# ANNAMACHARYA UNIVERSITY

EXCELLENCE IN EDUCATION; SERVICE TO SOCIETY

(ESTD UNDER AP PRIVATE UNIVERSITIES (ESTABLISHMENT AND REGULATION) ACT, 2016)

RAJAMPET, Annamayya District, A.P – 516126, INDIA.


## DEPARTMENT OF CHEMISTRY

Course Structure and Syllabi for Pre Ph.D Programme

### SUBJECT – 1

| S.No | Course Code | Title of the Course |
|---|---|---|
| 1 | 24CMGT01T | Research Methodology |

### SUBJECT - 2

| S.No | Course Code | Title of the Course |
|---|---|---|
| 1 | 24CMGT02T | Research and Publication Ethics |

### CORE SUBJECTS
### Choose any Two subjects from the following list

| S.No | Course Code | Title of the Course |
|---|---|---|
| 1 | 24CCHE01T | Inorganic Chemistry |
| 2 | 24CCHE02T | Organic Chemistry |
| 3 | 24CCHE03T | Physical Chemistry |
| 4 | 24CCHE04T | Advanced Instrumental Methods for Chemical Characterization and Analysis |
| 5 | 24CCHE05T | Chemistry & Environment |
| 6 | 24CCHE06T | Chemistry of Biological Processes |
| 7 | 24CCHE07T | Chemistry of Polymers and their Applications |
| 8 | 24CCHE08T | Nanostructured Materials for Clean Energy Systems |

# Inorganic Chemistry(24CCHE01T)

## 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 $\Delta o$ 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.
3. Wulfsberg, G. *Inorganic Chemistry*. University Science Books, 2000.
4. Figgis, B. N. *Introduction to Ligand Fields*. Krieger Pub Co., 1976.
5. Lee, J. D. *Concise Inorganic Chemistry*. 5th Ed., Wiley-Blackwell, 1996.
6. Jolly, W. L. *Modern Inorganic Chemistry*. 2nd Ed., McGraw-Hill, 1991.
7. Kettle, S. F. *Coordination Compounds*. Springer, 1975.

# Organic Chemistry (24CCHE02T)

## 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.
3. Bruice, Paula Yurkanis. *Organic Chemistry*. 4th Ed., Prentice Hall, 2003.
4. Clayden, Jonathan, Nick Greeves, Stuart Warren, and Peter Wothers. *Organic Chemistry*. Oxford University Press, 2001.
5. Wade, Leroy G. Jr., Jan William Simek, and M. S. Singh. *Organic Chemistry*. 9th Ed., Pearson, 2017.
6. Carey, Francis A., and Richard J. Sundberg. *Advanced Organic Chemistry, Part A: Structure and Mechanism*. Springer, 2007.
7. Miller, Bernard. *Advanced Organic Chemistry: Reactions and Mechanisms*. 2nd Ed., Pearson, 1997.
8. Ege, Seyhan N. *Organic Chemistry: Structure and Reactivity*. 3rd Ed., Prentice Hall and Macmillan, 1994.
9. Eliel, Ernest L. *Stereochemistry of Organic Compounds*. John Wiley & Sons, 2008.
10. Juaristi, Eusebio. *Introduction to Stereochemistry and Conformational Analysis*. 1st Ed., Wiley, 1991.
11. Nasipuri, D. *Stereochemistry of Organic Compounds: Principles and Applications*. 4th Ed., New Age International, 2020.
12. Kalsi, P. S. *Stereochemistry, Conformation and Mechanism*. 8th Ed., New Age International, 2015.

# Physical Chemistry (24CCHE03T)

## 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.
3. Levine, Ira N. *Quantum Chemistry*. 6th ed., Prentice Hall, 2009.
4. Chandra, Manas. *Atomic Structure and Chemical Bond*. Tata McGraw Hill, 1974.
5. Laidler, K. J. *Chemical Kinetics*. 3rd ed., McGraw Hill, 1987.
6. Rajaraman, J., and J. Kuriacose. *Kinetics and Mechanism of Chemical Transformations*. Macmillan, 1993.
7. Glasstone, S. *Thermodynamics for Chemists*. D. Van Nostrand Company, 1947.
8. Klotz, I. M. *Chemical Thermodynamics*. 3rd ed., John Wiley & Sons, 1972.
9. Dole, M. *Statistical Thermodynamics*. Prentice Hall, 1954.
10. Bockris, J. O. M., and A. K. N. Reddy. *Modern Electrochemistry*, Vol. I & II. 2nd ed., Plenum Press, 1998.
11. Glasstone, S. *An Introduction to Electrochemistry*. 3rd ed., Affiliated East-West Press, 1965.

# Advanced Instrumental Methods for Chemical Characterization and Analysis (24CCHE04T)

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

# Chemistry & Environment (24CCHE05T)

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

# Chemistry of Biological Processes (24CCHE06T)

**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. Pannerselvam, R. *Production and Operations Management*. 3rd ed., Prentice Hall India Learning Pvt. Ltd, 2012.
2. Savsar, M. *Quality Assurance and Management*. InTech-Croatia, 2012.
3. Montgomery, D. C. *Statistical Quality Control*. 5th ed., John Wiley & Sons, 2005.
4. Starr, M. K. *Production and Operations Management*. Biztantra, 2004.
5. Shah, D. H. *QA Manual*. Business Horizons, 2000.

6. Besterfield, D. H., Besterfield Michna, C., Besterfield, G. H., Besterfield-Sacre, M. *Total Quality Management*. 3rd ed., Pearson Education, Inc., 2003.
7. Konieczka, P., Namiesnik, J. *Quality Assurance and Quality Control in the Analytical Chemical Laboratory: A Practical Approach*. 1st ed., CRC Press, 2009.
8. Hoyle, D. *ISO 9000 Quality Systems Handbook*. 5th ed., Butterworth Heinemann-Elsevier, 2006.
9. Prichard, E., Barwick, V. *Quality Assurance in Analytical Chemistry*. John Wiley & Sons, 2007.

# Chemistry of Polymers and their Applications (24CCHE07T)

## 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.
3. Glasstone, Samuel, and Laidler, Keith J. *Physical Chemistry*. 3rd ed., Pearson Education, 1951.

# Nanostructured Materials for Clean Energy Systems (24CCHE08T)

**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.
3. Silver, Bruce and Atkins, Peter. *Inorganic Chemistry.* 6th ed., Oxford University Press, 2013.

4. US Department of Energy (EG&G Technical Services and Corporation). *Fuel Cell Handbook.* 7th ed., US Department of Energy, 2004.
5. Tiwari, Arvind, and Shyam, S. *Handbook of Solar Energy and Applications.* 1st ed., Springer, 2016.
6. Jäger, Klaus, et al. *Solar Energy Fundamentals, Technology, and Systems.* 2nd ed., Delft University Press, 2014.
7. Klebonoff, Leonard. *Hydrogen Storage.* 1st ed., CRC Press, 2013.