P; Free energy change and spontaneity (for ideal gases). Relation between Joule Thomson effect and other thermodynamic parameters; inversion temperature; Gibbs-Helmholtz equation; Maxwell relations.

UNIT – 4: Third Law and Thermodynamics **(3 Lectures)**

Statement of third law, unattainability of absolute zero, Partial molar quantities, dependence of thermodynamic parameters on composition; Gibbs Duhem equation dilute

UNIT – 5: Systems of Variable Composition & Colligative Properties **(6 Lectures)**

Solutions chemical potential of ideal mixtures; lowering of vapour pressure, Raoult's and Henry's laws and their applications. Thermodynamic derivation to derive relations between the four Colligative properties (i) relative lowering of vapour pressure, (ii) elevation of boiling point, (iii) depression of freezing point, (iv) osmotic pressure

Essential/recommended readings

1. Peter, A.; Paula, J. de. (2011), Physical Chemistry, 9th Edition, Oxford University Press.
2. Castellan, G. W. (2004), Physical Chemistry, 4th Edition, Narosa.
3. Kapoor, K.L. (2015), A Textbook of Physical Chemistry, Vol 2, 6th Edition, McGraw Hill Education.
4. Kapoor, K.L., A Textbook of Physical Chemistry, Vol 3, 5th Edition, McGraw Hill Education. 5. McQuarrie, D. A.; Simon, J. D. (2004), Molecular Thermodynamics, Viva Books Pvt. Ltd.

Sangeeta

DSC-7
INORGANIC CHEMISTRY-II
Chemistry of s- and p-Block Elements
(Credits: 03)
(Theory-45 hrs)

Course Objectives
1. To develop an understanding of the general principles of metallurgy, including extraction, reduction, and purification of metals based on their occurrence and reactivity.
2. To explain the properties and chemical behavior of s-block elements, including alkali and alkaline earth metals and their important compounds.
3. To study the trends and characteristics of p-block elements with reference to electronic configuration, periodic properties, oxidation states, and chemical behavior.
4. To understand the structure, properties, and reactivity of important hydrides and oxoacids of p-block elements, with emphasis on their acidic/basic nature and stability.

Learning Outcomes
After successful completion of this course, students will be able to:
1. Explain the extraction and purification of metals using metallurgical principles such as Ellingham diagrams, electrolytic reduction, hydrometallurgy, and refining methods.
2. Describe the general characteristics and chemical reactions of s-block elements and compare the properties of their important compounds such as oxides, hydrides, carbonates, nitrates, and sulphates.
3. Interpret periodic trends in p-block elements including atomic size, electronegativity, ionization enthalpy, catenation, and variable oxidation states, and relate them to their chemical properties.
4. Analyze the properties and reactions of hydrides and oxoacids of p-block elements, and explain their stability, acidic/basic nature, and behavior on heating and hydrolysis.

UNIT – 1: General Principles of Metallurgy **(10 Lectures)**
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 with reference to cyanide process for silver and gold. Methods of purification of metals: Electrolytic process, Van Arkel-De Boer process, Zone refining.

UNIT – 2: Chemistry of s-Block Elements **(13 Lectures)**
General characteristics: melting point, flame colouration, reducing nature, diagonal relationships and anomalous behavior of first member of each group. Reactions of alkali and alkaline earth metals with oxygen, hydrogen, nitrogen and water. Common features such as ease of formation, thermal stability, energetics of dissolution, and solubility of the following alkali and alkaline earth metal compounds: hydrides, oxides, peroxides, superoxides, carbonates, nitrates, sulphates.

UNIT – 3: Chemistry of p-Block Elements **(9 Lectures)**
Electronic configuration state atomic and ionic size, metallic/non-metallic character, melting point, ionization enthalpy, electron gain enthalpy, electronegativity, Catenation. Variable oxidation.

UNIT – 4: Compounds of p-Block Elements **(13 Lectures)**

Acidic/basic nature, stability, ionic/covalent nature, oxidation/reduction, hydrolysis, action of heat on the following:

Part-I Hydrides of Group 13 (only diborane), Group 14, Group 15 (EH_3 where E=N, P, As, Sb, Bi), Group 16 and Group 17.

Part-II Oxoacids of phosphorus, sulphur and chlorine

Essential/recommended readings

1. Lee, J. D.; (2010), Concise Inorganic Chemistry, Wiley India.
2. Huheey, J. E.; Keiter, E. A.; Keiter; R.L.; Medhi, O.K. (2009), Inorganic Chemistry- Principles of Structure and Reactivity, Pearson Education.
3. Atkins, P. W.; Overton, T. L.; Rourke, J. P.; Weller, M. T.; Armstrong, F. A. (2010), Shriver and Atkins Inorganic Chemistry, 5th Edition, Oxford University Press.
4. Miessler, G. L.; Fischer P. J.; Tarr, D. A. (2014), Inorganic Chemistry, 5th Edition, Pearson.
5. Housecraft, C. E.; Sharpe, A. G., (2018), Inorganic Chemistry, 5thEdition, Pearson.
6. Canham, G. R., Overton, T. (2014), Descriptive Inorganic Chemistry, 6 th Edition, Freeman and Company.
7. Greenwood, N. N.; Earnsaw, A., (1997), Chemistry of Elements, 2nd Edition, Elsevier.

DSC-8
PRACTICAL-II
(Credits: 03)
(45 labs of 2 hrs each=90 hrs)

Course Objectives

- To develop practical skills in organic synthesis through reactions such as acetylation, benzoylation, bromination, nitration, oxidation, and haloform reaction using both conventional and green chemistry approaches.
- To provide hands-on experience in quantitative and qualitative analysis, including estimation of inorganic compounds, redox titrations, iodometric titrations, flame photometry, and semi-micro inorganic analysis of cations and anions.
- To train students in thermochemical experiments involving determination of heat capacity, enthalpy of neutralization, enthalpy of solution, enthalpy of hydration, and related thermodynamic parameters.
- To enhance understanding of analytical techniques and laboratory methods for identifying functional groups, determining chemical composition, and interpreting experimental results with scientific accuracy.

Learning Outcomes

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

- Perform organic synthesis reactions and apply green chemistry principles for the preparation, purification, and identification of organic compounds.
- Analyze unknown samples using volumetric, iodometric, redox, and instrumental methods such as flame photometry, and accurately determine their composition.
- Conduct thermochemical experiments to calculate heat capacity, enthalpy changes, basicity of acids, and hydration energies, and interpret the thermodynamic significance of the results.
- Identify inorganic radicals and organic functional groups through systematic qualitative analysis, and explain the chemical principles involved in the reactions and observations.

1. Acetylation of any one of the following compounds: amines (aniline, o-, m-, p-toluidines and o-, m-, p-anisidine) and phenols (β-naphthol, salicylic acid) by any one method:
   i. Using conventional method
   ii. Using green approach
2. Benzolyation of one of the following amines (aniline, o-, m-, p-toluidines and o, m-, p-anisidine) or one of the following phenols (β-naphthol, resorcinol, p-cresol) by Schotten-Baumann reaction.
3. Bromination of acetanilide/aniline/phenol by anyone of the following:
   i. Green method
   ii. Conventional method
4. Nitration of nitrobenzene/chlorobenzene/phenols.
5. Haloform reaction of ethanol.
6. Oxidation of benzyl alcohol to benzoic acid
7. Estimation of the given sample of phenol/amine by: 1) Acetylation 2) Bromate-Bromide method.
8. Functional group tests for alcohols, phenols, carboxylic acids, phenols, carbonyl compounds, esters.

9. Determination of heat capacity of a calorimeter for different volumes using change of enthalpy data of a known system (method of back calculation of heat capacity of calorimeter from known enthalpy of solution of sulphuric acid or enthalpy of neutralization).
10. Determination of heat capacity of a calorimeter for different volumes using heat gained equal to heat lost by cold water and hot water.
11. Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
12. Determination of integral enthalpy solution of endothermic salts.
13. Determination of integral enthalpy solution of exothermic salts.
14. Determination of basicity of a diprotic acid by the thermochemical method in terms of the changes of temperatures observed in the graph of temperature versus time for different additions of a base. Also calculate the enthalpy of neutralization of the first step.
15. Determination of enthalpy of hydration of salt. (i) Study of the solubility of benzoic acid in water and determination of ΔH. Any other experiment carried out in the class.
16. Qualitative semi-micro analysis of mixtures containing 3 anions and 3 cations. Emphasis should be given to the understanding of the chemistry of different reactions. The following radicals are suggested:

    CO_3^{2-}, NO_2^-, S^{2-}, SO_3^{2-}, SO_4^{2-}, $S_2O_4^{2-}$, 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+}, Sn^{2+}, Sb^{3+}, Fe^{3+}, Al^{3+}, Cr^{3+}, Zn^{2+}, Mn^{2+}, Co^{2+}, Ni^{2+}, Ba^{2+}, Sr^{2+}, Ca^{2+}, Mg^{2+}

    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 e.g. 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.
17. **Redox Titrations**
    i. Estimation of Fe (II) with $K_2Cr_2O_7$ using diphenylamine as internal indicator.
    ii. Estimation of Fe (II) with $K_2Cr_2O_7$ using N-phenyl anthranilic acid as internal indicator.
    iii. Estimation of Fe (II) with $K_2Cr_2O_7$ using external indicator.
18. **Iodo/Iodimetric Titrations**
    i. Estimation of Cu(II) using sodium thiosulphate solution (Iodometrically).
    ii. Estimation of $K_2Cr_2O_7$ using sodium thiosulphate solution (Iodometrically).
    iii. Estimation of antimony in tartaremetic iodimetrically.
    iv. Estimation of Iodine content in iodized salt.
19. **Flame photometry:** Estimation of Sodium, Potassium, calcium and magnesium by flame photometry

Essential/recommended readings

1. Mann, F.G., Saunders, B.C. (2009), Practical Organic Chemistry, 4th Edition, Pearson Education.
2. Furniss, B.S., Hannaford, A.J., Smith, P.W.G., Tatchell, A.R. (2005), Vogel's Textbook of Practical Organic Chemistry, Pearson.
3. Ahluwalia, V.K., Aggarwal, R. (2004), Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press.
4. Ahluwalia, V.K., Dhingra, S. (2004), Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press.

5. Pasricha, S., Chaudhary, A. (2021), Practical Organic Chemistry: Volume–I, I K International Publishing house Pvt. Ltd, New Delhi.
6. Pasricha, S., Chaudhary, A. (2021), Practical Organic Chemistry: Volume–II, I K International Publishing house Pvt. Ltd, New Delhi.
7. Khosla, B.D.; Garg, V.C.; Gulati, A. (2015), Senior Practical Physical Chemistry, R. Chand & Co, New Delhi.
8. Kapoor, K.L. (2019), A Textbook of Physical Chemistry, Vol.7, 1st Edition, McGraw Hill Education.
9. Garland, C. W.; Nibler, J. W.; Shoemaker, D. P. (2003), Experiments in Physical Chemistry, 8th Edition, McGraw-Hill, New York.
10. Levine, I.N. (2010), Physical Chemistry, Tata Mc Graw Hill.
11. Assael, M. J.; Goodwin, A. R. H.; Stamatoudis, M.; Wakeham, W. A.; Will, S. (2011), Commonly asked Questions in Thermodynamics. CRC Press.
12. Jeffery, G. H.; Bassett, J.; Mendham, J.; Denney, R. C. (1989), Vogel's Text book of Quantitative Chemical Analysis, John Wiley and Sons.
13. Harris, D. C.; Lucy, C. A. (2016), Quantitative Chemical Analysis, 9th Edition, Freeman and Company.
14. Day, R. A.; Underwood, A. L. (2012), Quantitative Analysis, 6th Edition, PHI Learning Private Limited.

SEC-2
PESTICIDE CHEMISTRY
Credits:02
Lectures:30

Course Objectivse:

- Pesticide plays an important role in controlling quantity as well quality of the economic crops by protecting them from the various pests.
- They are used for prevention of much spoilage of stored foods and also used for prevention of certain diseases, which conserves health and has saved the lives of millions of people and domestic animals.
- Keeping the importance of pesticides in mind this course is aimed to introduce synthesis and application of pesticides.

Course Learning Outcomes:

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

- Students will be able to learn about the basic role of pesticide in everyday life, various ingredients and their role in controlling the pest.
- Students can also educate the farmers/gardeners to choose the appropriate pesticides for their crop production

UNIT 1: Introduction **(Lectures:12)**

Classification, synthesis, structure activity relationship (SAR), mode of action, uses and adverse effects of representative pesticides in the following classes: Organochlorines (DDT, Gammaxene), Organophosphates (Malathion, Parathion), Carbamates (Carbofuran and Carbaryl), Quinones (Chloranil), Anilides (Alachlor and Butachlor).

UNIT 2: Botanical Insecticides **(Lectures:8)**

[No structure elucidation or synthesis is required for the following compounds:] Alkaloids (Nicotine); Pyrethrum (natural and synthetic pyrethroids) Azadirachtin and Rotenone and Limonene

UNIT 3: Pesticide Formulations **(Lectures:6)**

Wettable powders, Surfactants, Emulsifiable concentrates, Aerosols, Dust and Granules, Controlled Release Formulations

UNIT 4: New Tools in Biological Pest Control **(Lectures:4)**

Repellants, Chemosterilants, Antifeedants, Sex attractants

Suggested Books:

1. Perry, A.S.; Yamamoto, I.; Ishaaya, I.;Perry, Y., (1998) Insecticides in Agriculture and Environment, Springer-Verlag Berlin Heidelberg.
2. Kuhr, R.J.; Derough, H.W.,Carbamate Insecticides: Chemistry (1976)Biochemistry and Toxicology, CRC Press,USA.

SEMESTER III

DSC-9
INORGANIC CHEMISTRY–III
Chemistry of d- and f- block elements & Nuclear Chemistry
(Credits: 03)
(Theory -45 hrs)

Course Objectives

- To develop an understanding of the chemistry of transition elements, including their electronic configuration, oxidation states, magnetic behavior, catalytic properties, and complex formation.
- To explain the properties of lanthanoids and actinoids, including lanthanoid contraction, oxidation states, spectral properties, and methods of separation.
- To study the structure of the nucleus, nuclear stability, radioactive decay processes, and nuclear models used to explain radioactivity and nuclear behavior.
- To provide knowledge of radiation detection methods, applications of radioactivity, and the basic principles of radiation chemistry and dosimetry.

Learning Outcomes

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

- Describe the characteristic properties of transition elements and explain trends in oxidation states, magnetic properties, catalytic activity, and complex formation using electronic structure concepts.
- Analyze the chemistry of lanthanoids and actinoids, including their electronic configurations, oxidation states, magnetic and spectral behavior, and the effects of lanthanoid contraction.
- Explain nuclear structure, nuclear stability, and different modes of radioactive decay, and apply concepts such as binding energy, radioactive series, and nuclear models to interpret nuclear phenomena.
- Demonstrate understanding of radiation detection techniques, applications of isotopes in analysis and dating, and the principles of radiation chemistry including dosimetry and radiation units.

UNIT – 1: Transition Elements **(Lecture:15)**

General group trends with special reference to electronic configuration, colour, variable valency,magnetic properties, catalytic properties, and ability to form complexes. Stability of various oxidation states and e.m.f. (Latimer diagrams), Frost diagrams of Mn and Cr. A brief discussion of differences between the first, second and third transition series.

UNIT – 2: Lanthanoids and Actinoids **(Lecture: 10)**

A brief discussion of electronic configuration, oxidation states, colour, spectral and magnetic properties. Lanthanoid contraction (causes and effects) separation of lanthanoids by ion exchange method.

UNIT –3: Nuclear Chemistry **(Lecture: 12)**

The nucleus: Subatomic particles, nuclear forces (Meson theory), nuclear size and density. Stability of nucleus: n/p ratio, binding energy, packing fraction, structure of nucleus- Shell model and Liquid drop model. Radioactivity: Natural and induced. Radioactive decay-α-decay, β-decay, γ-decay; neutron, emission, positron emission and electron capture. Group displacement law and radioactive series.

UNIT –4: Concept of radioactivity **(Lecture: 8)**

Radioactivity: ionization chamber, Geiger counters, scintillation counters. Applications: Carbon dating, neutron activation and isotope dilution analyses Radiation chemistry: Units of radiation; LET and G-Value. Dosimetry, radiation chemistry of oxygen.

Essential/recommended readings

1. Lee, J.D. (2010), **Concise Inorganic Chemistry**, Wiley India.
2. Huheey,J.E.; Keiter,E.A.; Keiter; R.L.;Medhi, O.K. (2009), **Inorganic Chemistry- Principles of Structure and Reactivity**, Pearson Education.
3. Atkins, P.W.; Overton, T.L.; Rourke, J.P.; Weller, M.T.; Armstrong, F.A. (2010), **Shriverand Atkins Inorganic Chemistry**, 5th Edition, Oxford University Press.
4. Miessler, G.L.; Fischer P.J.; Tarr, D. A. (2014), **Inorganic Chemistry**, 5th Edition,Pearson.
5. Pfennig, B. W. (2015), **Principles of Inorganic Chemistry**. John Wiley & Sons.
6. Cotton, F.A.; Wilkinson, G. (1999), **Advanced Inorganic Chemistry,** Wiley-VCH.
7. Das, A. K.; Das, M. (2014), **Fundamental Concepts of Inorganic Chemistry**, 1stEdition, Volume 1-3, CBS Publishers & Distributors Pvt. Ltd.
8. Chandrashekhar,V. (2005), **Inorganic and Organometallic Polymers**, 5th Edition,Springer Publications

DSC-10
ORGANIC CHEMISTRY –III
Carbonyls, Carboxylic acids, Amines, Nitro compounds and Diazoniums salts
(Credits: 03)
(Theory-45 hrs)

Learning objectives

The objectives of this course are as follows:

- To infuse students with the details of the chemistry of aldehydes, ketones, carboxylic acidsand their derivatives, nitro, amines and diazonium salts.
- To make students aware of the chemical synthesis, properties, reactions and key applications of the listed classes of compounds and develop understanding of detailed mechanistic pathways for each functional group to unravel the spectrum of organic chemistry and the extent of organic transformations.
- To aid in the paramount learning of the concepts and their applications.

Learning outcomes

By studying this course, students will be able to:

- Explain the chemistry of oxygen and nitrogen containing compounds.
- Use the synthetic chemistry learnt in this course to do functional group transformations.
- Propose plausible mechanisms for the reactions under study.

UNIT –1: Carbonyls Compounds **(Lecture: 12)**

Carbonyl Compounds: Reaction of carbonyl compounds with ammonia derivatives, 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, WolffKishner, $LiAlH_4$, $NaBH_4$, MPV, PDC), addition reactions of α,β-unsaturated carbonyl compounds: Michael addition

UNIT –2: Carboxylic acids & their derivatives **(Lecture: 10)**

Effect of substituents on acidic strength on carboxylic acids, HVZreaction, typical reactions of dicarboxylic acids and hydroxy acids. Comparative study of nucleophilic acyl substitution for acid chlorides, anhydrides, esters and amides, Mechanism of acidic and alkaline hydrolysis of esters, Dieckmann and Reformatsky reactions, Hoffmann- bromamide degradation and Curtius rearrangement

UNIT–3: Nitro Compounds **(Lecture: 8)**

Nitro compounds: General methods of preparation: from alkyl halides, alkanes, oxidation of amines and oximes. Henry reaction, Nef reaction, Reduction-electrolytic reduction, reaction with nitrous acid, reduction in acidic, basic and neutral medium (for aromatic compounds)

UNIT–4: Amines **(Lecture: 9)**

Amines: Preparation, chirality in amines (pyramidal inversion), Basicity of amines: Effect ofsubstituents, solvent and steric effects, distinction between Primary, secondary and tertiary amines using Hinsberg's method and nitrous acid, Gabriel Phthalimide synthesis, Carbylamine reaction, Mannich reaction, Hoffmann's exhaustive methylation, Hofmann-elimination reaction and Cope elimination.

UNIT–5: Diazonium salts **(Lecture: 6)**

Synthetic applications of diazonium salts including preparation of arenes,haloarenes, phenols, cyano and nitro compounds; Coupling reactions of diazonium salts (preparation of azo dyes).

Essential/recommended readings

1. Morrison, R. N., Boyd, R. N., Bhattacharjee, S.K. (2010), **Organic Chemistry**, 7th Edition, Dorling Kindersley (India) Pvt. Ltd., Pearson Education.
2. Finar, I.L. **Organic Chemistry** Volume 1, Dorling Kindersley (India) Pvt. Ltd., Pearson Education.

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3. Finar, I.L. **Organic Chemistry** Volume 2, Dorling Kindersley (India) Pvt. Ltd., Pearson Education.
4. Solomons, T.W.G., Fryhle, C.B.; Snyder, S.A. (2017), **Organic Chemistry**, 12th Edition, Wiley.

Suggestive Readings

1. Mukherji, S.M., Singh, S.P. (2017), **Reaction Mechanism in Organic Chemistry**, Trinity Press.
2. Singh,J., Awasthi, S. K., Singh, Jaya, **Fundamentals of Organic Chemistry-III**, Pragati Prakashan (2023)
3. Carey, F.A., Sundberg, R. J. (2008), **Advanced Organic Chemistry: Part B: Reaction and Synthesis**, Springer.
4. Bruice, P.Y. (2015), **Organic Chemistry,** 3rd Edition, Pearson.
   Patrick, G. (2003), **BIOS Instant Notes in Organic Chemistry**, Viva Books

DSC-11

PHYSICAL CHEMISTRY –III

Chemical equilibrium, Ionic equilibrium, conductance and solid state

(Credits: 03)

(Theory -45 hrs)

Course Objectives

- To develop an understanding of chemical equilibrium and the thermodynamic principles governing equilibrium in gaseous systems and spontaneous processes.
- To explain ionic equilibrium in solutions, including ionization, pH, buffer action, salt hydrolysis, solubility product, and acid–base titrations.
- To study the principles of electrolytic conductance, ionic mobility, transference number, and the applications of conductance measurements in chemical analysis.
- To provide knowledge of solid state chemistry, crystal structure, symmetry, X-ray diffraction, and the interpretation of crystal systems and diffraction patterns.
- **Learning Outcomes**
- After successful completion of this course, students will be able to:
- Apply thermodynamic concepts to explain chemical equilibrium, equilibrium constants, Gibbs free energy changes, and the effect of temperature, pressure, and concentration on equilibrium systems.
- Analyze ionic equilibrium in aqueous solutions by calculating pH, hydrolysis constants, buffer action, solubility product, and selecting suitable indicators for acid–base titrations.
- Interpret conductance behavior of strong and weak electrolytes, determine ionic mobility and transference numbers, and use conductance measurements for analytical applications.
- Explain the structural features of solids using crystal systems, Bravais lattices, Miller indices, and X-ray diffraction methods, and analyze simple powder diffraction patterns of ionic crystals.

UNIT– 1: Chemical Equilibrium **(Lecture: 6)**

Criteria of thermodynamic equilibrium, degree of advancement of reaction, Chemical equilibria in ideal gases, Thermodynamic derivation of relation between Gibbs free energy of a reaction and reaction quotient, Equilibrium constants and their dependence on temperature, pressure and concentration, Le Chatelier's Principle (Quantitative treatment), Free energy of mixing and spontaneity (qualitative discussion).

UNIT–2: Ionic equilibrium **(Lecture: 12)**

Strong, moderate and weak electrolytes, Arrhenius theory of electrolytic dissociation, 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; dissociation constants of mono and diprotic acids. Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions; derivation of Henderson equation and its applications. Solubility and solubility product of sparingly soluble salts – applications of solubility product principle. Qualitative treatment of acid – base titration curves. Theory of acid–base indicators; selection of indicators and the limitations.

UNIT– 3: Conductance **(Lecture: 12)**

Quantitative aspects of Faraday's laws of electrolysis, Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Molar conductivity at infinite dilution. Kohlrausch's law of independent migration of ions. Debye-Huckel-Onsager equation, Wien effect, Debye-Falkenhagen effect, Walden's rule. Ionic velocity, mobility and their determination, transference number and its relation to ionic mobility, determination of transference number using Moving Boundary methods. Applications of conductance measurement: (i) degree of dissociation of weak electrolytes, (ii) ionic product of water (iii)solubility and solubility product of sparingly soluble salts, (iv) conductometric titrations(v)hydrolysis constants of salts.

UNIT– 4: Solid state **(Lecture: 15)**

Nature of the solid state, law of constancy of interfacial angles, law of rational indices, Miller indices, elementary idea of symmetry, seven crystal systems and fourteen Bravais lattices; X-ray diffraction, Bragg'slaw, a simple account of rotating crystal method and powder pattern method. Analysis of powder diffraction patterns of NaCl, CsCl and KCl.

Essential/recommended readings

1. Peter, A.; Paula, J. de. (2011), **Physical Chemistry**, 9th Edition, Oxford University Press.
2. Castellan, G. W. (2004), **Physical Chemistry**, 4th Edition, Narosa.
3. Kapoor, K.L. (2015), **A Textbook of Physical Chemistry**, Vol 2, 6th Edition, McGraw Hill Education.
4. McQuarrie, D. A.; Simon, J. D. (2004), **Molecular Thermodynamics**, Viva Books Pvt. Ltd.
5. Kapoor, K.L. (2015), **A Textbook of Physical Chemistry**, Vol 1, 6th Edition, McGraw Hill Education.

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DSC-12
PRACTICAL-III
(Credits: 03)
(45 labs of 2 hrs each=90 hrs)

Course Objectives

- To develop practical skills in gravimetric analysis, inorganic preparations, organic derivative formation, and qualitative analysis of compounds
- To provide hands-on experience in instrumental techniques such as pH metry, conductometry, paper chromatography, ion exchange, and nanoparticle synthesis
- To enhance understanding of analytical methods, synthesis techniques, and basic computational skills relevant to chemistry laboratories

Learning Outcomes

- Perform gravimetric estimations, inorganic preparations, and organic derivative synthesis using standard laboratory procedures
- Carry out qualitative and chromatographic analysis for identification and separation of metal ions and organic compounds
- Apply pH metry, conductometry, and other instrumental methods for quantitative analysis and determination of physicochemical properties
- Understand crystal size determination, ion exchange processes, nanoparticle synthesis, and basic computer programming for chemistry applications

1. **Gravimetry**

a) Estimation of Ni (II) using dimethylglyoxime (DMG).

b) Estimation of copper as CuSCN.

c) Estimation of iron as Fe_2O_3 by precipitating iron as $Fe(OH)_3$. (by homogeneous and heterogeneous method)

d) Estimation of Al (III) by precipitating with oxime and weighing as Al(oxime)3 (aluminiumoxinate).

2. **Inorganic Preparations**

a) Potassium aluminium sulphate $KAl(SO_4)_2.12H_2O$ (potash alum) or Potassium chromium sulphate $KCr(SO_4)_2.12H_2O$ (chrome alum).

b) Manganese phosphate and

c) Sodium peroxoborate

3. **Paper chromatographic separation of following metal ions (minimum two should be done):**

a) Ni(II) and Co(II)

b) Cu(II) and Cd(II)

c) Fe(III) and Al(III)

4. Preparation of oximes for aldehydes/ketones (like benzaldehyde, ethyl methyl ketone, cyclohexanone etc.)

5. Preparation of semicarbazone derivatives for aldehydes/ketones (like benzaldehyde, ethyl methyl ketone, cyclohexanone etc.)

6. Hydrolysis of amides/esters.

7. Selective reduction of m-dinitrobenzene to m-nitroaniline.

8. Preparation of S-benzylisothiouronium salts for water soluble and water insoluble carboxylic acids.

9. Systematic qualitative analysis of the given organic compounds containing monofunctional groups (aromatic hydrocarbons, alcohols, phenol) and preparation of one suitable derivative. Students should be exposed to preparative routes for the synthesis of 3,5-dinitrobenzoate, benzoates, acetate derivatives.

Note: The above derivatives should be prepared using 0.5-1.0 g of the organic compound. The solid samples must be collected and may be used for recrystallization, melting point and compound analysis.

10. pH metry:

a) Study the effect of addition of HCl/NaOH on pH to the solutions of acetic acid, sodium acetate and their mixtures.

b) Preparation of buffer solutions of different pH values: Sodium acetate-acetic acid and Ammonium chloride-ammonium hydroxide

c) pH metric titration of Strong acid with strong base; Weak acid with strong base. Determination of dissociation constant of a weak acid.

11. Conductometry:

a) Determination of cell constant

b) Determination of conductivity, molar conductivity, degree of dissociation and dissociation constant of a weak acid.

c) Perform the following conductometric titrations: Strong acid vs. strong base;Weak acid vs. strong base; Mixture of strong acid and weak acid vs. strong base; Strong acid vs. weak base

12. Determination of approximate crystal size from a given set of p-XRD
13. Determination of cation exchange method
14. Determination of total difference of solids.
15. Synthesis of hydrogel by co-precipitation method.
16. Synthesis of silver and gold metal nanoparticles.
17. **Computer practicals:**

a. WAP to calculate sum and percentage of 5 subjects
b. WAP for Simple Interest and Compound Interest
c. WAP to calculate area and circumference of a circle
d. WAP for temperature conversion (Celsius to Fahrenheit)
e. WAP to swap two numbers
f. WAP to find greatest of three numbers
g. WAP to check even or odd number
h. WAP to check leap year
i. WAP using switch case statement
j. WAP to find factorial of a number
k. WAP to generate Fibonacci series
l. WAP to check prime number
m. WAP for sum of digits & reverse of a number
n. WAP for array operations (sum, min, max)
o. WAP for binary ↔ decimal conversion

Essential/recommended readings

1. Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C. (1989), **Vogel's Textbook of Quantitative Chemical Analysis,** John Wiley and Sons,
1. Harris, D. C.; Lucy,C. A.(2016), **Quantitative Chemical Analysis,** 9th Edition, Freeman and Company.
2. Day, R. A.; Underwood, A. L. (2012), **Quantitative Analysis,** Sixth Edition, PHI Learning Private Limited.
3. Marr, G.; Rockett, B.W. (1972), **Practical Inorganic Chemistry**, Van Nostrand Reinhold.
4. Khosla, B.D.; Garg, V.C.; Gulati, A. (2015), **Senior Practical Physical Chemistry**, R. Chand &Co, New Delhi.
5. Kapoor, K.L. (2019), **A Textbook of Physical Chemistry**, Vol.7, 1st Edition, McGraw Hill Education.
6. Garland, C. W.; Nibler, J. W.; Shoemaker, D. P. (2003), **Experiments in Physical Chemistry,** 8th Edition, McGraw-Hill, New York.
7. Levine, I.N. (2010), **Physical Chemistry**, Tata Mc Graw Hill.
8. Fahlman, B.D., *Materials Chemistry,* Springer, 2007

DSE-1
APPLICATIONS OF COMPUTERS IN CHEMISTRY
(Credits: 04)
(Theory -60 hrs)

Learning Objectives

The course aims to:

- Understand programming fundamentals (variables, data types, operators, control structures, functions)
- Develop problem-solving skills using algorithms and programming
- Learn basic data structures and their implementation
- Apply debugging and testing techniques
- Understand modular programming for better code organization
- Equip students with programming skills for solving chemistry-related problems
- **Learning Outcomes**
- After completing the course, students will be able to:
- Apply programming skills in chemistry problem-solving
- Develop and implement algorithms in C language
- Use conditional statements and loops effectively
- Design modular programs using functions
- Apply divide-and-conquer approach in programming

UNIT–1: Basic Computer System **(15 hrs)**

The fundamentals of digital computers, including basic operations such as input, processing, storage, and output. It covers the functional components of a computer system such as CPU, memory, and input/output devices, along with classification of computers based on size, purpose, and processing capability. The concept of operating systems is discussed in terms of their purpose, functions, services, and types (batch, time-sharing, real-time, distributed). Number systems including binary, octal, and hexadecimal are explained along with their interconversions and basic arithmetic operations. The unit also introduces problem-solving approaches through algorithms and flowcharts, characteristics of a good algorithm, and flowchart symbols. Different types of programming languages such as machine language, assembly language, and high-level languages are discussed along with translators like assembler, compiler, and interpreter.

UNIT–2 **(12 hrs)**

Programming fundamentals in C language, including standard input and output functions (printf, scanf). It introduces fundamental data types such as integer, character, floating-point, short, long, and unsigned types, along with type modifiers. Storage classes including automatic, register, static, and external variables are discussed with scope and lifetime. Constants, variables, and type casting. Operators and expressions are explained in detail, including arithmetic, relational, logical, assignment, increment/decrement, and bitwise operators. Operator precedence and associativity rules are discussed along with expression evaluation.

UNIT–3 **(12 hrs)**

Conditional program execution and control structures. It includes the use of if, if-else, nested if statements, and the switch statement with its limitations and usage of break and default. Iterative constructs such as while, do-while, and for. Modular programming, emphasizing code reusability and structured programming. Arrays and user-defined data types, array declaration, initialization, and manipulation of elements, along with one-dimensional and multidimensional arrays.

UNIT–4 **(11 hrs)**

String and String functions. Structures and unions with their definitions, differences, and applications. The concept of functions is covered in detail, including function declaration, definition, calling, and parameter passing techniques (call by value). Recursive functions and their applications are also introduced. Pointers (basic introduction), relationship between arrays and pointers its drawbacks. Searching & Basic Sorting Algorithms (Bubble, Insertion and Selection)

UNIT– 5 **(10 hrs)**

Introduction to Python programming, including working with the interactive shell, writing simple programs, and understanding basic data types such as integers, floating-point numbers, and strings, variable assignment, expressions, and basic input/output operations in Python. Software tools used in chemistry such as ChemDraw for drawing chemical structures and AutoCAD for basic design and visualization. Introduction to MS Office and their uses.

Reference Books:

1. Vikas Gupta, (2009). Computer Concepts and Programming in C, Wiley India Publication.
2., Anami, Angadi and Manvi, (2018) Computer Concepts and Programming PHI Publication.
3. Kernighan and Ritchie, (2015). C programming PHI.
4. Reema Thareja (2016). Computer Fundamentals and Programming in C., Oxford Publication
5. Balaguruswami E., (2011). Computer Concepts and Programming in C, McGraw Hill
6. Yadav, D.S. and Khanna, R., (2023). Computer Concepts and Programming in C., New Age International Publication.
7. Mittal, A. (2015). Programming in C, A Practical approach, Pearson Publication.
8. Gupta, K. K. (2015). Computer Fundamental and C programming, Acme Learning Publication.
9. Jeri R. Hanly, Elliot B. Koffman, (2006). Problem Solving and Program Design in C, Pearson Addison-Wesley.
10. Behrouz A. Forouzan, Richard F. Gilberg, (2007). Computer Science- A Structured Programming Approach Using C, Thomson, Third Edition [India Edition].

DSE-2
NOVEL INORGANIC SOLIDS
(Credits: 04)
(Theory -60 hrs)

Learning Objectives

- To develop an understanding of the synthesis, modification, and technological importance of inorganic solids and advanced materials.
- To familiarize students with nanomaterials, engineering materials, composites, specialty polymers, ceramics, and their industrial applications.
- To provide knowledge of structure–property relationships in modern materials and their role in scientific, engineering, and environmental applications.

Course Learning Outcomes

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

- Explain the synthesis and modification methods of inorganic solids and describe their technological importance in areas such as solid electrolytes, pigments, and molecular materials.
- Understand the classification, preparation, properties, and applications of nanomaterials including metallic nanoparticles, carbon nanotubes, and bio-inorganic nanomaterials.
- Analyze the composition, mechanical properties, and applications of engineering materials, composite materials, and their performance in industrial use.
- Describe the structure, properties, and applications of specialty polymers, ion-exchange resins, ceramics, and refractory materials in modern technology.

Unit-1 Synthesis and modification of inorganic solids **(10 hrs)**

Conventional heat and beat methods, Co-precipitation method, Sol-gel methods, Hydrothermal method, Ion-exchange and Intercalation methods.

Unit-2 Inorganic solids of technological importance **(10 hrs)**

Solid electrolytes – Cationic, anionic, mixed Inorganic pigments – coloured solids, white and black pigments. One-dimensional metals, molecular magnets, inorganic liquid crystals.

Unit-3 Nanomaterials (10 hrs)

Overview of nanostructures and nanomaterials: classification. Preparation of gold and silver metallic nanoparticles, self-assembled nanostructures-control of nanoarchitecture-one dimensional control. Carbon nanotubes and inorganic nanowires. Bio-inorganic nanomaterials, DNA and nanomaterials, natural and artificial nanomaterials, bionano composites.

Unit-4 Introduction to engineering materials for mechanical construction **(10 hrs)**

Composition, mechanical and fabricating characteristics and applications of various types of cast irons, plain carbon and alloy steels, copper, aluminum and their alloys like duralumin, brasses and bronzes cutting tool materials, super alloys thermoplastics, thermosets and composite materials.

Unit-5 Composite materials **(10 hrs)**

Introduction, limitations of conventional engineering materials, role of matrix in composites, classification, matrix materials, reinforcements, metal-matrix composites, polymer-matrix.composites, fibre-reinforced composites, environmental effects on composites, applications of composites.

Unit-6 Speciality polymers **(10 hrs)**

Conducting polymers - Introduction, conduction mechanism, polyacetylene, polyparaphenylene and polypyrole, applications of conducting polymers, Ion-exchange resins and their applications. Ceramic & Refractory: Introduction, classification, properties, raw materials, manufacturing and applications.

Reference Books:

1. Atkins, Peter, Overton, Tina, Rourke, Jonathan, Weller, Mark and Armstrong, Fraser Shriver & Atkins' Inorganic Chemistry, V Edition, Oxford University Press 2011-2012
2. Adam, D.M. Inorganic Solids: An introduction to concepts in solid-state structural chemistry, John Wiley and Sons, London, New York, Sydney, Toronto, 1974
3. Poole Jr., Charles P., Owens, Frank J., Introduction to Nanotechnology John Wiley and Sons, 2003.
4. Priti Malhotra and Shikha Gulati (2022), *Novel Inorganic Solids and Nanomaterials*, TechSar Pvt. Ltd. Covers inorganic solids, nanomaterials, molecular materials, composite materials, ion-exchange resins, and specialty polymers aligned with UG syllabus.
5. Prasanna Chandrasekhar (2018), *Conducting Polymers: Fundamentals and Applications including Carbon Nanotubes and Graphene*, 2nd Edition, Springer. Useful for conducting polymers, CNTs, graphene, and applications of specialty polymers.
6. Callister, W.D. and Rethwisch, D.G. (2020), *Materials Science and Engineering: An Introduction*, 10th Edition, Wiley. Standard reference for engineering materials, composites, ceramics, and mechanical properties.
7. Raghavan, V. (2015), *Materials Science and Engineering: A First Course*, 6th Edition, PHI Learning. Covers engineering materials, alloys, steels, cast irons, and composite materials.
8. Chaoying Wan, Xingyi Huang, and Chris Bowen (2021), *Two-dimensional Inorganic Nanomaterials for Conductive Polymer Nanocomposites*, Royal Society of Chemistry. Useful for nanomaterials and conductive polymer nanocomposites.
9. Kashma Sharma, Santosh K. Tiwari, Vijay Kumar, and Susheel Kalia (2024), *Novel Bio-nanocomposites for Biomedical Applications*, Springer. Useful reference for bionanomaterials and bionano composites.
10. Silvia Gross (Ed.) (2024), *Unconventional Green Synthesis of Inorganic Nanomaterials*, Royal Society of Chemistry.
11. Dr. Kavita Khatana (2024), *Inorganic Polymer Chemistry*, Academic Guru Publishing House.

SEC-3

GREEN CHEMISTRY & DISASTER MANAGEMENT

Credits:02

Lectures:30

Learning objectives

The objectives of this course are as follows:

- To create awareness about the chemistry that is not harmful for human health and the environment.
- To provide thorough knowledge of the green chemistry principles that can be used to develop chemistry in greener way.
- To familiarize students with new remediation technologies for the cleaning up of hazardous substances.
- The course is intended to provide a general concept in the dimensions of disasters caused by nature beyond the human control as well as the disasters and environmental hazards induced by human activities with emphasis on disaster preparedness, response and recovery
- To increase the knowledge and understanding of the disaster phenomenon, its different contextual aspects, impacts and public health consequences.
- To ensure knowledge, skills and abilities to analyze potential effects of disasters and the strategies and methods for disaster reduction

Learning outcomes

By studying this course, students will be able to:

- List the twelve principles of green chemistry and build the basic understanding of toxicity, hazard and risk related to chemical substances.
- Calculate atom economy, E-factor and relate them in all organic synthesis
- State the uses of catalyst over stoichiometric reagents
- Debate and use green solvents, renewable feedstock, and renewable energy sources for carrying out safer chemistry
- Learning and understanding the basic knowledge of Disaster Management concept and different approaches to reduce the impact of disaster
- To provide basic conceptual understanding of disasters
- To understand approaches of Disaster Management
- To build skills to respond to disaster

UNIT – 1 Introduction **(Lectures: 8)**

Environmental laws, pollution prevention Act of 1990, emergence of green chemistry, need for Green Chemistry. Goals of Green Chemistry. Limitations/ Obstacles in the pursuit of the goals of Green Chemistry. Green chemistry insustainable development

UNIT-2 Principles of Green Chemistry **(Lectures: 8)**

Brief introduction of twelve principles of Green Chemistry, with examples, special emphasis on atom economy, reducing toxicity, green solvents, Green Chemistry and catalysis and alternative sources of energy, Green energy and sustainability

Unit: 3 Disaster Hazards **(Lectures: 10)**

Definition and types of disaster Hazards and Disasters, Risk and Vulnerability in Disasters, Natural and Man-made disasters, earthquakes, floods drought, landside, land subsidence, cyclones, volcanoes, tsunami, avalanches, global climate extremes. Man-made disasters: Terrorism, gas and radiations leaks, toxic waste disposal, oil spills, forest fires and important disasters.

Unit: 4 Mitigation and Management techniques of Disaster **(Lectures: 4)**

Basic principles of disasters management, Disaster Management cycle, Disaster management policy, National and State Bodies for Disaster Management, Early Warming Systems, Building design and construction in highly seismic zones, retrofitting of buildings.

Reference Books:

1. Anastas, P.T. and Warner, J.K., (1998). Oxford Green Chemistry- Theory and Practical, University Press.
2. Matlack, A.S. (2001). Introduction to Green Chemistry, Marcel Dekker.
3. Cann, M.C. and Connely, M.E., (2000). Real-World Cases in Green Chemistry, American Chemical Society, Washington.
4. Ryan, M.A. and Tinnes, M., (2002). Introduction to Green Chemistry, American Chemical Society, Washington.
5. Sharma, R.K., Sidhwani, I.T. and Chaudhari, M.K., (2013). Green Chemistry Experiments: A monograph, I.K. International Publishing House Pvt Ltd. New Delhi, Bangalore ISBN 978-93-81141-55-7.
6. Lancaster, Mike, (2010). Green Chemistry: An Introductory Text 2nd Ed., RSC Publishing, ISBN 978-1-84755-873-2.
7. Disaster Management Guidelines, (2009-2012) GOI-UND Disaster Risk Program
8. Damon, P. Copola, (2006) Introduction to International Disaster Management, Butterworth Heineman.
9. Gupta A.K., Niar S.S and Chatterjee S. (2013) Disaster management and Risk Reduction, Role of Environmental Knowledge, Narosa Publishing House, Delhi.
10. Murthy D.B.N. (2012) Disaster Management, Deep and Deep Publication PVT. Ltd. New Delhi.
11. . Modh S., (2010). Managing Natural Disasters, Mac Millan publishers India LTD.

SEMESTER IV

DSC-13
INORGANIC CHEMISTRY–IV
Coordination Chemistry and Reaction Mechanism
(Credits: 03)
(Theory -45 hrs)

Learning Objectives

The Objectives of this course are as follows:

- To familiarize the students with coordination compounds which find manifold applications in diverse areas.
- To acquaint the student with the concept of Inorganic reaction mechanism.

Learning Outcomes

By studying this course, the students will be able to:

- Explain the terms- ligand, denticity of ligands, chelate, coordination number and use standard rules to name coordination compounds.
- Discuss the various types of isomerism possible in such compounds.
- Use Valence Bond Theory to predict the structure and magnetic behaviour of metal complexes and understand the terms inner and outer orbital complexes.
- Explain the meaning of the terms Δo, Δt, pairing energy, CFSE, high spin and low spin complexes and how CFSE affects thermodynamic properties like lattice enthalpy and hydration enthalpy.
- Explain magnetic properties and colour of complexes on the basis of Crystal Field Theory.
- Explain the reaction mechanism of coordination compounds and differentiate between kinetic and thermodynamic stability.

Unit-1: Coordination Chemistry **(Lecture:14)**

Werner's Coordination theory, simple problems based on this theory. IUPAC nomenclature of coordination compounds, isomerism in coordination compounds (coordination numbers 4 and 6). Valence bond theory and its application to complexes of coordination numbers 4 and 6.

Unit-2: Crystal field theory **(Lecture:14)**

Crystal field theory measurement of Δo. Calculation of CFSE in weak and strong fields, concept of pairing energies, factors affecting the magnitude of Δo. Octahedral vs. tetrahedral coordination, tetragonal distortions from octahedral geometry: Jahn-Teller theorem, square planar geometry.

Unit-3: Stability of complexes **(Lecture:7)**

Brief discussion of thermodynamic and kinetic stability, Factors affecting stability of complexes,such as chelate effect, macrocyclic effect, resonance effect etc., trends in step wise formation constant, interpretation of lability and inertness based on VBT and CFT.

Unit-4: Inorganic Reaction Mechanism **(Lecture:10)**

Introduction to inorganic reaction mechanisms, concept of reaction pathways, transition state, intermediate and activated complex. Substitution reactions in square planar complexes, factors affecting the rate of Substitution reactions in square planar complexes- such as charge effect, solvent effect and Trans- effect (Theories of trans-effect).

Essential/recommended readings

1. Atkins, P.W.; Overton, T.L.; Rourke, J.P.; Weller, M.T.; Armstrong, F.A. (2010), **Shriver and Atkins Inorganic Chemistry**, 5th Edition, Oxford University Press.
2. Miessler, G.L.; Fischer P.J.; Tarr, D. A. (2014), **Inorganic Chemistry**, Fifth Edition, Pearson.
3. Huheey, J.E.; Keiter, E.A.; Keiter; R. L.; Medhi, O.K. (2009), **Inorganic Chemistry-Principles of Structure and Reactivity**, Pearson Education.
4. Pfennig, B. W. (2015), **Principles of Inorganic Chemistry,** John Wiley & Sons.
5. Cotton, F.A.; Wilkinson, G. (1999), **Advanced Inorganic Chemistry,** Wiley-VCH.
6. Sodhi G.S. (2018), **Principles of Inorganic Chemistry,** Viva Books India.

DSC-14

ORGANIC CHEMISTRY –IV

Nitriles, Isonitriles and Heterocyclic Compounds

(Credits: 03)

(Theory -45 hrs)

Learning Objectives

The Objectives of this course are as follows:

- To familiarize students with nitrogen containing functional groups and heterocyclic compounds
- To enable students to develop novel, efficient, convenient, selective and environmentally benign synthetic methods for synthesis of heterocyclic compounds.

Learning outcomes

By studying this course, the students will be able to:

- Describe uses and applications of nitrogen containing functional groups.
- Use the synthetic chemistry learnt in this course to do functional group transformations.
- Use the chemistry of heterocycles to better serve the mankind.

(Lecture:8)

Unit-1: Nitriles

Preparation using following reactions: Dehydration of amides and aldoximes, substitution reaction in alkyl halides and tosylates, from Grignard reagents and from dehydrogenation of primary amines. Properties: Physical properties, discussion on the following reactions with mechanism: 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.

(Lecture:7)

Unit-2 Isonitriles

Preparation from the following reactions: Carbylamine reaction, sustitution in alkyl halides and dehydrogenation of N-substituted formamides. Properties: Physical properties, discussion on the following reactions with mechanism: Hydrolysis, reduction, addition of– HX, X_2 and sulphur, Grignard reaction, oxidation and rearrangement.

(Lecture:10)

Unit-3: Introduction of Heterocyclic Compounds

Classification and nomenclature of heterocyclic compounds (containing only one hetero atom). Structure, aromaticity in 5-membered and 6-membered rings containing one heteroatom; Basicity and relative reactivity towards electrophilic substitution reactions (amongst five membered and six membered rings.

Lecture:10)

Unit-4: Heterocyclic Compounds synthesis

General methods of synthesis for: furan, thiophene, pyrrole (Paal-Knorr synthesis, Hantzsch synthesis), pyridine (Hantzsch synthesis), indole (Fischer Indole synthesis), quinoline (Skraup synthesis, Friedlander's synthesis, Knorr quinoline synthesis, Doebner-Miller synthesis)

(Lecture: 10)

Unit-5: Heterocyclic Compounds Properties

Physical properties, discussion on the following reaction (with mechanism) for furan, pyrrole, thiophene, pyridine, indole and quinoline: Electrophilic substitution- nitration, sulphonation, halogenation, formylation, acylation, mercuration and carboxylation. Oxidation, reduction, addition, reactions showing acidic /basic character, reaction with diazonium salts, ring opening, ring expansion and nucleophilic substitution reaction wherever applicable should be discussed.

Essential/recommended readings

1. Berg, J.M., Tymoczko,J. L.,Stryer, L. (2019), **Biochemistry**, 9th Edition W.H.Freeman and Co.
2. Nelson, D.L., Cox, M.M., Lehninger,A.L. (2017), **Principles of Biochemistry**. W.H. Freeman and Co., International Edition.
3. Morrison,R.N., Boyd, R.N., Bhattacharjee, S.K. (2010), **Organic Chemistry**, 7th Edition, Dorling Kindersley (India) Pvt. Ltd., Pearson Education.

4. Parashar, R.K., Negi, B. (2016) **Chemistry of Heterocyclic Compounds**, Ane Books Pvt Ltd.
5. Kuashik, S., Singh, A. (2023), **Biomolecules: From Genes to Proteins**, I[st] Edition,Berlin, Boston: De Gruyter.
6. Finar, I.L., (2012), **Organic Chemistry**Volume1,6[th]Edition, Pearson Education.
7. Singh J, Awasthi SK, Singh J, **Fundamentals of Organic Chemistry**, Pragati Prakashan Meerut.

DSC-15

PHYSICAL CHEMISTRY – IV

Electrochemical Cells, Chemical Kinetics and Catalysis

(Credits: 03)

(Theory -45 hrs)

Learning Objectives

- To provide a detailed understanding about galvanic cells and their types
- To explain the applications of galvanic cells and EMF measurements.
- To get an understanding of the kinetics of simple and complex chemical reactions
- To give basic concept about catalysts and enzymes.

Learning outcomes

By studying this course, the students will be able to:

- Explain the working of electrochemical cells and different types of galvanic cell.
- Devise a spontaneous galvanic cell using various combinations of half-cells.
- Understand the concept of concentration cell
- Use the appropriate galvanic cell to measure pH, calculate thermodynamic parameters and perform potentiometric titrations.
- Write rate law and derive rate equations for simple and complex reactions and understanding of theories of reaction rates.
- Understand different types of catalysts and mechanism of enzyme catalysis.

Unit-1: Electrochemical Cells **(21 hrs)**

Rules of oxidation reaction and reduction reaction of ions based on half-cell potentials, Chemical cells, reversible and irreversible cells with examples. Electromotive force of a cell and its measurement, Nernst equation; Standard electrode(reduction)potential and its application to different kinds of half-cells. Application of EMF measurements in determining (i) free energy, enthalpy and entropy of a cell reaction, (ii) equilibrium constants, and (iii) pH values, using hydrogen cell. Concentration cells with and without transference, liquid junction potential; determination of activity coefficients and transference numbers. Qualitative discussion of potentiometric titrations (acid-base, redox, precipitation).Structure of electric double layer (qualitative aspects only), Lithium Battery, Battery & Fuel cell

Unit-2: Chemical Kinetics **(18 hrs)**

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 for determination of rate laws, kinetics of complex reactions (integrated rate expressions up to first order only): (i) Opposing reactions (ii) parallel reactions and (iii) consecutive reactions and their differential rate equations (steady-state approximation in reaction mechanisms) (iv) chain reactions.Temperature dependence of reaction rates; Arrhenius equation; activation energy. Collision theory of reaction rates.

Unit-3: Catalysis **(6 hrs)**

Types of catalyst, specificity and selectivity, mechanisms of catalyzed reactions at solid surfaces. Enzyme catalysis, Michaelis-Menten mechanism, acid-base catalysis.

Essential/recommended readings:

1. Atkins, P.W.; Paula, J.de. (2014), Atkin's Physical Chemistry Ed., 10th Edition, Oxford University Press.
2. Ball, D. W. (2017), Physical Chemistry, 2nd Edition, Cengage Learning, India.
3. Castellan, G. W. (2004), Physical Chemistry, 4th Edition, Narosa.
4. Kapoor, K.L. (2015), A Textbook of Physical Chemistry, Vol 3, 6th Edition, McGraw Hill Education.
5. Kapoor, K.L. (2015), A Textbook of Physical Chemistry, Vol 5, 3rd Edition, McGraw Hill Education.
6. Laidler K.J. (2003), Chemical Kinetics, 3rd Edition, Pearson Education India.

DSC-16
PRACTICAL-IV
(Credits: 03)
(45 labs of 2 hrs each=90 hrs)

Course Objectives

1. To develop practical skills in volumetric, gravimetric, complexometric, and potentiometric methods for quantitative chemical analysis.
2. To provide hands-on experience in synthesis and study of coordination compounds, reaction kinetics, and instrumental analytical techniques.
3. To train students in qualitative and quantitative organic analysis, including functional group identification and determination of physicochemical constants.
4. To enhance understanding of environmental, soil, water, and air analysis using modern analytical methods and pollution assessment techniques.

Learning Outcomes

1. Students will be able to perform accurate quantitative estimations using titrimetric, gravimetric, potentiometric, and spectrophotometric methods for inorganic and organic samples.
2. Students will be able to synthesize coordination compounds, study their properties, and apply chromatographic, flame photometric, and ion exchange techniques in analysis.
3. Students will be able to investigate reaction kinetics, interpret titration behavior, and identify organic compounds through systematic qualitative analysis.
4. Students will be able to analyze soil, water, and air samples for important environmental parameters such as hardness, alkalinity, COD, BOD, dissolved oxygen, and pollution indicators.

(A) Argentometry

Estimation of Cl^-

(i) By Mohr's method
(ii) By Vohlard's method and
(iii) By Fajan's method

(B) Complexometric Titrations:

(i) Complexometric estimation of Mg^{2+}/ Zn^{2+} using EDTA
(ii) Estimation of total hardness of water samples
(iii) Estimation of Ca^{2+} in solution by substitution method
(iv) Estimation of Ca/Mg in drugs or biological samples.

(C) Properties of Complexes

Synthesis of ammine complexes of Ni(II) and its ligand exchange reactions (e.g. bidentate ligands like acetylacetone, dimethyl glyoxime, glycine) by substitution method.

(D) Potentiometry:

Perform the following potentiometric titrations:

1. Strong acid vs. strong base
2. Weak acid vs. strong base
3. Dibasic acid vs. strong base
4. Mixture of strong and weak acid vs strong base
5. Potassium dichromate vs. Mohr's salt

(E) Chemical Kinetics:

Study the kinetics of the following reactions

1. Iodide-persulphate reaction by Initial rate method
2. Acid hydrolysis of methyl acetate with hydrochloric acid.
3. Saponification of ethyl acetate by conductometric measurements.

Suggested experiments

1. To study the kinetics of Iodide-persulphate reaction using integrated rate method.
2. Comparison of the strengths of HCl and H_2SO_4 by studying kinetics of hydrolysis of methyl acetate.

(F) Organic Practicals

1. Estimation of sugars by using Fehling solution.
2. Functional group tests for amine, nitro and amides.
3. Determination of saponification value of the given oil.
4. Determination of iodine number of the given oil.
5. Systematic qualitative analysis of the given organic compounds containing monofunctional groups (carboxylic acids, carbonyl compounds, carbohydrates and esters) and preparation of one suitable derivative.

(G) DSE Practicals

1. Analysis of soil.
2. (i) Determination of pH of soil, Total soluble salts, carbonate and bicarbonate,calcium and magnesium by titration.

(ii) Estimation of Potassium, calcium and magnesium by flame photometry.

3. Separation of constituents of leaf pigments by thin layer chromatography.
4. Determination of the ion exchange capacity of an anion exchange resin.
5. Determination of the ion exchange capacity of a cation exchange resin.
6. Separation of amino acids by ion exchange chromatography.
7. Spectrophotometric analysis of Co^{2+} and Ni^{2+} ions in a mixture.
8. Spectrophotometric analysis of Caffeine and Benzoic acid in a soft drink
9. Gravimetric estimation of Ni^{2+} using Dimethylglyoxime.
10. Gravimetric estimation of Al^{3+} using oxine.
11. Any suitable experiment (other than the listed ones) based upon analyticaltechniques discussed in theory section.
12. Determination of dissolved oxygen in water.
13. Determination of Chemical Oxygen Demand (COD)
14. Determination of Biological Oxygen Demand (BOD)
15. Percentage of available chlorine in bleaching powder.
16. Measurement of chloride, sulphate and salinity of water samples by simple titration method ($AgNO_3$ and potassium chromate).
17. Estimation of total alkalinity of water samples (CO_3^{2-}, HCO_3^-) using double titration method.
18. Measurement of dissolved CO_2.
19. Study of some of the common bio-indicators of pollution.
20. Estimation of SPM in air samples.
21. Preparation of borax/ boric acid.

Reference Books:

1. Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C. (1989), Vogel's Textbook of Quantitative Chemical Analysis, John Wiley and Sons,
2. Harris, D. C.; Lucy, C. A. (2016), Quantitative Chemical Analysis, 9th Edition, Freeman and Company.
3. Day, R. A.; Underwood, A. L. (2012), Quantitative Analysis, Sixth Edition, PHI Learning Private Limited.
4. Vogel, A.I. (2012), Quantitative Organic Analysis, Part3,Pearson Education.
5. Mann, F.G., Saunders, B.C. (2009), Practical Organic Chemistry, Pearson Education.
6. Ahluwalia,V.K., Dhingra,S.(2004), Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press.
7. Ahluwalia,V.K., Aggarwal,R. (2004), Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press
8. Pasricha, S., Chaudhary, A. (2021), Practical Organic Chemistry: Volume–I, I KInternational Publishing house Pvt. Ltd, New Delhi
9. Pasricha, S., Chaudhary, A. (2021), Practical Organic Chemistry: Volume–II, I K International Publishing house Pvt. Ltd, New Delhi
10. Khosla, B.D.; Garg, V.C.; Gulati, A. (2015), Senior Practical Physical Chemistry, R. Chand &

Co, New Delhi.
11. Kapoor, K.L. (2019), A Textbook of Physical Chemistry, Vol.7, 1st Edition, McGraw Hill Education.
12. Garland, C. W.; Nibler, J. W.; Shoemaker, D. P. (2003), Experiments in Physical Chemistry, 8th Edition, McGraw-Hill, New York
13. E. Stocchi: *Industrial Chemistry*, Vol-I, Ellis Horwood Ltd. UK.
14. R.M. Felder, R.W. Rousseau: *Elementary Principles of Chemical Processes*, Wiley Publishers, New Delhi.
15. J. A. Kent: Riegel's *Handbook of Industrial Chemistry*, CBS Publishers, New Delhi.
16. S. S. Dara: *A Textbook of Engineering Chemistry*, S. Chand & Company Ltd. New Delhi.
17. K. De, *Environmental Chemistry*: New Age International Pvt., Ltd, New Delhi.
18. S. M. Khopkar, *Environmental Pollution Analysis*: Wiley Eastern Ltd, New Delhi.

DSE-3
ANALYTICAL METHODS
(Credits: 04)
(Theory -60)

Learning Objectives

- To introduce the principles and importance of analytical and separation techniques used in chemical analysis
- To develop understanding of spectroscopic methods, solvent extraction, and chromatographic techniques for qualitative and quantitative analysis
- To create awareness about accuracy, precision, error analysis, and the application of instrumental methods in chemical investigations

Learning Outcomes

By studying this course, students will be able to:

- Understand and explain different types of errors and statistical treatment of analytical data
- Describe the principles and applications of optical and spectroscopic methods of analysis
- Apply Beer–Lambert law for concentration determination and interpretation of UV-Visible spectra
- Explain the principles and instrumentation of atomic absorption and emission spectroscopy
- Understand solvent extraction processes and their use in analytical separations
- Describe chromatographic techniques and evaluate their applications in chemical analysis

(12 Lectures)

Unit I: Errors in Chemical Analysis

Types of errors, systematic errors, random errors, gross errors, accuracy and precision, absolute and relative uncertainty, propagation of uncertainty, significant figures, mean, median and standard deviation, Gaussian distribution, confidence intervals, statistical treatment of analytical data.

(10 Lectures)

Unit II: Optical Methods of Analysis

Origin of spectra, electromagnetic radiation, interaction of radiation with matter, absorption and emission of radiation, fundamental laws of spectroscopy, selection rules, Beer–Lambert law, deviations from Beer–Lambert law, applications of optical methods in chemical analysis.

(14 Lectures)

Unit III: UV-Visible Spectrophotometry and Atomic Spectroscopy

UV-Visible spectrophotometry, principle and instrumentation of single beam and double beam spectrophotometers, sources of radiation, monochromators, detectors, determination of concentration of unknown compounds, composition of metal complexes by Job's method and mole ratio method, Flame Atomic Absorption Spectroscopy, Flame Emission Spectroscopy, principle and instrumentation, atomization techniques, sample introduction methods, background correction, chemical interferences and their minimization.

(12 Lectures)

Unit IV: Separation Techniques

Solvent extraction, classification, principle and efficiency of extraction, distribution law, partition coefficient, mechanism of extraction by solvation and chelation, factors affecting extraction, batch extraction, continuous extraction, countercurrent extraction, applications of solvent extraction in analytical chemistry.

(12 Lectures)

Unit V: Chromatography

Principles of chromatographic separation, classification of chromatographic techniques, adsorption and partition chromatography, Thin Layer Chromatography, Column Chromatography, Paper Chromatography, Gas Chromatography (basic idea), efficiency of separation, resolution, efficiency of resolution, theoretical plates, plate height, applications of chromatography in qualitative and quantitative analysis.

References:

1. Willard, H.H. (1988), Instrumental Methods of Analysis, 7th Edition, Wardsworth Publishing Company.
2. Christian, G.D. (2004), Analytical Chemistry, 6th Edition, John Wiley & Sons, New York.
3. Harris, D. C. (2007), Quantitative Chemical Analysis, 6th Edition, Freeman.
4. Skoog, D.A.; Holler F.J.; Nieman, T.A. (2005), Principles of InstrumentalAnalysis, Thomson Asia Pvt. Ltd.
5. Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C. (1989), Vogel's Textbookof Quantitative Chemical Analysis, John Wiley and Sons.

DSE-4

INDUSTRIAL CHEMICALS AND ENVIRONMENT

(Credits: 04)

(Theory -60 hrs)

Course Objectives

- To introduce the principles of industrial chemistry, environmental chemistry, and sustainable chemical processes
- To develop understanding of industrial gases, inorganic chemicals, metallurgy, pollution control, and energy resources
- To create awareness about environmental protection, waste management, water treatment, and the role of biocatalysis in green chemistry

Learning Outcomes

- Understand the manufacture, properties, uses, and hazards of important industrial gases and inorganic chemicals
- Explain the preparation of ferrous, non-ferrous, and ultrapure metals used in industry and semiconductor technology
- Describe the causes, effects, and control methods of air pollution and water pollution
- Analyze industrial waste management practices, sludge disposal, and water purification techniques
- Discuss conventional and non-conventional energy sources and their environmental impact, including nuclear pollution
- Explain the concept of biocatalysis and its importance in green chemistry and chemical industries

(10 hrs)

Unit-1 Industrial Gases and Inorganic Chemicals:

Industrial Gases: Large scale production, uses, storage and hazards in handling of the following gases: oxygen, nitrogen, argon, neon, helium, hydrogen, acetylene, carbon monoxide, chlorine, fluorine, sulphur dioxide and phosgene. Inorganic Chemicals: Manufacture, application, analysis and hazards in handling the following chemicals: hydrochloric acid, nitric acid, sulphuric acid, caustic soda, common salt, borax, bleaching powder, sodium thiosulphate, hydrogen peroxide, potash alum, chrome alum, potassium dichromate and potassium permanganate.

(4 hrs)

Unit-2 Industrial Metallurgy

Preparation of metals (ferrous and nonferrous) and ultrapure metals for semiconductor technology.

(12 hrs)

Unit-3 Environment and its segments

Ecosystems. Biogeochemical cycles of carbon, nitrogen and sulphur. Air Pollution: Major regions of atmosphere. Chemical and photochemical reactions in atmosphere. Air pollutants: types, sources, particle size and chemical nature; Photochemical smog: its constituents and photochemistry. Environmental effects of ozone, Major sources of air pollution. Pollution by SO_2, CO_2, CO, NOx, H_2S and other foul smelling gases. Methods of estimation of CO, NOx, SOx and control procedures. Effects of air pollution on living organisms and vegetation. Greenhouse effect and Global warming, Ozone depletion by oxides of nitrogen, chlorofluorocarbons and Halogens, removal of sulphur from coal. Control of particulates.

(8 hrs)

Unit-4 Water Pollution

Hydrological cycle, water resources, aquatic ecosystems, Sources and nature of water pollutants, Techniques for measuring water pollution, Impacts of water pollution on hydrological and ecosystems. Water purification methods. Effluent treatment plants (primary, secondary and tertiary treatment). Industrial effluents from the following industries and their treatment: electroplating, textile, tannery, dairy, petroleum and petrochemicals, agro, fertilizer, etc.

(10 hrs)

Unit-5 Sludge disposal

Industrial waste management, incineration of waste. Water treatment and purification (reverse osmosis, electro dialysis, ion exchange). Water quality parameters for waste water, industrial water and domestic water. **(10 hrs)**

Unit-6 Energy & Environment

Sources of energy: Coal, petrol and natural gas. Nuclear Fusion / Fission, Solar energy, Hydrogen, geothermal, Tidal and Hydel, etc. Nuclear Pollution: Disposal of nuclear waste, nuclear disaster and its management. **(6 hrs)**

Unit-7 Biocatalysis

Introduction to biocatalysis: Importance in —Green Chemistry and Chemical Industry.

Reference Books:

1. E. Stocchi: Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK.
2. R.M. Felder, R.W. Rousseau: Elementary Principles of Chemical Processes, Wiley Publishers, New Delhi.
3. J. A. Kent: Riegel's Handbook of Industrial Chemistry, CBS Publishers, New Delhi.
4. S. S. Dara: A Textbook of Engineering Chemistry, S. Chand & Company Ltd. New Delhi.
5. K. De, Environmental Chemistry: New Age International Pvt., Ltd, New Delhi.
6. S. M. Khopkar, Environmental Pollution Analysis: Wiley Eastern Ltd, New Delhi.
7. S.E. Manahan, Environmental Chemistry, CRC Press (2005).
8. G.T. Miller, Environmental Science 11th edition. Brooks/ Cole (2006).
9. A. Mishra, Environmental Studies. Selective and Scientific Books, New Delhi (2005).

SEC -4
FUELCHEMISTRY
Credits:02
Lectures:30

Course Objectives

- To understand the composition and industrial uses of coal and its by-products.
- To study petroleum refining and the applications of petrochemical products.
- To explain fractional distillation, cracking, reforming, and alternative fuels.
- To learn the classification, properties, and uses of lubricants.

Learning Outcomes

- Describe the processing and uses of coal, petroleum, and petrochemical products.
- Explain the production and applications of conventional and alternative fuels.
- Analyze refining processes such as distillation, cracking, and reforming.
- Classify lubricants and evaluate their properties for industrial use.

Unit -1 Coal **(Lecture 8)**

Uses of coal (fuel and nonfuel) in various industries, its composition, carbonization of coal. Coal gas, producer gas and water gas—composition and uses. Fractionation of coal tar, uses of coal tar bases chemicals, requisites of a good metallurgical coke, Coal gasification (Hydrogasification and Catalytic gasification), Coal liquefaction and Solvent Refining.

Unit -2 Petroleum and Petrochemical Industry: **(Lecture 5)**

Composition of crude petroleum, Refining and different types of petroleum products and the its applications.

Unit -3 Fractional Distillation (Principle and process) **(Lecture 12)**

Cracking (Thermal and catalytic cracking), Reforming Petroleum and non-petroleum fuels (LPG, CNG, LNG, bio-gas, fuels derived from biomass), fuel from waste, synthetic fuels (gaseous and liquids), clean fuels. Petrochemicals:Vinylacetate, Propylene oxide, Isoprene, Butadiene, Toluene and its derivatives Xylene.

Unit -4 Lubricants: **(Lecture 5)**

Classification of lubricants, lubricating oils (conducting and non-conducting) Solid and semisolid lubricants, synthetic lubricants. Properties of lubricants (viscosity index, cloud point, pore point) and their determination.

Reference Books:

1. E. Stocchi. (2015). Industrial Chemistry,Vol-I, Ellis Horwood Ltd. UK.
2. Jain, P.C. and M. Jain, M., (2018). Engineering Chemistry, Dhanpat Rai & Sons, Delhi.
3. Sharma B.K. (2016). Industrial Chemistry, Goel Publishing House, Meerut.
4. Vairam and others. (2014). Engineering Chemistry of Wiley India Pvt. Ltd., , 2nd Edition,
5. Prasanth Rath, (2015). Engineering Chemistry, Cengage Learning. Edition

VAC- 2

HANDS ON TRANING -UV-VIS SPECTROSCOPY

Credits:02

(Lectures:30)

Course Objectives:

- To impart basic practical skills in advanced instrumental analysis.
- Actual sample analysis and hands on training of UV-Visible spectroscopy.
- To train students regarding calibration, assay and maintenance of the instrument.
- To equip students with professional skills required to work in industry.

Learning outcomes:

- Understand the theoretical and practical background of UV-Visible spectroscopy
- Demonstrate knowledge of sampling methods
- Develop skills to perform experiments on UV-Visible spectrophotometer and method calibration

UNIT-1 **(Lectures: 07)**

Instrumentation of UV-Visible spectrophotometer, design of single beam and double beam spectrophotometers, radiation source, monochromators and detectors.

UNIT-2 **(Lectures; 08)**

Basic principle of UV-Visible spectroscopy, types of transitions, solvents used, Beers- Lambert law and its limitations. Applications of UV-Visible spectroscopy to qualitative and quantitative analysis.

Practical Component (15 sessions of 2 hours each)

- Verification of Beer's-Lambert's Law and calculation of Molar Extinction Coefficient at different wavelength for $KMnO_4$/$K_2Cr_2O_7$/& other compounds using UV-Visible Single/double beam spectrophotometer.
- Determination of concentration of unknown solutions and λmax values.
- Estimation of organic pollutants in industrial effluents
- Determination of band gap of semiconductors

Essential Readings

1. Sharma Y. R. 2022. Elementary Organic Spectroscopy, S. Chand Publication.
2. Skoog, 2007. Principles of instrumental analysis, 6th edition., Thomson Publication.
3. Harvey, D., 2000. Modern Analytical Chemistry, ACS Publication.,.
4. Perkampus, H.H., 1992. UV-VIS Spectroscopy and Its Applications. Berlin, Heidelberg: Springer Berlin Heidelberg.
5. Akash, M.S.H., Rehman, K., Akash, M.S.H. and Rehman, K., 2020. Ultraviolet-visible (UV-VIS) spectroscopy. Essentials of pharmaceutical analysis, pp.29-56.
6. Thomas, M., 2008. Ultraviolet and Visible spectroscopy, John Wiley & Sons.

SEMESTER V

DSC-17
ORGANIC CHEMISTRY-V
(Credits: 04)
THEORY:60 hrs

Learning Objectives: To impart knowledge of spectroscopic techniques and their applications in characterization of organic compounds

Learning Outcomes: Upon successful learning, students will be able to learn

- The fundamental principles of different instrumentation techniques and their use in applied sciences.
- Knowledge and Applications of UV spectroscopy in organic chemistry
- Applications of IR spectroscopy in characterization of functional groups present in organic compounds
- Basic principle and applications of NMR spectroscopy in identification of organic compounds
- Basic principle and applications of Mass spectrometry in identification of organic compounds
- Handling of samples and spectra recording and data collection.

Unit I: UV Spectroscopy **(Hours:12)**

Basic principles of instrumentation (choice of source, monochromator and detector) for single and double beam instrument. General principles Introduction to absorption and emission spectroscopy. Beer-Lambert Law, Types of electronic transitions, λ_{max}, Chromophores and Auxochromes, Bathochromic and Hypsochromic shifts, Intensity of absorption; Application of Fieser-Woodward Rules for calculation of λ_{max} for the following systems: α,β unsaturated aldehydes, ketones, carboxylic acids and esters; Conjugated dienes: alicyclic, homoannular and heteroannular; Extended conjugated systems (aldehydes, ketones and dienes); distinction between cis and trans isomers.

UNIT II: IR Spectroscopy **(Hours:12)**

Principle of Infra-red spectroscopy, Instrumentation, Molecular Vibrations, Fundamental and non-fundamental molecular vibrations; Selection rules; Hookes law, Effect of H- bonding, conjugation, resonance and ring size on IR absorptions; IR absorption positions of hydrocarbons, Identification of ortho, meta and para substitution of aromatic compounds, IR absorption positions of O, N and S containing functional groups. Fingerprint region and its significant applications in functional group analysis.

UNIT III: NMR Spectroscopy **(Hours:12)**

Basic principles of Proton Magnetic Resonance, Theory, Instrumentation, relaxation process, Number of signals, Internal standards, chemical shift and factors influencing it; Shielding and deshielding effects, Anisotropic effects in alkene, alkyne, aldehydes and aromatics, Spin–Spin coupling and coupling constant; Peak area and proton count. ^{13}C NMR and other nuclei.

Unit IV: Mass Spectrometry (MS) **(Hours:15)**

Introduction to mass spectrometry: basic concept of ionization and mass-to-charge ratio (m/z), significance and simple overview of technique; general instrumentation—sample introduction, ion source, mass analyzer, detector and vacuum system (elementary idea); ionization methods—Electron Ionization (EI) and simple idea of soft ionization techniques such as Electrospray Ionization (ESI) and MALDI; types of mass analyzers—quadrupole and Time-of-Flight (TOF) (basic working principles only); simple interpretation of mass spectra—molecular ion peak, base peak, fragmentation patterns, isotopic peaks and nitrogen rule.

Unit V: Applications of Spectroscopy **(Hours:09)**

Applications of UV spectroscopy for identification of simple organic molecules. Applications of IR spectroscopy for identification of organic compounds. Applications of NMR spectroscopy for identification of organic compounds. Applications of Mass spectrometry for identification of organic compounds. Combined applications of IR, UV, NMR and MS for identification of simple organic molecules.

Reference Books:

1. Kemp, W., *Organic Spectroscopy*, **3rd ed.**, Palgrave Macmillan (Red Globe Press), 2008.
2. Sharma, Y. R., *Elementary Organic Spectroscopy: Principles and Chemical Applications*, **5th ed.**, S. Chand & Company, New Delhi, 2023.
3. Jag Mohan, *Organic Spectroscopy: Principles and Applications*, 3rd ed., Narosa Publishing House, New Delhi, 2020.
4. D. L. Pavia, G. M. Lampman, G. S. Kriz, J. R. Vyvyan, *Introduction to Spectroscopy*, 6th ed., Cengage Learning, 2018.
5. R. M. Silverstein, F. X. Webster, D. J. Kiemle, D. L. Bryce, *Spectrometric Identification of Organic Compounds*, 9th ed., Wiley, 2019.
6. P. Crews, J. Rodríguez, M. Jaspars, *Organic Structure Analysis*, 3rd ed., Oxford University Press, 2019.
7. J. M. Hollas, *Modern Spectroscopy*, 5th ed., Wiley, 2018.
8. N. E. Jacobsen, *NMR Spectroscopy Explained: Simplified Theory, Applications and Examples*, 3rd ed., Wiley, 2020.
9. T. D. W. Claridge, *High-Resolution NMR Techniques in Organic Chemistry*, 4th ed., Elsevier, 2021.
10. P. Larkin, *Infrared and Raman Spectroscopy: Principles and Spectral Interpretation*, 2nd ed., Elsevier, 2018.
11. D. A. Skoog, F. J. Holler, S. R. Crouch, *Principles of Instrumental Analysis*, 7th ed., Cengage Learning, 2018.
12. C. N. Banwell, E. M. McCash, *Fundamentals of Molecular Spectroscopy*, 5th ed., McGraw-Hill Education, reprint 2019.

DSC-18
INORGANIC CHEMISTRY-V
(Credits: 04)
THEORY:60 hrs

Learning Objectives

- To familiarize the students with the interactions of metal atom with organic molecules (or not so typical organic molecule), which is in an entirely different fashion as compared to coordination compounds.
- To familiarize the students with the structure and bonding in organometallic compounds
- To familiarize the student with how organometallic compounds can act as good catalysts for organic transformations and hence have industrial importance associated with medicines, bioorganic synthesis, and energy production.
- **Learning Outcomes**

  By studying this course, the students will be able to:
- Identify and classify organometallic compounds of different types.
- Explain the stability of organometallic compounds and hence the requirement of special experimental conditions for their synthesis.
- Explain the bonding modes through VBT and MOT in these compounds.
- Explain the chemical nature of these compounds through various reactions thus acquiring skills to understand their applications.
- Explain the mechanism of catalysis by these compounds. This may prepare the student to predict the catalytic pathways for new reactions

Unit-1: Introduction to Organometallic Chemistry **(Hours: 10)**

Basics of Organometallic Chemistry: Definition, brief history, classification of organometallic compounds on the basis of bond type. Common notation used in organometallic chemistry, concept of hapticity of organic ligands, importance of organometallic chemistry, organometallic compounds as reagents, additives, and catalysts. Introduction to the 18-electron rule or effective atomic number rule, electron count of mononuclear, polynuclear and substituted metal carbonyls of 3d series and finding metal-metal bonds.

Unit-2: Structure and Bonding in Organometallic Compounds **(Hours:15)**

Structures of mononuclear and binuclear carbonyls of Cr, Mn, Fe, Co and Ni using VBT. Molecular orbital theory applied to organometallic compounds, description of bonding of two electron ligands to transition metals. π-acceptor behavior of CO (MO diagram of CO to be discussed), π-bonding of CO with metal (synergic effect) and use of IR data to explain extent of back bonding, bonding modes of CO, symmetry of metal carbonyls. Bonding between metal atoms and organic π- systems: linear (ethylene, allyl, butadiene) and cyclic (cyclopentadiene, benzene), Zeise's salt and comparison of synergic effect with that in carbonyls. Metal alkyls and Metal-carbene complexes

Unit-3: Synthesis, Reactions and Applications of Organometallic Compounds (Hours: 20)

General methods of synthesis of metal carbonyls: direct carbonylation, reductive carbonylation, thermal and photochemical decomposition, of mono and binuclear carbonyls of 3d series. Reaction of metal carbonyls: reduction, oxidation, photochemical substitution, migratory insertion of carbonyls, and nucleophilic addition of CO. Synthesis of metal-alkene complexes through ligand addition, reduction and substitution and reaction of metal bound alkenes, Zeise's salt Metal–sandwich compounds: Ferrocene: synthesis, physical properties and reactions: acylation, sulfonation, alkylation metallation, acetylation, chloromercuration, Mannich reaction, comparison of aromaticity and reactivity of ferrocene with that of benzene. Synthesis and reactions of Metal alkyls and Metal-carbenes

Unit-4: Catalysis by Organometallic Compounds **(Hours: 15)**

General principles of catalysis, properties of catalysts, homogeneous and heterogeneous catalysis. (Catalytic steps, examples and industrial applications), deactivation and regeneration of catalysts, (catalytic poisons and promoter). Organometallic catalysis of the following reactions of commercial importance and their mechanism:

1. Alkene hydrogenation (using Wilkinson's Catalyst)
2. Synthetic gasoline preparation (Fischer Tropsch reaction)
3. Polymerisation of ethene using Ziegler-Natta catalyst
4. Wacker oxidation process (Smidth process)
5. Hydroformylation reaction (Oxo-process)
6. Monsanto Acetic Acid process

Essential/recommended readings

1. Miessler, G. L.; Fischer, P. J.; Tarr, D. A. (2014), *Inorganic Chemistry*, 5th Edition, Pearson Education.
2. Weller, M.; Overton, T.; Rourke, J.; Armstrong, F. (2018), *Shriver and Atkins' Inorganic Chemistry*, 6th Edition, Oxford University Press.
3. Cotton, F. A.; Wilkinson, G.; Murillo, C. A.; Bochmann, M. (1999), *Advanced Inorganic Chemistry*, 6th Edition, Wiley.
4. Porterfield, W. W. (1993), *Inorganic Chemistry: A Unified Approach*, 2nd Edition, Academic Press.
5. Huheey, J. E.; Keiter, E. A.; Keiter, R. L.; Medhi, O. K. (2006), *Inorganic Chemistry: Principles of Structure and Reactivity*, 4th Edition, Pearson Education.
6. Green, M. L. H.; Parkin, G.; Mingos, D. M. P. (2010), *Organometallic Chemistry*, 3rd Edition, Royal Society of Chemistry.
7. Cotton, F. A.; Wilkinson, G.; Gaus, P. L. (1995), *Basic Inorganic Chemistry*, 3rd Edition, Wiley India.
8. Greenwood, N. N.; Earnshaw, A. (1997), *Chemistry of the Elements*, 2nd Edition, Elsevier.
9. Gupta, B. D.; Elias, A. J. (2013), *Basic Organometallic Chemistry: Concepts, Syntheses and Applications*, 2nd Edition, Universities Press.
10. Housecroft, C. E.; Sharpe, A. G. (2025), *Inorganic Chemistry*, 6th Edition, Pearson Education.
11. House, J. E.; House, K. A. (2020), *Descriptive Inorganic Chemistry*, 3rd Edition, Academic Press.

DSC-19
PRACTICAL-V
(Credits: 04)
(60 labs of 2 hrs each=120 hrs)

Course Objectives

- To develop practical understanding of modern analytical techniques such as UV-Visible spectroscopy, FTIR spectroscopy, cyclic voltammetry, potentiometry, conductometry, and spectrophotometry for qualitative and quantitative chemical analysis.
- To impart hands-on training in the synthesis, characterization, and interpretation of coordination compounds, organometallic compounds, nanoparticles, fertilizers, and alloy samples using instrumental and classical methods.
- To enhance the ability to interpret molecular structure, bonding, spectral behavior, and chemical properties using computational chemistry software and molecular modeling tools.
- To strengthen analytical, experimental, and problem-solving skills through laboratory-based investigations involving inorganic, organic, physical, and computational chemistry concepts.

Learning Outcomes

- Students will be able to perform instrumental analysis using UV-Visible, FTIR, cyclic voltammetry, and conductivity methods for identification, estimation, and structural interpretation of chemical compounds.
- Students will be able to synthesize coordination complexes, nanoparticles, and inorganic compounds, and evaluate their composition, spectral properties, and chemical behavior.
- Students will be able to analyze fertilizers, alloys, and synthetic samples using gravimetric, volumetric, spectrophotometric, and potentiometric techniques with accuracy and precision.
- Students will be able to use computational chemistry software to optimize molecular structures, visualize molecular orbitals, compare molecular properties, and correlate theoretical predictions with experimental observations.

1. To determine λmax of $KMNO_4/K_2Cr_2O_7$ using UV-Visible Spectrophotometer.
2. To verify Beer-Lambert law.
3. To determine the concentration of unknown solution with the help of UV-Visible Spectrophotometer.
4. To analyze the effect of concentration on N-H and O-H stretching vibrational frequency of the compounds with the help of FTIR spectrophotometer.
5. To differentiate primary, secondary and tertiary amines with the help of FTIR spectrophotometer.
6. To differentiate primary, secondary and tertiary alcohols with the help of recorded FTIR spectra.
7. To identify unsubstituted and ortho, meta & para derivatives of aromatic compounds with the help of IR bands observed in fingerprint region of recorded FTIR spectra.
8. Analysis of polymer films and sheets with the help of FTIR spectrophotometer.
9. Analysis of different functional groups through given FTIR spectra.
10. Hands on data collection methods and different file formats of recorded spectra with the help of FTIR spectrometer.
11. To study and compare the UV-Vis spectrum of ferrocene (in methanol or acetonitrile) and potassium ferrocyanide (in water).
12. To study the cyclic voltammogram of ferrocene.
13. Preparation of Bis(acetylacetonato) copper (II) complex and characterisation through UV-Visible spectrum of its aqueous solution.
14. Preparation of tris(acetylacetonato) manganese (III) complex.
15. Preparation of Potassium tris(oxalato)ferrate (III) complex.
16. Preparation of Tetraamminecopper (II) sulphate monohydrate complex.

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17. Preparation of Pentaamminechloridocobalt (III) chloride.
18. Preparation of Hexaamminecobalt (III) chloride
19. Determination of number of chloride ions in ionisation sphere to confirm the formula of complexes prepared through potentiometric titration or conductance measurements.
20. Compare and interpret the visible spectrum of complexes prepared for shifts in wavelength maxima.

    Any other organometallic compounds synthesised from time to time may also be included.
21. Detection of constituents of Ammonium Sulphate fertilizer (Ammonium and Sulphate ions) by qualitative analysis and determine its free acidity.
22. Detection of constituents of CAN fertilizer (Calcium, Ammonium and Nitrate ions) fertilizer and estimation of Calcium content.
23. Detection of constituents of Superphosphate fertilizer (Calcium and Phosphate ions) and estimation of phosphoric acid content.
24. Analysis of (Cu, Ni) in alloy or synthetic samples (methods involving Gravimetry and Spectrophotometry). 5. Analysis of (Cu, Zn) in alloy or synthetic samples (Multiple methods involving Iodometry, and Potentiometry).
25. Synthesis of pure ZnO and Cu doped ZnO nanoparticles.
26. Synthesis of silver nanoparticles by green and chemical approach methods and its characterization using UV-visible spectrophotometer
27. Compare the optimized C-C bond lengths in ethane, ethene, ethyne and benzene. Visualize the molecular orbitals of the ethane ζ bonds and ethene, ethyne, benzene and pyridine π bonds.
28. (a) Perform a conformational analysis of butane. (b) Determine the enthalpy of isomerization of *cis* and *trans* 2-butene.
29. Visualize the electron density and electrostatic potential maps for LiH, HF, N_2, NO and CO and comment. Relate to the dipole moments. Animate the vibrations of these molecules.
30. (a) Relate the charge on the hydrogen atom in hydrogen halides with their acid character. (b) Compare the basicities of the nitrogen atoms in ammonia, methylamine, dimethylamine and trimethylamine.
31. (a) Compare the shapes of the molecules: 1-butanol, 2-butanol, 2-methyl-1-propanol, and 2-methyl-2-propanol. Note the dipole moment of each molecule. (b) Show how the shapes affect the trend in boiling points: (118 °C, 100 °C, 108 °C, 82 °C, respectively).
32. Build and minimize organic compounds of your choice containing the following functional groups. Note the dipole moment of each compound: (a) alkyl halide (b) aldehyde (c) ketone (d) amine (e) ether (f) nitrile (g) thiol (h) carboxylic acid (i) ester (j) amide.
33. Determine the heat of hydration of ethylene. (b) Compute the resonance energy of benzene by comparison of its enthalpy of hydrogenation with that of cyclohexene.
34. Arrange 1-hexene, 2-methyl-2-pentene, (*E*)-3-methyl-2-pentene, (*Z*)-3-methyl-2-pentene, and 2,3-dimethyl-2-butene in order of increasing stability.
35. (a) Compare the optimized bond angles H_2O, H_2S, H_2Se. (b) Compare the HAH bond angles for the second row dihydrides and compare with the results from qualitative MO theory.

    Note: Software: ChemSketch, ArgusLab (www.planaria-software.com), TINKER 6.2 (dasher.wustl.edu/ffe), WebLab Viewer, Hyperchem, or any similar software.

Recommended Books:

1. Vogel, A. I., Tatchell, A. R., Furnis, B. S., Hannaford, A. J., and Smith, P. W. G. *Vogel's Textbook of Practical Organic Chemistry*. 5th ed., Pearson, 1989.
2. Young, P. R. *Practical Spectroscopy: The Rapid Interpretation of Spectral Data*. 5th ed., Cengage Learning, 2000.
3. Yadav, L. D. S. *Organic Spectroscopy*. Springer, 2005.
4. Field, L. D., Li, H. L., and Magill, A. M. *Organic Structures from Spectra*. 6th ed., Wiley, 2020.
5. Singh, J., and Singh, J. *Organic Spectroscopy: Principles, Problems and Their Solutions*. 3rd ed., Pragati Prakashan, 2021.

6. Singh, P. P., and Ambika. *Organic Spectroscopy*. Viva Books, 2018.
7. S. S. M. Hassan, *Practical Handbook of Instrumental Methods of Analysis*, latest ed., CBS Publishers & Distributors, New Delhi, 2023.
8. V. K. Ahluwalia, S. Dhingra, *Comprehensive Practical Organic Chemistry: Qualitative Analysis, Synthesis and Spectral Identification*, latest ed., Universities Press, 2021.
9. ChemTexts (2020) 6:22, https://doi.org/10.1007/s40828-020-00119-6
10. Mendham, J.; Denney, R. C.; Barnes, J. D.; Thomas, M. J. K. (2000), *Vogel's Textbook of Quantitative Chemical Analysis*, 6th Edition, Pearson Education.
11. Svehla, G. (1996), *Vogel's Qualitative Inorganic Analysis*, 7th Edition, Pearson Education.
12. Banewicz, J. J.; Kenner, C. T. (1952), "Determination of Calcium and Magnesium in Limestones and Dolomites," *Analytical Chemistry*, 24(7), 1186–1187.
13. Ghorbani, H. R.; Mehr, F. P.; Pazoki, H.; Rahmani, B. M. (2015), "Synthesis of ZnO Nanoparticles by Precipitation Method," *Oriental Journal of Chemistry*, 31(2).
14. Orbaek, A. W.; McHale, M. M.; Barron, A. R. (2015), "Synthesis and Characterization of Silver Nanoparticles for an Undergraduate Laboratory," *Journal of Chemical Education*, 92, 339–344.
15. A.R. Leach, Molecular Modelling Principles and Application, Longman, 2001.
16. J.M. Haile, Molecular Dynamics Simulation Elementary Methods, John Wiley and Sons, 1997.
17. Satya Prakash Gupta, QSAR and Molecular Modeling, Springer - Anamaya Publishers, 2008.

DSE-5
INORGANIC MATERIALS OF INDUSTRIAL IMPORTANCE
(Credits: 04)
Theory-60 hrs

Learning Objectives

- To impart knowledge about the role of inorganic materials in industrial applications and daily life.
- To develop understanding of the synthesis, properties, and applications of silicates, fertilizers, coatings, energy materials, and nanomaterials.
- To introduce students to emerging trends in materials chemistry and sustainable technologies.

Learning Outcomes

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

- Explain the composition, properties, and industrial applications of glass and cement.
- Describe the chemistry and manufacture of important fertilizers and evaluate their agricultural suitability.
- Understand the formulation, composition, and protective mechanisms of surface coatings.
- Compare different batteries and energy devices based on working principles and applications.
- Analyze the synthesis, properties, and applications of nanomaterials and advanced inorganic materials.

Unit 1: Silicate Industries **(12 Lectures)**

Glassy state: Structure, properties, and characteristics of amorphous materials; classification of glasses into silicate and non-silicate types. Raw materials, manufacturing processes, and processing techniques of glass. Composition, properties, and applications of commercial glasses: soda lime glass, lead glass, armoured and safety glass, borosilicate glass, fluorosilicate glass, coloured glass, photosensitive and photochromic glass, glass wool, and optical fibres. Cement: Manufacture of Portland cement; composition and role of major constituents; mechanism of setting and hardening. Types of cement: quick-setting cement, pozzolanic cement, slag (eco-friendly) cement, and their industrial applications.

Unit 2: Fertilizers **(10 Lectures)**

Classification of fertilizers: nitrogenous, phosphatic, and potassic fertilizers; importance in agriculture and soil fertility. Chemistry and industrial manufacture of fertilizers: urea, calcium ammonium nitrate, ammonium phosphates, superphosphate of lime, and potassium nitrate. Interaction of fertilizers with soil and plant nutrient uptake. Environmental impact of fertilizers including eutrophication and soil degradation. Introduction to sustainable fertilizers and controlled-release systems.

Unit 3: Surface Coatings **(18 Lectures)**

Introduction and classification of surface coatings; objectives and industrial importance. Paints and pigments: formulation, composition, and properties. Pigment volume concentration (PVC) and critical pigment volume concentration (CPVC). Role of binders, fillers, solvents, thinners, and emulsifying agents. Types of paints: water-based paints, oil-based paints, enamels, and plastic paints. Special coatings: heat-resistant, fire-retardant, and eco-friendly coatings. Surface preparation techniques for coating applications. Metallic coatings: electrolytic and electroless plating with reference to nickel and chromium plating. Advanced surface coating techniques: physical vapor deposition (PVD), chemical vapor deposition (CVD), galvanizing, carburizing, nitriding, boriding, sherardising, and cementation. Mechanism of corrosion protection by coatings.

Unit 4: Batteries and Energy Devices **(10 Lectures)**

Primary and secondary batteries; characteristics of an ideal battery. Construction, working principles, and applications of batteries: lead-acid batteries, lithium metal batteries, Lithium-ion battery, lithium polymer batteries, and solid-state batteries. Introduction to fuel cells, solar cells, and polymer electrolyte cells. Comparative evaluation of different energy storage and conversion systems based on efficiency, energy density, cost, safety, and environmental impact.

Unit 5: Nanodimensional Materials **(10 Lectures)**

Introduction to nanomaterials: classification into zero-, one-, and two-dimensional systems. Size-dependent properties and their significance. Synthesis methods: top-down and bottom-up approaches including sol-gel, chemical vapor deposition, and mechanical methods. Structure, properties, and applications of fullerenes, carbon nanotubes, and carbon fibres. Semiconducting and superconducting oxides: basic concepts and applications. Role of nanomaterials in electronics, catalysis, energy storage, environmental remediation, and biomedical fields.

Essential/recommended readings

1. West, A. R. (2014), *Solid State Chemistry and Its Applications*, 2nd Edition, Wiley.
2. Smart, L. E.; Moore, E. A. (2012), *Solid State Chemistry: An Introduction*, 4th Edition, CRC Press, Taylor & Francis.
3. Weller, M.; Overton, T.; Rourke, J.; Armstrong, F. (2018), *Shriver and Atkins' Inorganic Chemistry*, 6th Edition, Oxford University Press.
4. Kent, J. A. (Ed.) (2010), *Riegel's Handbook of Industrial Chemistry*, 10th Edition, Springer.
5. Poole, C. P. Jr.; Owens, F. J. (2003), *Introduction to Nanotechnology*, 1st Edition, John Wiley & Sons.

DSE-6
MOLECULAR MODELLING & DRUG DESIGN
(Credits: 04)
Theory -60 hrs

Course Objectives

- To introduce the basic concepts of molecular modelling, coordinate systems, potential energy surfaces, and molecular graphics used in computational chemistry.
- To explain force fields, bonded and non-bonded interactions, and their role in describing molecular structure and behavior.
- To study energy minimization techniques, computer simulation methods, and molecular dynamics and Monte Carlo approaches for analyzing molecular systems.
- To provide knowledge of structure prediction, molecular docking, QSAR, and computational approaches in drug design and discovery.

Learning Outcomes

- Explain the fundamental concepts of molecular modelling, including coordinate systems, energy surfaces, and visualization of molecular structures.
- Analyze molecular interactions using force field models and describe the role of bonded and non-bonded forces in molecular simulations.
- Apply energy minimization, molecular dynamics, and Monte Carlo simulation methods to study molecular behavior and interpret simulation results.
- Understand structure prediction, molecular docking, and QSAR techniques, and evaluate their applications in drug design and chemoinformatics.

Unit-1 Introduction to Molecular Modelling **(10 hrs)**

Introduction. Useful Concepts in Molecular Modelling: Coordinate Systems. Potential Energy Surfaces. Molecular Graphics. Surfaces. Computer Hardware and Software. The Molecular Modelling Literature.

Unit-2 Force Fields **(14 hrs)**

Fields. Bond Stretching. Angle Bending. Introduction to nonbonded interactions. Electrostatic interactions. van der Waals Interactions. Hydrogen bonding in Molecular Mechanics. Force Field Models for the Simulation of Liquid Water.

Unit-3 Energy Minimization and Computer Simulation **(12 hrs)**

Minimization and related methods for exploring the energy surface. Non-derivative method, First and second order minimization methods. Computer simulation methods. Simple thermodynamic properties and Phase Space. Boundaries. Analyzing the results of a simulation and estimating Errors.

Unit-4 Molecular Dynamics & Monte Carlo Simulation **(12 hrs)**

Molecular Dynamics Simulation Methods. Molecular Dynamics using simple models. Molecular Dynamics with continuous potentials. Molecular Dynamics at constant temperature and pressure. Metropolis method. Monte Carlo simulation of molecules. Models used in Monte Carlo simulations of polymers.

Unit-5 Structure Prediction and Drug Design **(12 hrs)**

Structure prediction - Introduction to comparative Modeling. Sequence alignment. Constructing and evaluating a comparative model. Predicting protein structures by 'Threading', Molecular docking. Structure based de novo ligand design, Drug Discovery – Chemoinformatics – QSAR.

Reference Books:

- A.R. Leach, Molecular Modelling Principles and Application, Longman, 2001.
- J.M. Haile, Molecular Dynamics Simulation Elementary Methods, John Wiley and Sons, 1997.
- Satya Prakash Gupta, QSAR and Molecular Modeling, Springer - Anamaya Publishers, 2008.

Semester-VI

DSC-20
ADVANCED PHYSICAL CHEMISTRY
Credit -4
Theory: 60 hrs

Course Objectives

- To understand the fundamental principles of quantum chemistry, including quantum mechanics, Schrödinger equation, and approximation methods for simple atomic and molecular systems.
- To explain chemical bonding through valence bond theory and molecular orbital theory, and compare their applications in describing molecular structure and stability.
- To study the interaction of electromagnetic radiation with molecules and the principles of rotational, vibrational, Raman, and electronic spectroscopy.
- To provide knowledge of advanced spectroscopic techniques such as NMR and ESR spectroscopy for structural interpretation and analysis of molecules.

Learning Outcomes

- Apply quantum mechanical concepts to explain particle in a box, harmonic oscillator, rigid rotator, hydrogen atom, and vibrational motion of molecules.
- Analyze covalent bonding using valence bond and molecular orbital approaches, and interpret bonding, antibonding, and molecular stability in simple molecules.
- Interpret rotational, vibrational, Raman, and electronic spectra to determine molecular properties such as bond length, force constants, and electronic transitions.
- Explain the principles of NMR and ESR spectroscopy and interpret proton NMR spectra and ESR patterns of simple organic molecules and radicals.

Unit-1: Quantum Chemistry: **(Lecture-15)**

Postulates of quantum mechanics, quantum mechanical operators and commutation rule, Setting up of 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; wave function, 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; Vibrational energy of diatomic molecules and zero-point energy. Angular momentum. Rigid rotator model of rotation of diatomic molecule. Schrodinger equation in Cartesian and spherical polar (derivation not required). Separation of variables, spherical harmonics, need for approximation methods, statement of variation theorem and application to simple systems (particle-in-a-box, harmonic oscillator, hydrogen atom).

Unit-2: Chemical Bonding: **(Lecture-10)**

Covalent bonding, valence bond and molecular orbital approaches, LCAO-MO treatment of H_2^+. Bonding and antibonding orbitals. Qualitative extension to H_2. Comparison of LCAO-MO and VB treatments of H_2 (only wave functions, 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).

Unit-3 Molecular Spectroscopy: **(Lecture-5)**

Interaction of electromagnetic radiation with molecules and various types of spectra; Born Oppenheimer approximation.

Unit-4 Rotational Spectroscopy: **(Lecture-5)**

Selection rules, intensities of spectral lines, determination of bond length of diatomic and linear

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triatomic molecules, isotopic substitution;

Unit-5 Vibrational Spectroscopy: **(Lecture-7)**

Classical equation of vibration, computation of force constants, 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.

Unit-6 Raman spectroscopy: **(Lecture-5)**

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.

Unit-7 Electronic Spectroscopy: **(Lecture- 5)**

Franck-Condon principle, electronic transition, singlet and triplet states, fluorescence and phosphorescence, dissociation and predissociation, calculation of electronic transition of polyenes, using free electron Models.

Unit-8 Nuclear Magnetic Resonance (NMR) Spectroscopy: **(Lecture-8)**

Principle of NMR spectroscopy, larmour procession, chemical shift and low resolution spectra, different scales (δ and τ), 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.

Reference Books:

1. Kemp, W. *Organic Spectroscopy*. 3rd ed., Palgrave Macmillan, 1991.
2. Williams, D. H., and Fleming, I. *Spectroscopic Methods in Organic Chemistry*. 6th ed., McGraw-Hill, 2008.
3. Pavia, D. L., Lampman, G. M., Kriz, G. S., and Vyvyan, J. R. *Introduction to Spectroscopy*. 5th ed., Cengage Learning, 2015.
4. Pretsch, E., Bühlmann, P., and Badertscher, M. *Structure Determination of Organic Compounds*. 4th ed., Springer, 2009.
5. Banwell, C. N., and McCash, E. M. *Fundamentals of Molecular Spectroscopy*. 4th ed., Tata McGraw-Hill, 1994.
6. Colthup, N. B., Daly, L. H., and Wiberley, S. E. *Introduction to Infrared and Raman Spectroscopy*. 3rd ed., Academic Press, 1990.
7. Keeler, J. *Understanding NMR Spectroscopy*. 2nd ed., Wiley, 2010.
8. Claridge, T. D. W. *High-Resolution NMR Techniques in Organic Chemistry*. 3rd ed., Elsevier, 2016.
9. McLafferty, F. W., and Tureček, F. *Interpretation of Mass Spectra*. 4th ed., University Science Books, 1993.
10. De Hoffmann, E., and Stroobant, V. *Mass Spectrometry: Principles and Applications*. 3rd ed., Wiley, 2007.
11. McQuarrie, D. A. *Quantum Chemistry*. University Science Books, 2008.
12. Levine, I. N. *Quantum Chemistry*. 7th ed., Pearson, 2014.
13. Griffiths, D. J., and Schroeter, D. F. *Introduction to Quantum Mechanics*. 3rd ed., Cambridge University Press, 2018.

DSC-21

POLYNUCLEAR HYDROCARBONS, PHOTOCHEMISTRY AND PERICYCLIC REACTIONS

Credits-4

(Theory: 60 hrs)

Learning objectives

The objectives of this course are as follows:

- To provide thorough knowledge of the chemistry of polynuclear hydrocarbons.
- To detail the basic principles and applications of pericyclic reactions and photochemistry

Learning outcomes

By studying this course, students will be able to:

- Discuss and use the chemistry of polynuclear hydrocarbons for application in real world problems.
- Discuss and use the pericyclic reactions and photochemistry for research and other applications.

Unit-1: Polynuclear Hydrocarbons **(Hours: 15)**

Introduction, classification, structure, nomenclature and uses. Aromaticity of polynuclear hydrocarbons, structure elucidation of Naphthalene and general methods of preparation of naphthalene and anthracene. Relative reactivity of naphthalene and anthracene in comparison to benzene. Discussion on the following reactions (with mechanism) for Naphthalene and Anthracene: Addition reactions, Oxidation, Electrophilic substitution- Friedel Craft reaction, Chloromethylation, Halogenation, Formylation, Nitration and sulphonation. Reduction reaction and Diels Alder reaction.

Unit-2: Photochemistry reactions **(Hours: 15)**

Introduction and basic principles of photochemistry, photochemical energy, Nature of light and electromagnetic radiation, Absorption of light: Beer–Lambert Law, Electronic transitions ($\sigma \rightarrow \sigma^*$, $\pi \rightarrow \pi^*$, $n \rightarrow \pi^*$) Franck–Condon principle, Jablonski diagram and photophysical processes Fluorescence and phosphorescence photolytic cleavage, photochemistry of carbonyl compounds (Norrish type 1, Norrish type 2 and Peterno Buchi reactions), Ferrocene & Phosphorescence

Unit -3 Pericyclic Reactions **(Hours: 20)**

Introduction: Types of pericyclic reactions (Electrocyclic, Cycloaddition and Sigmatropic Rearrangements), Symmetry in σ and π molecular orbitals, Frontier Molecular Orbitals. Electrocyclic Reactions: Conrotatory and Disrotatory motion in ring opening and ring closing reactions in (4n) and (4n+2) π electron systems, FMO method, Woodward Hoffmann rule. Cycloaddition Reactions: [2+2] and [4+2] π cycloaddition reactions, Diels Alder reaction (electron rich and electron poor dienes and dienophiles, Stereochemistry, Alder rule of endo addition). Sigmatropic Reactions: [1,3], [1,5] and [3,3] sigmatropic rearrangements, Cope rearrangement, Claisen Rearrangements.

Unit 4: Applications of Pericyclic Reactions **(Hours: 10)**

Organic synthesis applications, Stereospecific synthesis, Natural product synthesis, Industrial relevance Photochemistry in biological systems (photosynthesis basics), Photochemical smog, Photochromism Chemiluminescence and bioluminescence.

Essential/recommended readings:

1. Organic Chemistry **Authors:** Morrison & Boyd **Year:** 2010
2. Advanced Organic Chemistry Part A: Structure and Mechanisms **Author:** Francis A. Carey & Richard J. Sundberg **Year:** 2007
3. A Guidebook to Mechanism in Organic Chemistry **Author:** Peter Sykes **Year:** 1986
4. Molecular Photochemistry year 2012 **Author:** Nicholas J. Turro
5. Principles of Molecular Photochemistry: An Introduction year 2015 **Authors:** Nicholas J. Turro, V. Ramamurthy, Juan C. Scaiano

6. Organic Photochemistry year 2009**Author:** Jagdamba Singh
7. Fundamentals of Photochemistry year 2014 **Author:** K.K. Rohatgi-Mukherjee
8. Pericyclic Reactions year 2016 **Author:** Ian Fleming
9. Pericyclic Reactions: A Textbook **Author:** S.M. Mukherji **Year:** 2009
10. Organic Chemistry **Authors:** Jonathan Clayden et al. **Year:** 2020
11. Advanced Organic Chemistry Part B: Reaction and Synthesis **Authors:** Francis A. Carey & Richard J. Sundberg **Year:** 2007

DSC-22
Practical- VI
Credits: 04
(60 labs of 2 hrs each =120 hrs)

Course Objectives

- To understand the principles and applications of spectroscopic and analytical techniques.
- To develop practical skills in organic synthesis, purification, and separation methods.
- To study photochemical, pharmaceutical, fermentation, and electrochemical processes through laboratory experiments.
- To apply green chemistry principles for safe, sustainable, and eco-friendly chemical practices.

Learning Outcomes

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

- Apply spectroscopic and analytical methods to verify chemical laws, determine reaction kinetics, analyze spectra, and interpret experimental data for qualitative and quantitative analysis.
- Perform organic preparations, purification, and separation techniques efficiently, and explain the reaction mechanisms and stereochemical outcomes involved.
- Conduct experiments related to photochemistry, pharmaceuticals, fermentation, and electrochemistry, and relate laboratory observations to theoretical concepts and industrial relevance.
- Implement green chemistry principles in laboratory practices by selecting eco-friendly reagents, renewable resources, alternative solvents, and energy-efficient methods for sustainable chemical processes.

1. Verification of Lambert-Beer's Law
2. Determination of pK (indicator) for phenolphthalein or methyl red
3. Study the formation of a complex between ferric andthiocyanate (or salicylate) ions.
4. Study the kinetics of interaction of crystal violetwith sodium hydroxide colourimetrically.
5. Analysis of the given vibration-rotation spectrum of HCl(g)
6. Record the UV spectrum of p-nitrophenol (in 1:4 ethanol:water mixture). Repeat after adding a small crystal of NaOH. Comment on the difference, if any.
7. Record the U.V. spectrum of a given compound (acetone) in cyclohexane

(a) Plot transmittance versus wavelength.
(b) Plot absorbance versus wavelength.

Calculate the energy involved in the electronic transition in different units

8. **Organic Preparations**

- Nitration of Aromatic Compounds
- Friedel–Crafts Reaction (Acetylation)
- Bromination of Aromatic Hydrocarbon
- Oxidation Reactions
- Diels–Alder Reaction (Demonstration)

9. **Photochemistry Experiments**

- Photoreduction of benzophenone
- Study of Fluorescence and Phosphorescence
- Verification of Beer–Lambert Law
- Cis–Trans Isomerization

10. Pericyclic Reaction (Model Based)

- Molecular Model Kit Exercises
- Stereochemical Analysis (Endo vs Exo)
- Orbital Symmetry Demonstration

11. Purification & Separation Techniques

- Solvent Extraction
- Distillation (Simple, Fractional, Vacuum)
- Crystallization
- Chromatography: TLC, Column, HPLC (demo), GC (demo), Ion Exchange

12. Drugs & Pharmaceuticals

- Synthesis of Aspirin / Paracetamol
- Drug Identification
- Tablet Analysis
- Retrosynthesis Exercise

13. Fermentation

- Ethyl Alcohol Production
- Estimation of Alcohol
- Effect of pH & Temperature

14. Spectroscopy & Electrochemistry

- Flame Photometry
- AAS (Demo)
- Conductometry
- Potentiometry
- Polarography (Demo)

15. Thermal Analysis

- TGA (Demo)
- DSC
- Thermal Stability Study

16. **Safer starting materials**: Preparation and characterization of nano particles of gold using tea leaves.
17. **Using renewable resources**: Preparation and characterization of biodiesel from vegetable oil/ waste cooking oil

18. 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 + $OH^{-} \rightarrow$ propene + trimethylpropene + water H_2SO_4/H_2O

(II) 1-propanol $\longrightarrow$ propene + water

The other types of reactions, like addition, elimination, substitution and rearrangement should also be studied for the calculation of atom economy.

13. **Use of enzymes as catalysts**: Benzoin condensation using Thiamine Hydrochloride as a catalyst instead of cyanide

14. Alternative Green solvents

i. Extraction of D-limonene from orange peel using liquid CO_2 prepared from dry ice.
ii. Mechanochemical solvent free synthesis of azomethines

15. Alternative sources of energy

i) Solvent free, microwave assisted one pot synthesis of phthalocyanine complex of copper (II).
ii) Photoreduction of benzophenone to benzopinacol in the presence of sunlight.

Reference Books:

1. Young, P. R. *Practical Spectroscopy: The Rapid Interpretation of Spectral Data*. 5th ed., Cengage Learning, 2000.
2. Banwell, C. N., and McCash, E. M. *Fundamentals of Molecular Spectroscopy*. 4th ed., Tata

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McGraw-Hill, 1994.

3. Pavia, D. L., Lampman, G. M., Kriz, G. S., and Vyvyan, J. R. *Introduction to Spectroscopy*. 5th ed., Cengage Learning, 2015.
4. Vogel, A.I. (2012), **Quantitative Organic Analysis**, Part 3, Pearson Education.
5. Mann, F.G., Saunders, B.C. (2009), **Practical Organic Chemistry**, Pearson Education.
6. Furniss, B.S., Hannaford, A.J., Smith, P.W.G., Tatchell, A.R. (2012), **Vogel's Textbook of Practical Organic Chemistry**, Fifth Edition, Pearson.
7. Ahluwalia, V.K., Dhingra, S. (2004), **Comprehensive Practical Organic Chemistry: Qualitative Analysis**, University Press.
8. Ahluwalia, V.K., Aggarwal, R. (2004), **Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis**, University Press
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10. Pasricha, S., Chaudhary, A. (2021), **Practical Organic Chemistry: Volume–II**, I K International Publishing house Pvt. Ltd, New Delhi
8. Skoog et al., Principles of Instrumental Analysis, 6th Ed., 2007
9. Chatwal & Anand, Instrumental Methods of Chemical Analysis, 2013
10. Vogel's Practical Organic Chemistry, 5th Ed.
11. Furniss et al., Vogel's Textbook of Practical Organic Chemistry, 1989
12. Remington: The Science and Practice of Pharmacy, 22nd Ed., 201
13. Banwell, C.N.; McCash, E.M. (2006)
14. Khosla, B.D.; Garg, V.C.; Gulati, A. (2015), **Senior Practical Physical Chemistry**,
15. R. Chand & Co, New Delhi.
16. Garland, C. W.; Nibler, J. W.; Shoemaker, D. P. (2003), **Experiments in Physical Chemistry**, 8th Edition, McGraw-Hill, New York
17. Kapoor, K.L. (2019), **A Textbook of Physical Chemistry**, Vol.7, 1st Edition, McGraw Hill Education.
18. Anastas, P.T and Warner, J.C. *Green Chemistry: Theory and Practice,* Oxford University Press, 1998
19. Kirchoff, M. and Ryan, M.A. *Greener approaches to undergraduate chemistry experiment.* American Chemical Society, Washington DC, 2002
20. Ryan, M.A. *Introduction to Green Chemistry*, Tinnesand; (Ed), American Chemical Society, Washington DC, 2002.
21. Sharma, R.K.; Sidhwani, I.T. and Chaudhari, M.K. *Green Chemistry Experiments: A monograph,* I.K. International Publishing House Pvt Ltd. New Delhi, Bangalore ISBN 978-93-81141-55-7, 2013
22. Cann, M.C. and Connelly, M. E. *Real world cases in Green Chemistry*, American Chemical Society, 2008
23. Cann, M. C. and Thomas, P. *Real world cases in Green Chemistry,* American Chemical Society, 2008
24. Lancaster, Mike *Green Chemistry: An introductory text*: *2nd Ed.* RSC publishing, ISBN 978-1-84755-873-2
25. Pavia, D.L., Kriz, G.S., Lampman, G.M. and Engels, R.G. *Introduction to Organic Laboratory Techniques – a Microscale Approach* 4th Ed., Brooks-Cole Laboratory Series for Organic Chemistry, 2006

DSE-7
INDUSTRIAL AND ANALYTICAL CHEMISTRY
(Credits: 04)
Theory -60 hrs

Course Objectives

- To understand purification and instrumental methods used in quality control.
- To study drug design, development, and synthesis of important pharmaceuticals.
- To learn fermentation processes for industrial production of useful chemicals and antibiotics.
- To understand spectroscopic and thermal analysis techniques for chemical analysis.

Learning Outcomes

- Apply separation and purification techniques for chemical analysis and quality control.
- Explain the synthesis and importance of pharmaceutical drugs.
- Describe fermentation processes and their industrial applications.
- Interpret results from spectroscopic and thermal analysis methods.

Unit-1 Quality Control and Instrumental Methods of Analysis **(Hours 15)**
Purification and Separation: Sample preparation (isolation using a suitable solvent, extraction and separation), Solvent extraction. Distillation (simple, fractional and vacuum distillation), Crystallization. Chromatographic separation: High Performance Liquid Chromatography (HPLC), Gas Liquid Chromatography (GLC), Gas Chromatography (GC), Ion Exchange Chromatography.

Unit-2 Drugs and Pharmaceuticals **(Hours 15)**
Drug discovery, design and development; Basic Retrosynthetic approach. Synthesis of the representative drugs of the following classes: analgesics agents, antipyretic agents, anti-inflammatory agents (Aspirin, paracetamol, Ibuprofen); antibiotics (Chloramphenicol); antibacterial and antifungal agents

Unit-3 Fermentation Industries **(Hours 10)**
Aerobic and anaerobic fermentation. Production of (i) Ethyl alcohol and citric acid, (ii) Antibiotics; Pencillin, Cephalosporin, Chloromycetin and Streptomycin, (iii) Lysine, Glutamic acid, Vitamin B2 Vitamin B12 and Vitamin C

Unit-4: Spectroscopic Methods: **(Hours: 10)**
Flame Photometry, Atomic Absorption Spectroscopy (AAS), Induced Couple Plasma Spectroscopy (ICP), Atomic Fluorescence Spectroscopy, Polarography, Amperometry, Coulometry and Conductometry

Unit-5: Thermal Analysis **(Hours10)**
Thermal Gravimetric Analysis (TGA), Differential Thermal Analysis (DTA), Differential Scanning Calorimetery (DSC), Thermal Mechanical Analysis (TMA)

Reference Books

- Skoog, D.A., Holler, F.J., and Crouch, S.R. (2018), Principles of Instrumental Analysis, 7th Edition, Cengage Learning.
- Christian, G.D., Dasgupta, P.K., and Schug, K.A. (2014), Analytical Chemistry, 7th Edition, John Wiley & Sons.

- Chatwal, G.R. and Anand, S.K. (2019), Instrumental Methods of Chemical Analysis, Revised Edition, Himalaya Publishing House.
- Mendham, J., Denney, R.C., Barnes, J.D., and Thomas, M. (2000), Vogel's Textbook of Quantitative Chemical Analysis, 6th Edition, Pearson Education.

DSE-8
GREEN CHEMISTRY
Credits: 04
Theory: 60 Hrs

Course Objectives

- To introduce the principles and importance of Green Chemistry for sustainable development
- To develop understanding of eco-friendly chemical processes, green synthesis, and alternative reaction methods
- To create awareness about environmental protection, resource conservation, and industrial applications of green chemistry

Learning Outcomes

- Understand and explain the concepts and principles of Green Chemistry
- Describe atom economy, waste minimization, and safer chemical practices
- Identify green solvents, catalysts, and energy-efficient techniques
- Explain green synthesis of selected industrially important compounds
- Analyze the role of green chemistry in environmental protection and sustainability
- Apply green chemistry concepts to basic chemical processes and everyday life

Unit I: Introduction to Green Chemistry **(8 Hrs)**
Definition and scope of Green Chemistry, need and importance, goals of Green Chemistry, limitations and challenges, basic concepts of sustainability, green chemistry versus conventional chemistry

Unit II: Principles of Green Chemistry and Green Synthesis **(12 Hrs)**
Twelve principles of Green Chemistry, waste prevention, atom economy, safer solvents and reagents, energy efficiency, renewable feedstocks, concept of green synthesis, basic organic reactions: addition, substitution, elimination, rearrangement

Unit III: Green Chemistry Approaches **(10 Hrs)**
Green solvents: water, supercritical CO_2, ionic liquids, polyethylene glycol, solvent-free reactions, microwave-assisted synthesis, ultrasonic methods, comparison with conventional methods

Unit IV: Catalysis and Safer Processes **(10 Hrs)**
Catalysis in green chemistry, homogeneous catalysis, heterogeneous catalysis, biocatalysis, photocatalysis, advantages over stoichiometric reagents, inherently safer design: minimization, substitution, moderation, basic green analytical methods

Unit V: Green Synthesis and Applications **(12 Hrs)**
Green synthesis of adipic acid, green synthesis of catechol, green synthesis of disodium iminodiacetate, microwave-assisted reactions: Hofmann elimination, oxidation, hydrolysis, ultrasound-assisted reactions: Simmons–Smith reaction, supercritical CO_2 applications, biodegradable polymers: polylactic acid, environment-friendly products and processes

Unit VI: Future Trends in Green Chemistry **(8 Hrs)**
Green oxidation reagents and catalysts, biomimetic and multifunctional reagents, combinatorial green chemistry, solventless synthesis, co-crystal controlled solid-state synthesis, green chemistry for sustainable development

Reference Books:

- Ahluwalia, V. K., and Kidwai, M. R. *New Trends in Green Chemistry*. Anamalaya Publishers, 2005.
- Anastas, P. T., and Warner, J. K. *Green Chemistry: Theory and Practice*. Oxford University Press, 1998.
- Matlack, A. S. *Introduction to Green Chemistry*. Marcel Dekker, 2001.
- Cann, M. C., and Connelly, M. E. *Real-World Cases in Green Chemistry*. American Chemical Society, Washington, 2000.
- Ryan, M. A., and Tinnesand, M. *Introduction to Green Chemistry*. American Chemical Society, Washington, 2002.
- Lancaster, M. *Green Chemistry: An Introductory Text*. 2nd ed., RSC Publishing, ISBN: 978-1-84755-873-2.