

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 learning of 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, VSEPR theory and MO diagrams (homo- & hetero-nuclear diatomic molecules).
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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), **Shriver and 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.
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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, currently a frontier area of chemistry providing an interface between organic chemistry, inorganic chemistry and 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 and their 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 and the 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
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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 metalloproteins: 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

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**, 7th 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, SO_x, NO_x 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 CO₂ 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.