CHEMISTRY

Course Structure and Syllabi for Pre Ph.D. Programme

SUBJECT-1

S. No	Course Code	Title of the Course
1	26CPHY01T	Research Methodology for Sciences

SUBJECT-2

S. No	Course Code	Title of the Course
1	26CMGT02T	Research and Publications ethics for Sciences and Humanities

CORE SUBJECTS

Choose any **Two** subjects from the following list

S. No	Code	Title of the Course
1	26CCHE01T	Inorganic Chemistry
2	26CCHE02T	Organic Chemistry
3	26CCHE03T	Physical Chemistry
4	26CCHE04T	Advanced Instrumental Methods for Chemical Characterization and Analysis
5	26CCHE05T	Chemistry & Environment
6	26CCHE06T	Chemistry of Biological Processes
7	26CCHE07T	Chemistry of Polymers and their Applications
8	26CCHE08T	Nanostructured Materials for Clean Energy Systems

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RAJAMPET, YSR District, AP – 516126, INDIA

Title of the Course : Inorganic Chemistry
Course Code : 26CCHE01T
Course offered to : Chemistry
Credits : 4

Course Objectives	
1.	To impart knowledge of symmetry elements, symmetry operations, point groups, and group theory in chemistry
2.	To provide an understanding of coordination compounds, crystal field theory, stability, and magnetic properties of metal complexes
3.	To familiarize students with electronic spectroscopy, spectroscopic term symbols, and electronic transitions in transition metal complexes.
4.	To develop an understanding of the bonding, synthesis, classification, and reactions of organometallic compounds.
5.	To introduce the principles and applications of metal complexes in catalysis, medicinal chemistry, and antimicrobial studies.

Course Outcomes: After completion of the course, students will be able to	
1.	apply symmetry operations and point group theory to analyze molecular symmetry.
2.	explain coordination chemistry, crystal field theory, and magnetic properties of metal complexes.
3.	analyze the electronic spectra of transition metal complexes using term symbols and Tanabe–Sugano diagrams
4.	explain the bonding, synthesis, and reactions of organometallic compounds
5.	analyze the applications of metal complexes in catalysis and medicine.

Unit 1 Symmetry and group theory in chemistry

Symmetry elements and symmetry operations; Point groups: Mathematical requirements for a point group; schoenflies notations point groups; Systematic assignment of molecules to point groups; Sub-groups; Classes; Matrix representation of symmetry elements; Matrix representation of C2v, C3v and C4v point groups; Reducible and Irreducible Representations; Properties of Irreducible representations; Construction of character tables (C2v and C3v point groups); Mulliken symbolism rules for IRs; The standard reduction formula; The Direct product; Symmetry criteria for Optical activity; Symmetry restrictions on Dipole moments; Symmetry and Stereo-isomerism; Prediction of IR and Raman spectral activity of H2O molecule.

Unit 2 Coordination chemistry

Werner‟s theory Representative ligands, Nomenclature; Constitution and geometry- Coordination number, polymetallic complexes; Isomerism and Chirality- Square planar, Tetrahedral and octahedral complexes, ligand chirality.

Metal ligand Bonding: Crystal Field Theory (CFT) for bonding in transition metal complexes, crystal field splitting of „d‟- orbitals in octahedral, tetrahedral, tetragonal and square planar fields. Crystal Field Stabilization energy (CFSE) and its calculation in six and four coordinated complexes,

Spectrochemical series with reference to ligands and metal ions. Factors affecting the magnitude of Δo in octahedral complexes, Jahn-Teller effect and its consequences.
Thermodynamic origin- Step-wise and overall stability of the complex, Chelate, macrocyclic and crypate effects; Determination of stability constant of a complex using pHmetry, spectrophotometry and polarogaphic techniques. Magneto Chemistry: diamagnetism para-magnetism, ferro-and anti-ferromagnetism, susceptibility, magnetic moment, super exchange, Curie-Weiss law.

Unit 3 Electronic spectroscopy of transition metal complexes

Energy levels in an atom, microstates – calculation of microstates; Spectroscopic states – coupling of orbital angular momenta and spin angular momenta; Spin – orbit coupling (R-S coupling) Derivation of term symbols for p2 and d2 configurations. Determination of ground sate terms – Hunds Rules; Hole formalism. Electronic spectra of octahedral and tetrahedral complexes. Nature of electronic spectrum; Laporte orbital and spin selection rules; Transforming spectroscopic terms into Mullikan symbols. Spectra of d1 to d9 metal ions/complexes. Orgel diagrams, Tanabe Sugano diagrams and comparison between these diagrams. Charge transfer spectra in inorganic compounds. Nature of electronic spectra of f-block metal complexes.

Unit 4 Organometallic chemistry

Classification of ligands based on hapticity and polarity; σ and π – bonded organometallics; 18 electron rule, General methods for the preparation of main group and Transition metal organometallics.
Types of organometallic reactions, oxidative additions, reductive eliminations, insertion. Nature of M-C bond.
Synthesis, bonding and uses of organometallic compounds – Two electron ligands (olefinic and acetylicinc complexes) Three electron ligands (Allylic complexes), Four electron ligand (Butadiene and Cyclobutadiene complexes) Five electron ligand (Ferrocene complexes).

Unit 5 Metal complexes in catalysis and medicine

Homogeneous and Heterogeneous catalysis - Olefin hydrogenation, dimerization and isomerization - Hydroformylation - water gas shift reaction – Effects of surface site on adsorption - The Fischer – Tropsch Process; Ziegler – Natta olefin polymerization - Ammonia synthesis.
Metal complexes in Medicine: Metal deficiency and diseases; Toxic effects of metals; Metals used for diagnosis and chemo therapy. Gold complexes in the treatment of Rheumatoid arthritis; Anti-cancer Drugs platinum ammine halide; Metallocenes and gold complexes; platinum anticancer drugs – A case study of Bioinorganic chemistry of platinum anticancer Drugs; Design of new Inorganic anticancer Drugs; Determination of antibacterial and anti- fungicidal activities of metal complexes.

Prescribed Books:

1. Cotton, F. A., Wilkinson, G., Bochmann, M., and Grimes, R. N. Advanced *Inorganic Chemistry*. 5th Ed., John Wiley & Sons Inc., 1988.
2. Huheey, J. E., Keiter, E. A., and Keiter, R. L. *Inorganic Chemistry: Principles of Structure and Reactivity*. 4th Ed., Prentice Hall, 1997.

Reference Books:

1. Wulfsberg, G. *Inorganic Chemistry*. University Science Books, 2000.
2. Figgis, B. N. *Introduction to Ligand Fields*. Krieger Pub Co., 1976.
3. Lee, J. D. *Concise Inorganic Chemistry*. 5th Ed., Wiley-Blackwell, 1996.
4. Jolly, W. L. *Modern Inorganic Chemistry*. 2nd Ed., McGraw-Hill, 1991.

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Title of the Course : Organic Chemistry
Course Code : 26CCHE02T
Course offered to : Chemistry
Credits : 4

Course Objectives	
1.	To elucidate the principles of stereochemistry, optical and geometrical isomerism, chirality, and configuration of organic molecules.
2.	To analyze retrosynthetic strategies, organic synthesis pathways, and asymmetric catalysis.
3.	To examine oxidation, reduction, and the applications of organolithium, silicon, and boron reagents in organic synthesis.
4.	To explore modern organic synthetic reactions and their applications in the synthesis of complex organic molecules.
5.	To integrate advanced concepts in organic synthesis, including combinatorial synthesis, tandem reactions, and green chemistry techniques.

Course Outcomes: After completion of the course, students will be able to	
1.	apply stereochemical principles to determine the configuration of optically and geometrically active organic molecules.
2.	analyze retrosynthetic pathways and asymmetric synthesis strategies for selected organic compounds.
3.	apply oxidation, reduction, and organometallic reagents in organic synthesis.
4.	explain the mechanisms and applications of modern organic synthetic reactions.
5.	analyze modern synthetic techniques and green chemistry approaches for organic synthesis.

Unit 1 Stereochemistry

Optical Isomerism - Elements of symmetry and chirality – Configuration of optically active molecules, dl and RS notations - Relative and Absolute configurations- Resolution of Racemic mixtures. Cram‟s rule - Concept of dynamic enantiomerism, CD and ORD methods. Geometrical Isomerism: Determination of E-Z configuration by chemical and spectral methods.

Unit 2 Organic Synthesis and Asymmetric Catalysis

a) Design of Organic synthesis: Terminology, Retrosynthesis, FGI, disconnection, synthon synthetic equivalent, protecting groups, chemoselectivity, regioselectivity and stereoselectivity. Linear and convergent strategies, Use of disconnection approach in the synthesis of multistriatin, Warfarin and α-bisabolene.

Asymmetric Synthesis: Terminology, concepts of prochirality, enantioselectivity and diastereo selectivity. Methods for determination of enantiomer purity: Polarimeter, 1H-NMR and HPLC methods.

i) Asymmetric hydrogenation using chiral Wilkinson biphosphine and Noyori catalysts; approaches to L- DOPA and L-α- amino acids.

ii) Asymmetric aldol reaction and asymmetric Diels-Alder reaction.

iii) Chiron approach to stereoselective synthesis of (-) PGE2 and (-) shikimic acid

Unit 3 Oxidation-Reduction & Reagents

Oxidations: Swern, Prevost and Woodward oxidations. Birch reduction, Reduction with LiAlH4 , NaBH4 , BH_3, AlH_3, and tri-n-butyl tin hydride.

Use of Organo lithium, Silicon and boron reagents in Organic synthesis.

Unit 4 Modern Organic Synthetic Reactions

Aza-Cope and Aza-Wittig reactions, Baylis-Hillman reaction, BINAL and BINAP assisted reactions, Buchwald-Hartwig coupling, Click reaction, Grubb's catalyst and RCM olefin metathesis, Heck reaction, Julia- Lythgoe olefination, Mukayama aldol reaction, Mitsunobu reaction, McMurray reaction, Peterson's stereoselective
olefination, Suziki coupling.

Unit 5 Modern Concepts of Organic Chemistry and Green Chemistry

New Techniques and concepts in organic synthesis. i) Combinatorial synthesis ii) Phase transfer catalysis iii) Tandem synthesis iv) Mosher's method for configuration determination v) Baldwin rules vi) Kahne's glycosidation vii) Methods of oligonucleotide synthesis.

Green Chemistry: Introduction, principles of green chemistry, Different approaches to green synthesis: Microwave and Ultrasound assisted organic synthesis, Solid phase and aqueous phase organic synthesis

Prescribed Books:

1. Smith, Michael B., and Jerry March. *Advanced Organic Chemistry: Reactions, Mechanism and Structure*. 6th Ed., John Wiley & Sons, 2007.
2. Carey, Francis A. *Organic Chemistry*. 4th Ed., McGraw-Hill Higher Education, 2000.

Reference Books:

1. Bruice, Paula Yurkanis. *Organic Chemistry*. 4th Ed., Prentice Hall, 2003.
2. Clayden, Jonathan, Nick Greeves, Stuart Warren, and Peter Wothers. *Organic Chemistry*. Oxford University Press, 2001.
3. Wade, Leroy G. Jr., Jan William Simek, and M. S. Singh. *Organic Chemistry*. 9th Ed., Pearson, 2017.
4. Carey, Francis A., and Richard J. Sundberg. *Advanced Organic Chemistry, Part A: Structure and Mechanism*. Springer, 2007.

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Title of the Course : Physical Chemistry
Course Code : 26CCHE03T
Course offered to : Chemistry
Credits : 4

Course Objectives	
1.	To evaluate photochemical principles, laws of absorption, quantum yield, and photochemical reaction mechanisms.
2.	To develop an understanding of homogeneous, heterogeneous, and enzyme catalysis, including their kinetics and mechanisms.
3.	To introduce the fundamental principles of quantum mechanics, Schrödinger equation, and approximation methods.
4.	To explain phase equilibria, phase diagrams, adsorption phenomena, and adsorption isotherms in surface chemistry.
5.	To analyze chemical kinetics, chain reactions, thermodynamic principles, and the properties of dilute solutions.

Course Outcomes: After completion of the course, students will be able to	
1.	apply photochemical laws and principles to analyze photochemical processes and reaction kinetics.
2.	analyze the kinetics and mechanisms of catalytic and enzyme-catalyzed reactions.
3.	apply quantum mechanical principles to solve problems involving simple quantum systems.
4.	analyze phase diagrams and adsorption isotherms to interpret phase equilibria and surface phenomena.
5.	apply kinetic and thermodynamic principles to evaluate chemical reactions and the properties of dilute solutions.

Unit 1 Photochemistry

Types of Photochemical reactions; Laws of Absorption (Grothuss-Draper law & Einstein‟s law); Quantum yield; Primary & Secondary Photochemical processes; Jablonski Diagram: Fluorescence, Phosphorescence, Inter-System Crossing; Internal Conversion-Vibrational Cascade and Chemiluminescence. Kinetics of Photochemical reactions; Dissociation of HI; Reaction between Hydrogen and Chlorine

Unit 2 Catalysis and Enzyme Catalysis

Catalysis: Types of Catalytic Reagents; Types of Catalysis (Homogeneous and Heterogeneous catalysis); Catalytic activity; Acidity Functions; Acid-Base catalysis, Theory of Homogeneous catalysis; Theory of Heterogeneous catalysis (Chemical theory & Adsorption theory); Kinetics of heterogeneous reactions. Enzyme Catalysis: Specificity in Enzyme Catalyzed reactions; Michaelis-Menten mechanism; Influence of Concentration on Enzyme-Catalyzed reactions; Influence of Temperature on Enzyme Catalyzed reactions.

Unit 3 Quantum Mechanics

Introduction to Quantum Mechanics: Postulates of Quantum Mechanics; Schrödinger equation; Physical significance of wave function; Eigen values and Eigen functions; Particle in a one-dimensional box; Normalization; Orthogonality; Degeneracy.

Variation method & Perturbation theory; Applications to the Helium atom; Anti -symmetry. and exclusion principle; Slater‟s determinantal wave functions.

Unit 4 Phase rule and Surface Chemistry

Phase rule: Definition of Phase rule; Terminology in Phase rule; Phase diagram of two & three component systems; Stokes and Roozboom representation for three component systems-applications

Surface Chemistry: Adsorption; Factors influencing adsorption; Surface area and its measurements; Adsorption isotherm curves; Langmuir‟s adsorption isotherm- its limitations; B.E.T. Adsorption isotherm-its applications; Negative adsorption; Positive adsorption; Chemisorption; Physisorption and Determination of surface area.

Unit 5 Chemical Kinetics and Thermodynamics

Ionic reactions: Influence of solvent on the rate of reactions (single & double sphere A.C. model); Primary salt effect; Secondary salt effect; Influence of frequency factor; Influence of ionic strength.

Chain Reactions: Steady state treatment, H_2-Br_2 & H_2-O_2 reactions, Explosion limits

Thermodynamics: Laws of thermodynamics, Enthalpy and chemical reactions, isothermal and adiabatic processes, Carnot cycle, Entropy and spontaneous process, free energy, Gibbs and Helmholtz energies, standard Gibbs free energy of reaction, applications of thermodynamics.

Dilute solutions: Raoults law, Henry‟s law, Boiling point elevation, Freezing point depression

Prescribed Books:

1. Atkins, P. W. *Physical Chemistry*. ELBS, 6th ed., 1998.
2. Chandra, A. K. *Introduction to Quantum Chemistry*. 4th ed., Tata McGraw Hill, 1994.

Reference Books:

1. Levine, Ira N. *Quantum Chemistry*. 6th ed., Prentice Hall, 2009.
2. Chandra, Manas. *Atomic Structure and Chemical Bond*. Tata McGraw Hill, 1974.
3. Laidler, K. J. *Chemical Kinetics*. 3rd ed., McGraw Hill, 1987.
4. Rajaraman, J., and J. Kuriacose. *Kinetics and Mechanism of Chemical Transformations*. Macmillan, 1993.

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Title of the Course : Advanced Instrumental Methods for Chemical Characterization and Analysis
Course Code : 26CCHE04T
Course offered to : Chemistry
Credits : 4

Course Objectives	
1.	To elucidate the fundamental principles, theoretical concepts, instrumentation, and applications of UV-Visible and Infrared (IR) spectroscopy.
2.	To analyze the principles, instrumentation, interferences, and analytical applications of atomic absorption and emission spectroscopy.
3.	To evaluate chromatographic techniques, including GC, HPLC, LC-MS, and GC-MS, for the separation, identification, and quantification of chemical compounds.
4.	To interpret the principles of Nuclear Magnetic Resonance (NMR) and Mass Spectroscopy and utilize spectral data for structural elucidation of compounds.
5.	To investigate the principles and applications of polarography, amperometry, and cyclic voltammetry in qualitative and quantitative chemical analysis.

Course Outcomes: After completion of the course, students will be able to	
1.	apply the principles of UV-Visible and IR spectroscopy to identify functional groups, interpret spectra, and estimate the absorption maxima of organic compounds.
2.	explain and apply atomic absorption and emission spectroscopy techniques for the qualitative and quantitative determination of elements.
3.	compare and evaluate GC, HPLC, LC-MS, and GC-MS techniques for the separation, identification, and quantification of chemical compounds.
4.	interpret proton NMR, carbon-13 NMR, and mass spectra to determine the structures and molecular characteristics of organic compounds.
5.	apply polarography, amperometry, and cyclic voltammetry principles to analyze electrochemical processes and determine the qualitative and quantitative characteristics of chemical species.

Unit 1 UV-Visible and IR Spectroscopy

Introduction; Absorption Laws; Theory of Electronic Spectroscopy; Types of Electronic Transitions; Chromophore concept; Auxochrome; Solvent effect; Instrumentation; Woodward – Fischer rules for calculating absorption maxima in dienes and unsaturated carbonyl compounds; Steric hindrances and co-planarity; Estimation of ligand-metal ratio in complexes; Applications.

Introduction of IR; basic principles of IR; Selection rules, Normal modes of vibrations, finger print region, group frequency region, Instrumentation, Qualitative, Quantitative analysis and Applications

Unit 2 Atomic Absorption and Emission Spectroscopy

Absorption Spectroscopy Introduction and importance; principles and instrumentation; Interferences - Chemical & Spectral Evaluation methods; Applications for qualitative and quantitative analysis.

Emission Spectroscopy: Flame photometry; emission spectroscopy and ICP-OES-Principles and instrumentation; Evaluation methods and applications, Fluorescence and Phosphorescence methods.

Unit 3 Chromatographic Techniques

Gas Chromatography; HPLC, LC-MS & GC-MS: Introduction, basic principle and instrumentation, Comparison of GC and HPLC; Qualitative analysis, Quantitative analysis and Applications.

Unit 4 Nuclear Magnetic Resonance and Mass Spectroscopy

Nuclear magnetic resonance Spectroscopy: Principles of NMR, High resolution NMR – chemical shift, factors affecting the chemical shift, Spin-Spin coupling, Spin-Spin and Spin- lattice relaxation, decoupling, Chemical exchange, structure determination, hydrogen bonding; geometrical isomerism and applications of proton NMR, 13C-NMR spectroscopy principles and advantages.

Mass Spectroscopy: Introduction; basic principles, Instrumentation: ionizing sources, types of ions and applications.

Unit 5 Polarography & Cyclic voltammetry

Polarography: Principles-Polarographic wave, diffusion current, Half wave potential; effect of complex formation on diffusion current, polarographic maxima, qualitative analysis and, Quantitative analysis, Inorganic and Organic applications. Amperometry: Principles, amperometric titrations. Cyclic Voltammetry: Reversible and irreversible process; evaluation of number of electrons in a chemical reaction, application to Diphenyl fulvene.

Prescribed Books:

1. Veera Reddy, K. *Symmetry and Spectroscopy of Molecules*. New Age Publications, New Delhi.
2. Mendham, J., Denney, R. C., Barnes, J. D., and Thomas, M. J. *Vogel's Textbook of Quantitative Chemical Analysis*. 6th Ed., Pearson Education Asia, 2000.

Reference Books:

1. Willard, H. W., Merritt, L. L., and Dean, J. A. *Instrumental Methods of Analysis*. 7th Ed., Affiliated East-West Press, 1988.
2. Skoog, D. A., and West, D. M. *Principles of Instrumental Analysis*. 6th Ed., Cengage Learning, 2007.
3. Seader, J. D., and Henley, E. J. *Separation Process Principles*. 3rd Ed., John Wiley & Sons, 2011.
4. Berg, E. W. *Physical and Chemical Methods of Separation*. McGraw-Hill, 1963.

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Title of the Course : Chemistry & Environment
Course Code : 26CCHE05T
Course offered to : Chemistry
Credits : 4

Course Objectives	
1.	To analyze the principles, objectives, methodologies, and statutory requirements of Environmental Impact Assessment (EIA).
2.	To investigate the sources, characteristics, effects, monitoring, and control methods of air and water pollution.
3.	To evaluate environmental quality monitoring techniques and nanotechnology-based methods for pollutant remediation.
4.	To examine the sources, properties, treatment, recycling, and disposal methods of municipal, industrial, and hazardous wastes.
5.	To assess industrial pollutants and the environmental impacts of industrial activities and major environmental disasters.

Course Outcomes: After completion of the course, students will be able to	
1.	apply EIA methodologies to assess environmental impacts, evaluate alternative strategies, and recommend suitable mitigation measures for developmental projects.
2.	analyze the sources, transport, effects, and control of air and water pollutants using environmental quality standards and monitoring techniques.
3.	apply instrumental techniques and nanotechnology-based remediation methods to monitor environmental quality and remove pollutants from water and soil.
4.	evaluate municipal, industrial, and hazardous waste management practices, including waste minimization, recycling, resource recovery, and safe disposal.
5.	assess the environmental impacts of industrial pollutants and major industrial disasters, and recommend appropriate pollution prevention and solid waste management strategies.

Unit 1 Environmental Impact Assessment

Origin and development of EIA, National environmental policy and statutory requirements of EIA, objectives of EIA, Methodology of EIA; categorization and evaluation criteria; prediction and assessment of impact, interaction between environmental components and impacts. Alternate strategies and mitigation measures, environmental monitoring and audit. Case studies: river projects: oil refineries and petrochemicals etc.

Unit 2 Chemistry of Air Pollution

Sources and diffusion of SO2, CO, NOX smoke, particulates in air. Sampling techniques: analysis of different gases and solid particulates, effect of air Pollution on human health, control techniques, air quality criteria and case study. Levels of air pollution in India. Air pollution standards in India.

Physico Chemical Properties of Ground water & Surface wate Impact assessment of organic/inorganic water pollutants and their management.

Meteorological Fundamentals. Adiabatic process, plume Behaviour, Effects of Meteorological parameters on Transport and Diffusion, Pollutant Concentration variation.

Unit 3 Environmental Quality Monitoring and Pollutant Remediation

Water quality monitoring: Instrumental techniques involved in water quality monitoring – principles, applications, advantages and disadvantages (UV-VIS spectrophotometer, atomic absorption spectrophotometer, turbidimeter, mass spectrometry, chromatography Methods of monitoring of air pollutants, control techniques. Water and soil pollution, Bio-monitoring Introduction of nanotechnology, basics for nanotechnology, methods for the synthesis of nanomaterials, instrumental characterization of nanomaterials. Application of nanotechnology for remediation of pollutants from water. Pollutant removal process: Fenton and advanced Fenton process, photo-catalysis, ozonolysis, and adsorption; adverse impact of nanomaterials on the environment.

Unit 4 Waste Management

Definition-Sources, Type, Compositions, Properties of Waste Municipal Solid Waste, Industrial Waste-Physical, Chemical and Biological Property- Collection – Transfer Stations – Waste Minimization and Recycling; Waste to energy conversion processes Biological, Chemical and Thermo chemical processes, Reduction, reuse and recycling, resources recovery and utilization. Environmental Impacts. Definition & Identification of Hazardous Waste – Sources and Nature of Hazardous Waste – Impact on Environment –Waste Site –Disposal of Hazardous Waste, Underground Storage Tanks Construction, Installation & Closure.

Unit 5 Industrial Solid waste management

Pollutants from Industry: Polymers and Plastics; Sugar and Distillery; Drugs and Pharmaceuticals; Paper and Pulp; Metallurgical industries; Minamata disasters, Bhopal gas disaster.
Solid waste management: Types of solid waste, sources, effects of solid waste, industrial solid waste management, disposal, methods of solid waste managements and recycling.

Prescribed Books:

1. Kudesia, V.P. *Environmental Chemistry*. 6th ed., Pragathi Prakashan, Meerut, 2003.
2. Sodhi, G.S. *Fundamental Concepts of Environmental Chemistry*. 2nd ed., Narosa Publishing House Pvt. Ltd., New Delhi, 2002.

Reference Books:

1. Subramanian, V. *A Text Book in Environmental Science*. Narosa Publishing House Pvt. Ltd., New Delhi, 2002.
2. De, A.K. *Environmental Chemistry*. 5th ed., New Age International Publishers, New Delhi, 2003.
3. Sharma, B.K., and H. Kaur. *Solid Waste Management*. Goel Publishing House, Meerut, 1999.
4. Manahan, Stanley E. *Environmental Chemistry*. 10th ed., CRC Press, 2010.
5. Moore, John W., and Elizabeth A. Moore. *Environmental Chemistry*. Academic Press, 1976.

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Title of the Course : Chemistry of Biological Processes
Course Code : 26CCHE06T
Course offered to : Chemistry
Credits : 4

Course Objectives	
1.	To understand the classification, biological roles, and biosynthesis of natural products, including primary and secondary metabolites.
2.	To apply the principles of total synthesis and stereoselective synthesis of complex natural products and their importance in understanding biological activity.
3.	To analyze the sources, classification, extraction, and structural elucidation of alkaloids such as papaverine, morphine, and codeine.
4.	To describe the classification, isoprene rule, biogenesis, and structural elucidation of terpenoids, including santonin and abietic acid.
5.	To evaluate the structures, biosynthesis, and biological functions of steroids and prostaglandins, including cholesterol, estrogen, testosterone, PGE-1, and PGE-2.

Course Outcomes: After completion of the course, students will be able to	
1.	explain the roles of primary and secondary metabolites and analyze enzyme-catalyzed reactions involved in natural product biosynthesis and their applications.
2.	describe total synthesis and stereoselective strategies used in the synthesis of complex natural products, with reference to Taxol, vancomycin, and erythromycin.
3.	classify alkaloids and apply chemical and spectroscopic principles to explain the structural elucidation of papaverine, morphine, and codeine.
4.	classify terpenoids using the isoprene rule and explain the biogenesis and structural elucidation of santonin and abietic acid.
5.	interpret the structures, biosynthetic pathways, and biological functions of cholesterol, estrogen, testosterone, and prostaglandins, particularly PGE-1 and PGE-2.

Unit 1 Biosynthesis of Natural Products

Introduction to Natural Products, Primary and Secondary Metabolites: Roles in metabolism and ecological functions. Enzyme-Catalyzed Reactions in Natural Product Biosynthesis: Oxidation, reduction, hydrolysis, and condensation reactions. Enzymes involved: Polyketide synthases (PKS), non-ribosomal peptide synthetases (NRPS), terpene synthases, and cytochrome P450s. Applications: Drug discovery, agriculture, and synthetic biology.

Unit 2 Total Synthesis and Structural elucidation of Natural Products

Total Synthesis of Complex Natural Products: Importance of total synthesis in understanding biological activity. Case studies of key natural product syntheses (e.g., Taxol, Vancomycin, and Erythromycin). Stereoselective Synthesis: Strategies for achieving control of chirality in natural product synthesis. Enantioselective reactions, chiral auxiliaries, and chiral catalysts.

Unit 3 Alkaloids

Alkaloids-source and classification, extraction and general methods for determining structure, Structure elucidation of papavarine, morphine and codine.

Unit 4 Terpenoids

Classification, isoprene rule, special isoprene rule and structural elucidation of Santonin and Abatic acids, biogenesis of mono, di and sesqui terpinoids.

Unit 5 Steroids and Prostaglandin

Steroids: Structural determination of Cholesterol, Estrogen and testosterone, biogenesis of cholesterol.

Prostaglandin: Nomenclature, biological effects, biosynthesis, synthesis of prostaglandin, structural elucidation of PGE-1 and E-2 only.

Prescribed Books:

1. Dewick, P. M. Medicinal Natural Products: A Biosynthetic Approach. 3rd Edition, John Wiley & Sons, 2009.
2. Finar, I. L. Organic Chemistry, Volume 2: Stereochemistry and the Chemistry of Natural Products. 5th Edition, Pearson Education.2014.

Reference Books:

1. Nakanishi, K., Goto, T., Ito, S., Natori, S., and Nozoe, S. Natural Products Chemistry, Volumes 1 and 2, Academic Press, 1974.
2. Thomson, R. H. The Chemistry of Natural Products. Springer.
3. Mann, J. Secondary Metabolism. 2nd Edition, Oxford University Press, 1987.
4. Bhat, S. V., Nagasampagi, B. A., and Sivakumar, M. Chemistry of Natural Products. Springer, 2005.

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Title of the Course : Chemistry of Polymers and their Applications
Course Code : 26CCHE07T
Course offered to : Chemistry
Credits : 4

Course Objectives	
1.	To elucidate the fundamental concepts of polymers, polymerization mechanisms, molecular weight averages, and methods for molecular weight determination.
2.	To analyze the preparation, properties, classification, and applications of synthetic polymers, including thermoplastics, thermosetting plastics, fibers, elastomers, and resins.
3.	To investigate the structures, properties, chemical modifications, applications, and degradation mechanisms of natural polymers, modified cellulosics, and biodegradable polymers.
4.	To evaluate the preparation, classification, properties, and applications of hydrogels and polymer networks in drug delivery and controlled-release systems.
5.	To explore advanced polymer characterization techniques, including spectroscopy, X-ray diffraction, thermal analysis, and physical testing methods.

Course Outcomes: After completion of the course, students will be able to	
1.	explain polymer classification, polymerization mechanisms, molecular weight distribution, and apply suitable methods for determining the molecular weight of polymers.
2.	analyze the preparation, properties, and applications of synthetic polymers and distinguish between thermoplastics, thermosetting plastics, fibers, elastomers, and resins.
3.	evaluate the chemical structure, properties, modifications, and degradation behavior of natural polymers, modified cellulosics, and biodegradable polymers.
4.	explain hydrogel formation, polymer network structures, and drug delivery mechanisms, and assess their applications in controlled-release systems.
5.	apply various characterization method to evaluate structural, thermal, and physical properties of polymers

Unit 1 Polymers fundamental concepts

Basic concepts: monomers, degree of polymerization, linear, branched and network polymers, classification of polymers, Polymerization: condensation, addition and copolymerization, Mechanism of free radical, chain, ionic and coordination polymerization. Average molecular weight concepts: number, weight, viscosity average molecular weights, polydispersity and molecular weight distribution.

Measurement of molecular weight: End group, viscosity, light scattering, osmotic and ultracentrifugation methods, analysis and testing of polymers

Unit 2 Synthetic Polymers

Addition and condensation polymerization processes – Bulk, Solution, Suspension and Emulsion polymerization. Preparation and significance, classification of polymers based on physical properties, Thermoplastics, Thermosetting plastics, Fibers and elastomers, General Applications.

Preparation, properties and applications of Polymers based on different types of monomers, Olefin polymers, Diene polymers, nylons, Urea - formaldehyde, phenol - formaldehyde and melanine Epoxy and Ion exchange resins.

Unit 3 Natural Polymers & Modified cellulosics

Natural Polymers: Chemical & Physical structure, properties, source, important chemical modifications, applications of polymers such as cellulose, Chitin, lignin, starch, rosin, shellac, latexes, vegetable oils, gums and proteins.

Modified cellulosics: Cellulose esters and ethers such as Ethyl cellulose, CMC, HPMC, cellulose acetals, Liquid crystalline polymers; speciality plastics- PES, PAES, PEEK, PEAK.

Chemical degradation, physical degradation, ageing, crazing, degradation by microorganisms, Biodegradable polymers, Mechanism of degradation, secondary chain reaction, Self-reaction, depolymerisation, metal catalysed degradation.

Unit 4 Hydrogels of Polymer networks and Drug delivery

Definitions of Hydrogel, polymer networks, Types of polymer networks, Methods involved in hydrogel preparation, Classification, Properties of hydrogels, Introduction to drug to drug delivery systems including, drug development, regulation, absorption and disposition, routes of administration and dosage forms. Advanced drug delivery systems and controlled release. Applications of hydrogels in drug delivery.

Unit 5 Advanced characterization techniques of polymers

Chemical analysis: Introduction, preparation of the sample, Determination of purity. Physical tests. Preliminary examination, burning characteristics. Infrared UV and Raman spectroscopy. Introduction theoretical background. Studies in the physical and chemical nature of polymers. Orientation and crystallinity.

X-ray diffraction analysis – methods of production of X-ray, properties of X-ray. Diffraction of X-rays. Braggs law, lattice and powder diffraction methods. Small angle scattering of X-ray by polymers.

Differential thermal analysis – physical transitions, melting thermo grams. Heat of fusion and degree of crystallinity or isotacticity. Thermo gravimetric analysis: Introduction, instrumentation Determination of kinetic parameters. Method of freeman and Carroll, Methods of involving maximization of rate, method of multiple heating rates.

Prescribed Books:

1. Miller, Bernard. *Advanced Organic Chemistry*. 2nd ed., Prentice Hall, 1998.
2. Gowariker, Vasant R., Viswanathan, N. V., and Sreedhar, Jayadev. *Polymer Chemistry*. Wiley Eastern, 1986.

Reference Books:

1. Glasstone, Samuel, and Laidler, Keith J. *Physical Chemistry*. 3rd ed., Pearson Education, 1951.
2. Fried, J. R. Polymer Science and Technology. 3rd Edition, Prentice Hall, 2014.
3. Billmeyer, F. W. Textbook of Polymer Science. 3rd Edition, John Wiley & Sons, 1984.
4. Sperling, L. H. Introduction to Physical Polymer Science. 4th Edition, John Wiley & Sons, 2005.

ANNAMACHARYA UNIVERSITY
(ESTD UNDER AP PRIVATE UNIVERSITIES (ESTABLISHMENT AND REGULATION) ACT, 2016)
(UNIVERSITY LISTED IN UGC AS PER THE SECTION 2(f) OF THE UGC ACT, 1956)
RAJAMPET, YSR District, AP – 516126, INDIA

Title of the Course : Nanostructured Materials for Clean Energy Systems
Course Code : 26CCHE08T
Course offered to : Chemistry
Credits : 4

Course Objectives	
1.	To comprehend the fundamental principles of electrochemical cells, electrode potentials, electrochemical thermodynamics, electrode kinetics, and energy conversion processes.
2.	To examine the role of nanomaterials in hydrogen production and storage, fuel cells, and other electrochemical energy conversion systems.
3.	To interpret the principles, types, working mechanisms, and applications of nanomaterial-based photovoltaic solar cells and solar-water-splitting systems.
4.	To assess the design, materials, working principles, and performance characteristics of batteries, including lithium-ion and redox-flow batteries.
5.	To investigate the principles, electrode materials, and applications of electrochemical capacitors and supercapacitors for efficient energy storage.

Course Outcomes: After completion of the course, students will be able to	
1.	apply electrochemical principles, Faraday's laws, electrode potentials, and thermodynamic concepts to explain energy conversion processes and electrode reactions.
2.	analyze the design, working principles, and applications of nanomaterials in hydrogen production, hydrogen storage, and fuel cells, including PEMFC, DMFC, and SOFC.
3.	explain photovoltaic energy conversion and evaluate the working principles and performance of organic, dye-sensitized, quantum-dot-sensitized, perovskite, and hybrid solar cells.
4.	evaluate nanostructured electrode materials and their applications in lithium-ion batteries, redox-flow batteries, and other electrochemical energy storage systems.
5.	explain the working principles of electrochemical capacitors and supercapacitors and assess the suitability of carbon-based materials, metal oxides, porous materials, and conducting polymers for energy storage applications.

Unit 1 Fundamental Concepts in Energy Systems

Electrochemical Cell, Faraday's laws, Electrode Potentials, Thermodynamics of electrochemical cells, Polarization losses in electrochemical cells, Electrode process and kinetics, Electrical double layer, Photoelectrochemical cell, thermoelectric effect.

Unit 2 Nanomaterials for Energy Conversion Systems

Issues and Challenges of functional Nanostructured Materials for electrochemical Energy, Conversion Systems, Hydrogen generation & Storage, Fuel Cells, Principles and nanomaterials design for; Proton exchange membrane fuel cells (PEMFC); Direct methanol fuel cells (DMFC); Solid-oxide fuel cells (SOFC), Current status and future trends.

Unit 3 Nanomaterials for Photovoltaic Solar Energy Conversion Systems

Principles of photovoltaic energy conversion (PV), Types of photovoltics Cells, Physics of photovoltaic cells, Organic photovoltaic cell cells, thin film Dye Sensitized Solar Cells, Quntum dot (QD) Sensitized Solar Cells (QD-SSC), Perovskite solar cells, Organic-Inorganic Hybrid Bulk Hetero Junction (BHJ-SC) Solar cells, Solar-water splitting, Current status and future trends

Unit 4 Nanomaterials for Energy Storage (Batteries) Systems

Issues and Challenges of functional Nanostructured Materials for electrochemical Energy Storage Systems, Primary and Secondary Batteries (Lithium ion Batteries), Cathode and anode materials, redox-flow batteries for HEV/EV transportation and stationary applications, Nanostructured Carbon based materials, Nano-Oxides, Novel hybrid electrode materials, Current status and future trends

Unit 5 Nanomaterials for Energy Storage (Capacitor) Systems

Capacitor, Electrochemical supercapacitors, electrical double layer model, Principles and materials design, Nanostructured Carbon based materials, porous materials, Redox capacitor Nano-Oxides, Conducting polymers based materials, Current status and future trends.

Prescribed Books:

1. Levine, Ira N. *Advanced Physical Chemistry.* 6th ed., McGraw-Hill, 2009.
2. Bahl, Arun, and Bahl, B.S., and Tuli, G.D. *Essentials of Physical Chemistry.* 25th ed., S. Chand & Company Ltd., 2021.

Reference Books:

1. Silver, Bruce and Atkins, Peter. *Inorganic Chemistry.* 6th ed., Oxford University Press, 2013.
2. US Department of Energy (EG&G Technical Services and Corporation). *Fuel Cell Handbook.* 7th ed., US Department of Energy, 2004.
3. Tiwari, Arvind, and Shyam, S. *Handbook of Solar Energy and Applications.* 1st ed., Springer, 2016.
4. Jäger, Klaus, et al. *Solar Energy Fundamentals, Technology, and Systems.* 2nd ed., Delft University Press, 2014.