Cooch Behar Panchanan Barma University

Department of Chemistry

NCCF B.Sc. 4th Year Chemistry Syllabus

SEMESTER - VII

Paper Code: Major 13

Paper Name: Research Methodologies in Chemistry and Ethics

Theory (Credit: 4)

Practical (Credit: 2)

Course Objective. This course aims to impart fundamental concepts of methodologies required for carrying out laboratory experiments and research ethics to the students and some practical experiments.

Syllabus:

Theory (Credit: 4)

Research Methodologies:

Module-1: Introduction to basic principles, Widths and Intensities of spectral transitions, LASERS. Microwave Spectroscopy: Classifications of molecules based on moments of inertia, Rotational spectra, Rigid and nonrigid rotor model, Selection rules, Spectral intensity, degeneracy and relative population of energy levels, Isotopic substitution. Symmetric top molecules. (20 Lectures)

Module-2: ^{1}H NMR. Principle, instrumentation and different techniques (CW & FT) of NMR spectroscopy, factors influencing chemical shift, spin-spin interactions, coupling constant (J), spin decoupling, spin tickling, classification of ABX, AMX, ABC, A2B2 in proton NMR. 13C-NMR, DEPT. (20 Lectures)

Module-3: Powder XRD analysis. (10 Lectures)

Module-4: **Research Ethics:** Philosophy and Ethics, Scientific Conduct, Publication Ethics, Open Access Publishing, Publication Misconduct, Databases and Research Metrics. (10 Lectures)

Practical:(Credit: 2) (60 Hours)

Isolation of Natural products (Any three):

1. Extraction of curcumin from turmeric.

2. Extraction of caffeine from tea/coffe.

3. Extraction of cinnamaldehyde from cinnamom

4. Extraction of Eugenol from clove

5. Extraction of Lycopene from tomatoes

One stage preparation and Recrystallisation (any Ten):

1. Benzilic acid rearrangement: Benzilic acid from benzil

2. Sandmeyer reaction: p-Nitroiodobenzene from p-nitroaniline

3. Heterocyclic compound: 7-Hydroxy-4-methylcoumarin from resorcinol

4. Acetylation: Mannitol hexaacetate from mannitol Acetanilide from Aniline. Glucose pentacetate from glucose

5. Claisen-Schmidt reaction Dibenzalacetone from benzaldehyde

6. Oxidation: Fluorenone from fluorine Benzoic acid from Benzaldehyde

7. Acetylation: Acetylferrocene from ferrocene

8. Hydrolysis: Benzoic acid from Benzamide.

9. Bromination: p-Bromoacetanilide from Acetanilide.

10. Nitration: m-dinitrobenzene from Nitrobenzene. p-nitroacetanilide from acetanilide

11. Benzoylation: Benzanilide from Aniline.

Suggested Text Books:

1. Fundamentals of Molecular Spectroscopy -- C. N. Banwell
2. Introduction to Molecular spectroscopy -- G M Barrow
3. Organic Spectroscopy-- Dyer & Silverstein
4. Fundamentals of photochemistry: K. K. Rohatgi-Mukherjee
5. An Introduction to X-ray Crystallography – M.M. Wolfson
6. X-ray Diffraction Methods – M.J. Buerger

Paper Code: Major 14 (Elective related to major Discipline)

Paper Name: Advanced Materials
Credit: 6 (Theory: 4, Practical: 2)

Course Objective. This course aims to introduce the fundamentals, properties, processing, and applications of advanced materials including polymers, composites, electronic, optical, magnetic, biomaterials, and smart materials. It helps students understand the relationship between material structure and performance, with emphasis on modern technological, industrial, energy, and sustainable applications.

Syllabus:

Module 1: Fundamentals of Materials Science. Scope and importance of materials chemistry, Relationship between structure, properties, processing, and applications, Historical development of advanced materials, Classification of engineering and functional materials, Modern applications of advanced materials in technology and industry.
(08 Lectures)

Module 2: Polymer and Composite Materials. Fundamentals of polymer chemistry, classification of polymers, molecular weight, degree of polymerization, and stereochemistry of polymers. Polymerization techniques such as addition polymerization, condensation polymerization, free radical polymerization, ionic polymerization, and copolymerization. Thermoplastic and thermosetting polymers, elastomers, fibers, engineering plastics, biodegradable polymers, conducting polymers, hydrogels, and smart polymers. Applications of polymeric and composite materials in aerospace, automotive, packaging, biomedical, and electronic industries.
(20 Lectures)

Module 3: Electronic, Optical and Magnetic Materials. Conductors, semiconductors, and insulators, including their electronic structures, conductivity, and applications. Intrinsic and extrinsic semiconductors, p-type and n-type semiconductors, doping processes, and semiconductor devices. The band theory of solids, valence and conduction bands, Fermi level, and band gap concepts. Optical fibers, laser materials, photonic materials, luminescent materials, fluorescence, phosphorescence, and photochromic materials along with their applications in communication and display technologies. Diamagnetic, paramagnetic, ferromagnetic, ferrimagnetic, and antiferromagnetic materials, ferrites, magnetic storage materials, and industrial applications of magnetic materials in data storage and sensor technologies. (20 Lectures)

Module 4: Biomaterials and Smart materials. Lithium-ion batteries, sodium-ion batteries, solid-state batteries, fuel cells, hydrogen storage materials, electrode materials, electrolytes, and supercapacitors with emphasis on energy conversion and storage technologies. Sustainable and green materials such as biodegradable plastics, recyclable materials, environmentally friendly synthesis methods, and waste-to-material technologies. Shape memory polymers, piezoelectric materials, thermoelectric materials, self-healing materials, sensors, and actuators used in modern engineering applications.
(12 Lectures)

Practical: (60 Hours)
1. Synthesis and conductivity study of conducting polymers.
2. Synthesis of hydrogel materials and swelling studies.

References

- Material science and Engineering, W D Callister, Wiley.
- Principles of Polymer Science, Bahadur P and N.V Shastry, Narosa, New Delhi, 2000.
- *Electronic, Magnetic, and Optical Materials* by Pradeep Fulay and Jung-Kun Lee (2nd Edition, CRC Press).

Paper Code: Major 14 (Elective related to major Discipline)

Paper Name: Biological Chemistry

Credit: 6 (Theory: 4, Practical: 2)

Course Objective. The course aims to introduce students to the chemical principles underlying biological systems and processes. It provides an interdisciplinary understanding of biomolecules, biological reactions, bioenergetics, metal ions in biological systems, and the physicochemical basis of life processes. The course integrates concepts of bio-organic chemistry, biophysical chemistry, and bioinorganic chemistry with practical laboratory techniques relevant to modern biological and chemical sciences. Students will develop a strong foundation in the chemistry of living organisms and its applications in medicine, biotechnology, environmental science, and industry.

Syllabus:

Module 1: Bioorganic Chemistry and Biomolecules. Classification, structure, stereochemistry, properties, and biological significance of carbohydrates, amino acids, proteins, lipids, nucleic acids, vitamins, and hormones. Denaturation, and biological functions of proteins. The chemistry of lipids includes fatty acids, triglycerides, phospholipids, glycolipids, steroids, and biological membranes. Nucleic acids include nucleotides, DNA and RNA structures, Watson–Crick base pairing, replication, and the role of nucleic acids in heredity and protein synthesis. Classification of enzymes, mechanism of enzyme action, enzyme specificity, coenzymes, cofactors, and enzyme inhibition.
(15 Lectures)

Module 2: Biophysical Chemistry. Thermodynamics of biological processes, free energy changes, entropy, enthalpy, and Gibbs free energy in living organisms. Acid-base balance in biological systems, buffer action, osmotic pressure, membrane transport, diffusion, dialysis, and colligative properties relevant to physiology. Biophysical techniques such as UV-visible spectroscopy, fluorescence spectroscopy, circular dichroism, centrifugation, electrophoresis, and chromatography used for the analysis of biological molecules. Protein folding, intermolecular interactions, hydrogen bonding, hydrophobic interactions, and molecular recognition.
(15 Lectures)

Module 3. Bioinorganic Chemistry and Biological Processes. Bioinorganic aspects of sodium, potassium, calcium, magnesium, iron, copper, zinc, cobalt, and manganese, their role in enzymes and metabolic processes. Metalloproteins such as hemoglobin, myoglobin, cytochromes, ferritin, chlorophyll; oxygen transport and electron transfer reactions. The chemistry of coordination compounds in biology, chelation therapy, metal ion homeostasis, and bioinorganic medicinal chemistry. Inorganic drugs, cisplatin and metal-based anticancer agents, and metal toxicity.
(18 Lectures)

Module 4. Applied Biological Chemistry. DNA replication, transcription, translation, mutation, genetic code, regulation of gene expression, recombinant DNA technology, polymerase chain reaction (PCR), and basic biotechnology. Concept of clinical biochemistry, blood chemistry, diagnostic enzymes, immunochemistry, antibiotics, ELISA, antibody-drug conjugates. (12 Lectures)

Practical: (60 Hours)

1. Estimation of glucose by colorimetric method.
2. Estimation of protein concentration using Bradford assay.
3. Gel- Electrophoretic separation of proteins.

References.

- Lehninger Principles of Biochemistry – David L. Nelson and Michael M. Cox.
- Biophysical Chemistry – Upadhyay, Upadhyay and Nath.
- Principles of Bioinorganic Chemistry – Stephen J. Lippard and Jeremy M. Berg.

Paper Code: Major 15 (Paper related to major discipline)

Paper Name: Advanced Organic Chemistry (Credit 4)

Seminar: (Credit 2)

Course Objective. This course aims to impart knowledge on (i) different oxidative and reductive process, (ii) Nucleophilic and electrophilic aromatic substitution, (iii) Selective name reactions and reagents, and (iv) multicomponent reaction and click chemistry

Syllabus:

Module 1: Oxidative processes and Reductive processes (25 Lectures)

Oxidation of functional groups:

Synthetic applications of the following reagents in the oxidation of functional groups like alkenes, alkynes, alcohols, aldehydes and ketones: 1) Oxidations by using DMSO involving alkoxy sulphonium salts (Kornblum oxidation), DCC-DMSO (Pfitzner-Muffat reagent),Swern oxidation, Corey-Kim oxidation, Albright-Goldman oxidation 2) Oxidations by using IBX, DMP, TEMPO, 3)Oxidation by using DDQ 4)$Pb(OAC)_4$ 5) HIO_4 6)SeO_2 7) CrO3(Sodium or potassium dichromate in H_2SO_4, Collins reagent, Jones reagent, Etard reagent, CrO_3 in acetic anhydride, PCC (Coreys reagent), PDC, (Babler oxidation), 8) MnO_2 9) $KMnO_4$ 10) OsO_4 11) CAN 12)TPAP, 13) Baeyer-villiger oxidation and prilizheav epoxidation 14) Oxidation of alkenes using Woodward and Prevost reagents 15) Thallium nitrate 16) Oxidative coupling of phenols and alkynes 17) Oxidations with ruthenium tetraoxide.

Reduction of functional groups:
(1) Catalytic reductions: Homogeneous (Wilkinsons Catalytic reduction) and heterogeneous catalytic reductions and their synthetic applications. (2) Reductions by using electrophilic nucleophilic metal hydrides: $LiAlH_4$ (Various examples of reductions and cram's ruule), related reagents of LAH, $NaBH_4$, $NaBH_3CN$, Trialkyl Borohydrides (Super Hydride and Selectride). (3) Reductions by using electrophilic metal hydrides: BH_3, DIBAL (4) Reductions by dissolving metals: Clemmenson reduction, Acyloin condensation, Bouveault-Blanc reduction, Birch reduction (Various examples should be discussed). (5) Reductions by using Diimide and Wolf-Kishner Reduction and Huang-Minlon modification (6) Hydrogenolysis (7) Reductions by using tri n-butyl tin hydride.

Module-2: Nucleophilic and Electrophilic Aromatic substitution: (12 Lectures)
Aromatic Nucleophilic substitution: SN_1(Ar), SN_2 (Ar), and benzyne mechanisms; evidence for the structure of benzyne. Von Richter rearrangement. Definition and types of ambident nucleophiles. The arenium ion mechanism, orientation and reactivity, energy profile diagrams. The ortho/para ratio, ipso attack, orientation in other ring systems. Quantitative treatment of reactivity in substrates and electrophiles. Diazonium coupling, Vilsmeir reaction, Gattermann-Koch reaction.

Module-3: Selective Name Reactions and Reagents in organic synthesis: (15 Lectures)
Use of following reagents in organic synthesis and functional group transformations – complex metal hydrides, Gilman's reagent, lithium dimethyl cuprate, LDA, DCC, Merrifield resin, Peterson's synthesis, Lawesson's reagent, Wilkinson's catalyst, Baker yeast., hypervalent organoiodines

(introduction) and reagents of non-transition metals – Zn, Cd, Sm and In, Organopalladium chemistry: Sujuki reaction, Sonogashira reaction, Heck reaction, Alkene metathesis reaction. Barton, Baylis Hillman reaction, Chichibabin Reaction, Darzens reaction, Dieckman condensations, Henry reaction, Knovengeal reaction, Mannich, McMurry, Perkin, Peterson olefination, Robinson Annulation. Stobbe, Stork enamine reaction and selective mono and dialkylation via enamines, Mitsonobu Reaction.

Module-4: Multi-component reactions and click chemistry: (8 Lectures)
Biginelli, Strecker synthesis, Hantszch pyridine synthesis, Multicomponent reactions using alkyl isocyanides: Passerini and Ugi-4-componentsynthesis. Click chemistry: criterion for click reaction, Sharpless azides cycloadditions, Domino/cascade reactions.

Seminar: 2 Credit

Students will have to attend and participate Six College/University/Research Institute level Seminar (out of which one must be from home college and at least four must be from outside of home college) during the academic session and attendance certificates are to be submitted. Also, the students will have to deliver a power-point seminar presentation in the respective department and a Seminar Presentation Report is to be submitted. Every student will have to remain present at seminar presentation of all other students of the same batch and their attendance are to be recorded. (60 Hours)

Suggested Text Books:

1. Adam Jacobs, Understanding organic reaction mechanism. Cambridge University press (1997)
2. F.A. Carey and R. J. Sundberg (Part A and B) Kluwer Academic / Plenum Publishers (2000)
3. E,L.Eliel, Stereochemistry of carbon compounds. John Wiley (1997)
4. Modern Organic Synthesis-an introduction by George S.Zweifel and Michael H. Nantz, W.H. Freeman & company, New York
5. Some Modern Methods of Organic Synthesis W. Carothers, Third Edition, Cambridge University Press, Cambridge, 1988.
6. Advanced Organic Synthesis, Part B-Reactions and Synthesis, Francis A. Carey and Richard J. Sudenburg, Fourt edition, Kluwer academic publishers, New York.
7. Photochemistry and Pericyclic Reactions by Jagdamba Singh
8. Organic Reactions and Orbital Symmetry by Gilchrist and Storr

Paper Code: Major 16 (Paper related to major discipline)

Paper Name: Advanced Inorganic Chemistry

Credit: 6 (Theory: 4, Practical: 2)

Course Objective. This course aims to impart knowledge on (i) Coordination Chemistry (ii) Structure & Bonding of Inorganic molecule (iii) Reaction Mechanism-I and (iv) Cluster.

Syllabus:

Module-1: Coordination Chemistry: Adjusted CFT, Effect of crystal field stabilization on ionic radii, lattice energy, hydration enthalpy and stabilization of complexes (Irving Williams order). Site preference in mixed metal oxides (Spinel and inverse spinel structures). Tetrahedral distortion and Jahn Teller effect, Static and Dynamic Jahn-Teller effect. Microstates, Russell-sander's terms, energy ordering of terms and Racah parameters, interelectronic repulsion parameters in complex ion terms-vs-free ion terms, hole formalism, determination of ground and excited state terms of d^n ions, spin-orbit coupling, effect of crystal field on Russell- Sander's terms, concept of correlation diagram. Orgel diagrams (qualitative approach), Tanabe-Sugano diagrams (26 Lectures)

Module-2: Structure & Bonding of Inorganic molecule: Bonding in homonuclear and heteronuclear diatomic molecules of 2nd period. Bonding in triatomic (H_3^+, BeH_2, H_2O), tetra-atomic (BH_3, NH_3) and CH_4. MO diagrams, Walsh diagrams. Models of structure prediction. (10 lectures)

Module-3: Reaction Mechanism-I: Inert and labile complexes, consideration of octahedral substitution reactions in the light of VBT and CFT. Mechanism of substitution reactions, Classification of reactions of complex compounds, energy profile diagram of ligand substitution reactions- associative (A), dissociative (D), interchange (I) etc. type pathways, relation between intimate and stoichiometric mechanisms of ligand substitution. (12 lectures)

Module-4: Cluster: Higher boranes, carboranes, metalloboranes and metallocarboranes. Metal carbonyls and halide clusters, compounds with metal-metal multiple bonds, (12 lectures)

Practical: (60 Hours)

Inorganic qualitative analysis: Less common metals – Be, Mo, W, Ti, Zr, Th, V, U, Ce and all the radicals included in the 6th Semester Chemistry syllabus.

Suggested Text Books:

1. Ligand field theory and its application by B. N. Figgis
2. Inorganic chemistry: Principle of Structure and Reactivity by J. E. Huheey, E. A. Keiter, R. L. Keiter, O. K. Medhi.
3. Inorganic Chemistry, 4th edition by C. E. Housecroft, A. G. Sharpe
4. Inorganic Chemistry by Shriver and Atkins

5. Inorganic Chemistry, Vol.- 5 by A. K. Das, M. Das
6. Elements of magnetochemistry by R. L. Dutta, A. Shyamal
7. Chemistry of elements by N. N. Greenwood and A. Earnshaw
8. Inorganic Chemistry: Principles, D. Banerjea
9. Hand book of Inorganic analysis, G. N. Mukherjee
10. Vogel's Quantitative Inorganic analysis, G. Svehla& B. Shivasankar

SEMESTER - VIII

Paper Code: Major 17

Paper Name: Advanced Quantum Chemistry and Advanced Electrochemistry

Credit: 6

Course Objective. The course is designed to provide the students a comprehensive understanding on theoretical aspects of chemistry at a more advanced level than they have learnt in their previous classes. Variational and perturbation methods will help them interpret experimentally observed atomic data, electronic spin and antisymmetry principle will provide an understanding of the electronic structure of atomic and molecular systems, molecular symmetry and group theoretical knowledge will help in solving molecular structure and spectral data interpretation. Knowledge on advanced electrochemistry will help in overcoming the practical problems that arises in setting up of electrochemical experiment and in interpreting experimental observations.

Syllabus:

Module-1: Advanced Quantum Chemistry: The variational method, Eckart's theorem, Linear variational method, Perturbation theory (time independent), Application of variational method and nondegenerate perturbation theory to the helium atom problem. Electron spin, Antisymmetry principle, Spectroscopic term symbols, Spin-orbit coupling. (28 Lectures)

Module-2: Molecular Symmetry and Group theory: Symmetry elements and symmetry operations, Group theory: definitions and theories, multiple symmetry operations, multiplication table, molecular point groups, Simple ideas of representation and character table, direct product. (17 Lectures)

Module-3: Advanced Electrochemistry: Ion-association, Formation of ion-pairs, triplets etc; Ion-solvent interactions, The Born model, structural treatment of ion-solvent interactions, ion-quadruple theory of solvation, The solvation number, Debye- Hückel theory, Debye-Hückel-Onsagar theory. (15 Lectures)

Practical: (60 Hours)

1. Studies on alkali hydrolysis of ethyl acetate conductometrically.
2. Determination of pK_1 and pK_2 of phosphoric acid potentiometrically.
3. Ternary phase diagram of $H_2O/C_6H_6/CH_3COOH$.
4. Potentiometric estimation of Fe (II) using $K_2Cr_2O_7$.

Suggested Text Books:

1. Chemical Applications of Group Theory by F. A. Cotton.
2. Quantum Chemistry by A B Sannigrahi
3. Quantum Chemistry by Donald A McQuarrie
4. Quantum Chemistry by Ira N Levine
5. Physical methods in inorganic chemistry: R. S. Drago
6. Fundamental concepts of inorganic chemistry, vol - 7, A. D. De
7. Fundamentals of Molecular Spectroscopy: C. N. Banwell

Paper Code: Major 18 (Elective related to major Discipline)
Paper Name: Quantitative Analysis
Credit: 6 (Theory: 4, Practical: 2)

Course Objectives. The course aims to provide students with a comprehensive understanding of quantitative chemical analysis and its applications in chemical, environmental, pharmaceutical, and industrial sciences. It introduces the principles and techniques of volumetric, gravimetric, instrumental, and statistical methods of analysis, along with laboratory skills required for accurate chemical measurements and data interpretation.

Syllabus

Module 1: Volumetric Analysis and Titrimetric Methods. Concepts of accuracy, precision, significant figures, analytical errors, calibration of glassware, preparation and standardization of solutions, and the use of primary and secondary standards. Acid-base titrations include strong acid–strong base, weak acid–strong base, strong acid–weak base, and polybasic acid titrations, theory of indicators, neutralization curves, buffer solutions, and selection of suitable indicators. Redox titrations include potassium permanganate, potassium dichromate, iodometric, and iodimetric titrations with emphasis on oxidation-reduction reactions and equivalent weight calculations. Complexometric titrations using EDTA include stability constants, metal ion indicators, masking and demasking agents, and determination of hardness of water. Applications of titrimetric methods in pharmaceutical, industrial, food, and environmental analysis. (15 Lectures)

Module 2. Gravimetric and Electroanalytical Methods. Gravimetric analysis, precipitation methods, digestion, filtration, washing, drying, ignition, and weighing techniques. Factors affecting precipitation, co-precipitation, post-precipitation, and purity of precipitates. Gravimetric estimations of sulfate, chloride, nickel, copper, and barium. Electroanalytical methods - conductometry, potentiometry, pHmetry, and electrogravimetry. Electrochemical cells, electrodes, Nernst equation, potentiometric titrations, conductometric titrations, and applications of electroanalytical methods in water analysis and industrial chemistry. (15 Lectures)

Module 3: Advanced Instrumental Methods of Quantitative Analysis. The principles, instrumentation, operation, and applications of High-Performance Liquid Chromatography (HPLC), Gas Chromatography (GC), and Mass Spectrometry (MS). High Performance Liquid Chromatography includes types of chromatography, mobile and stationary phases, normal phase and reverse phase HPLC, column efficiency, detectors, sample injection systems, gradient elution, and quantitative applications in pharmaceutical, biochemical, food, and environmental analysis. Gas Chromatography includes carrier gases, columns, injectors, detectors such as flame ionization detectors (FID) and thermal conductivity detectors (TCD), retention time, qualitative and quantitative analysis of volatile compounds, and applications in petrochemical, forensic, and environmental analysis. Mass spectrometry includes ionization methods, mass analyzers, molecular ion peaks, fragmentation patterns, interpretation of mass spectra, and applications in molecular weight determination, structural elucidation, proteomics, pharmaceutical analysis, and metabolomics. (20 Lectures)

Module 4: Environmental and Applied Quantitative Analysis. Environmental analysis of water hardness, dissolved oxygen, alkalinity, chloride, sulfate, nitrate, and chemical oxygen demand (COD). Quantitative analysis in food products, fertilizers, ores, and biological samples. (10 Lectures)

Practical: (60 Hours)
1. Estimation of hardness of water by EDTA method.
2. Determination of chemical oxygen demand (COD) of water.
3. Estimation of KHP percentage from a mixture.
4. Estimation of chloride from a mixture.

References.

- Quantitative Chemical Analysis – Daniel C. Harris.
- Instrumental Methods of Chemical Analysis – Gurdeep R. Chatwal and Sham K. Anand.
- Vogel's Textbook of Quantitative Chemical Analysis – G.H. Jeffery, J. Bassett, J. Mendham and R.C. Denney.
- Fundamentals of Analytical Chemistry – Douglas A. Skoog, Donald M. West and F.J. Holler.

Paper Code: Major 18 (Elective related to major Discipline)
Paper Name: Introduction to Nanotechnology
Credit: 6 (Theory: 4, Practical: 2)

Course Objectives. The course aims to introduce students to the fundamental concepts, synthesis, characterization, properties, and applications of nanomaterials and nanotechnology. It provides an interdisciplinary understanding of nanoscale science with emphasis on chemical principles, size-dependent properties, modern analytical techniques, and applications in medicine, energy, electronics, catalysis, and environmental science.

Syllabus

Module 1: Fundamentals of Nanoscience and Nanomaterials. Historical development of nanotechnology, nanoscale dimensions, classification of nanomaterials, and unique properties of materials at the nanoscale. Zero-dimensional, one-dimensional, two-dimensional, and three-dimensional nanostructures with examples such as nanoparticles, nanowires, nanotubes, quantum dots, and thin films. Surface area to volume ratio, quantum confinement effect, surface energy, and size-dependent optical, electrical, thermal, magnetic, and catalytic properties of nanomaterials. Carbon nanostructures such as fullerenes, carbon nanotubes, graphene, and nanodiamonds with emphasis on their structure and applications. (15 Lectures)

Module 2: Synthesis and Fabrication of Nanomaterials. Top-down and bottom-up approaches to nanomaterial synthesis. Top-down methods include mechanical milling, lithography, laser ablation, and sputtering techniques. Bottom-up methods include sol-gel synthesis, chemical reduction, hydrothermal synthesis, chemical vapor deposition (CVD), electrochemical deposition, precipitation methods, and self-assembly techniques. Green synthesis of nanoparticles using biological and environmentally friendly methods. Stabilization of nanoparticles, surfactants, capping agents, and factors affecting particle size and morphology. (15 Lectures)

Module 3: Characterization Techniques in Nanotechnology. Principles, instrumentation, and applications of X-ray diffraction (XRD), scanning electron microscopy (SEM), transmission electron microscopy (TEM), atomic force microscopy (AFM), scanning tunneling microscopy (STM), dynamic light scattering (DLS), UV-visible spectroscopy, Fourier transform infrared spectroscopy (FTIR), fluorescence spectroscopy, and Raman spectroscopy. Particle size analysis, morphology, crystal structure determination, surface analysis, and optical characterization of nanomaterials.
(15 Lectures)

Module 4. Applications and Impacts of Nanotechnology. Applications of nanomaterials in medicine, drug delivery, cancer therapy, biosensors, diagnostics, and tissue engineering. Environmental applications include water purification, air purification, photocatalysis, and nanomaterials for pollution control. Nanotechnology in food science, cosmetics, textiles, and agriculture. Ethical, environmental, and health aspects of nanotechnology, nanotoxicology, and safety regulations.
(15 Lectures)

Practical: (60 Hours)
1. Synthesis of Silica nanoparticles and characterization using DLS.
2. Study of surface plasmon resonance in nanoparticles.

References

- Introduction to Nanotechnology – Charles P. Poole Jr. and Frank J. Owens.
- C.N.R. Rao, A. Muller and A.K. Cheetham, The Chemistry of nanomaterials: Synthesis, Properties and Applications, Vol-I
- Nanomaterials – A.K. Bandyopadhyay.

Paper Code: Major 19 (Paper related to major discipline)

Paper Name: Advanced Spectroscopy and Instrumentation

Credit: 6 (Theory: 4, Practical: 2)

Course Objective. The course aims to introduce fundamental concepts of various types of spectroscopic methods applied for analysis of chemical samples and techniques for sample preparations and handling of different instruments. After learning the objectives of this course the students will be able to prepare their samples and take spectroscopic and other instrumental readings.

Syllabus:

Module-1: Mass Spectroscopy: Introduction, Mass spectral fragmentation of organic compounds, common functional groups, molecular ion peak, metastable peak, McLafferty rearrangement. Nitrogen rule, example of Mass fragmentation of organic compounds with respect to their structure determination. Problems based on spectroscopic techniques. High resolution mass spectrometry – ESIMS and MALDI-TOF. Examples of mass spectral fragmentation of organic compounds. 19F-NMR and 31P- NMR spectroscopy: Principles and applications. (15 Lectures)

Module-2: 13C NMR spectroscopy; DEPT, CD, ORD; ESR, Mössbaur & EXAFS. (12 Lectures)

Module-3: Principles of fluorescence spectra, Jabonlanski diagram, mirror image` rule, intersystem crossing, selection of exciting wavelength, quantum yield, effect of temperature, solvent polarity and viscosity, quenching of fluorescence, inner-filter effect, fluorescence of biomolecules. (9 Lectures)

Module 4. Instrumentation Techniques **(**24 Lectures)

Working Principle, Sample Preparation Methods, and Data Analysis for the following analytical and characterization techniques:

(a) Spectroscopic and Structural Characterization Techniques -UV–Visible (UV–Vis) Spectrophotometry, Fourier Transform Infrared Spectroscopy (FT–IR), including Attenuated Total Reflectance (ATR) mode, X-ray Diffraction (XRD)

(b) Microscopy and Surface Characterization Techniques - Transmission Electron Microscopy (TEM), Scanning Electron Microscopy (SEM), Atomic Force Microscopy (AFM)

(c) Electrochemical and Thermal Analysis Techniques- Cyclic Voltammetry (CV), Differential Pulse Voltammetry (DPV), Linear Sweep Voltammetry (LSV), Thermogravimetric Analysis (TGA), Differential Scanning Calorimetry (DSC), Dynamic Light Scattering (DLS) and Zeta Potential Analysis

(d) Separation and Mass Analysis Techniques- High-Performance Liquid Chromatography (HPLC), Gas Chromatography (GC), Mass Spectrometry (MS)

Practical: (60 Hours)

1.Taking IR Spectra of the following organic and inorganic compounds and band assignment.

[Curcumin, caffeine of tea/coffee, cinnamaldehyde, Eugenol, Lycopene. Cobalt acetylacetonate, cis and trans [Co(en)2Cl2], Co(salen), $Cu(acac)_2.H_2O$].

2. Spectral Data analysis of UV, IR and NMR and structure determination of unknown compounds.

References:

1. Quantitative Chemical Analysis – Daniel C. Harris.
2. Fundamentals of Analytical Chemistry – Douglas A. Skoog, Donald M. West and F.J. Holler.
3. Fundamentals of Photochemistry – K.K. Rohatgi-Mukherjee
4. Spectrometric Identification of Organic Compounds, 8th Ed., John Wiley & Sons Inc. (2014)- Silverstein, R. M.

NOTE: Students HAVING HONOURS WITH RESEARCH will have to UNDERTAKE RESEARCH WORK FOR MAJOR-16 (7th Semester) and MAJOR-19 (8th Semester) instead of Syllabus mentioned here for the respective Major Courses.

SEMESTER – VII and VIII

Minor -5/6

Chemistry

General Chemistry -III

Credit 06 (Theory 04, Practical 02)

Course Overview: This course aim to provide knowledge about different aspects of biological chemistry including bioinorganic and biochemistry. It also helps to understand preliminary knowledge about spectroscopic methods and separation techniques used in various industry.

Course Outcomes. Students from various backgrounds can learn the chemistry of biological systems and know several techniques for separation methods. This learning would be helpful in their respective fields.

Part A: Inorganic Chemistry	**20 Lectures**

Coordination Chemistry: Werner's theory, IUPAC nomenclature of coordination compounds, isomerism in coordination compounds. Stereochemistry of complexes with 4 and 6 coordination numbers. valence bond theory (inner and outer orbital complexes), electroneutrality principle and back bonding. Crystal field theory, measurement of 10 Dq (Δo), CFSE in weak and strong fields, pairing energies, factors affecting the magnitude of 10 Dq (Δo, Δt).

Bioinorganic Chemistry: Elements of life: essential, major, trace and ultra-trace elements. Basic chemical reactions in the biological systems and the role of metal ions (specially Na^{+}, K^{+}, Mg^{2+}, Ca^{2+}, $Fe^{3+/2+}$, $Cu^{2+/+}$, and Zn^{2+}). Ionophores, Sodium potassium pump. Biological functions of hemoglobin and myoglobin, cytochromes and ferredoxins, carboxypeptidase, carbonic anhydrase. Biological nitrogen fixation, Photosynthesis: Photo system-I and Photosystem-II. Toxic metal ions and their effects, chelation therapy, Pt and Au complexes as drugs (examples only), metal dependent diseases.

Part B: Organic Chemistry	**20 Lectures**

Nucleic acid: Components of nucleic acids, Nucleosides and nucleotides; Structure and nomenclature of: Adenine, Guanine, Cytosine, Uracil and Thymine; Structure of polynucleotides.

Amino acids, Peptides, Proteins: Amino acids, Classifications of amino acids and their structure, Zwitterion, Isoelectric point and Electrophoresis. Reactions of amino acids: esterification, of $–CO_2H$, acetylation of $–NH_2$, complexation, ninhydrin test. Overview of primary, secondary, tertiary and quaternary structures of proteins, Determination of primary structure of peptides by degradation – Edman degradation (N-terminal), with thiohydantoin and carboxypeptidase enzyme (C-terminal).

Carbohydrates: Monosaccharides – Constitution and absolute configuration of glucose and fructose, epimers and anomers, mutarotation, Interconversions of aldoses and ketoses, Kiliani- Fischer synthesis, Oxidation and Reduction.

Part C: Physical & Analytical Chemistry	**20 Lectures**

Spectroscopy: Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules, validity of Beer-Lambert's law. UV-Visible Spectrometry: Basic principles of instrumentation (choice of source, monochromator and detector) for single and double beam instrument. Determination of composition of metal complexes using Job's method of continuous variation and mole ratio method.

Solvent Extraction and Separation techniques: Classification, principle and efficiency of the technique. Mechanism of separation: adsorption, partition & ion exchange. Development of chromatograms: frontal, elution and displacement methods. Affinity Chromatography, Paper Chromatography, Thin-layer Chromatography, Column Chromatography.

Practical 30 Lectures

1. Preparation of Mohr's salt.
2. Preparation of urea formaldehyde resin.
3. Verification of Beer-Lambert's law using $KMnO_4$ solution**.**
4. Separation of two amino acids using Paper Chromatography and calculation of R_f value.

Suggested Textbooks

1. Nelson, D.L., Cox, M.M. and Lehninger, A.L. (2009) Principles of Biochemistry. IV Edition. W.H. Freeman and Co.
2. Barrow, G. M. *Physical Chemistry,* Tata McGraw-Hill (2007).
3. R. L. Dutta & G.S. De, Inorganic Chemistry (Vol. 1), The New Book Stall, 1973.
4. Quantitative Chemical Analysis, Daniel C Harris: 10th Edition, W H Freeman and Company.

Reference Books for Practical

1. Vogel, A.I. A text book of Quantitative Analysis, ELBS 1986.
2. Practical Analytical Chemistry, Dr. G Devala Rao, 2010, Birla Publications P Limited.
3. An Advanced Course in Practical Chemistry, Nad, Mahapatra & Ghosal, New Central Book Agency (P) Limited, 2014.
4. Manual of Biochemistry Workshop, 2012, Department of Chemistry, University of Delhi.