DEPARTMENT OF CHEMISTRY
JAHANGIRNAGAR UNIVERSITY
SAVAR, DHAKA-1342

Curriculum/Syllabus for MS in Chemistry

SESSION: 2017-2018, 2018-2019, 2019-2020, 2020-2021

Course of study for a Master of Science (MS) degree in Chemistry shall have a duration of one academic year. The students willing to study MS courses can be enrolled either in Thesis group or in General. A candidate for MS degree in Chemistry will have to take up courses in Physical, Inorganic and Organic branches. Students of both the groups, General as well as the Thesis will have to take four 100 marks (1 unit) theoretical courses. A 1 unit (4 credits) theoretical course will involve three lecture hours per week and a total of 55 to 60 lecture hours. A student willing to specialize in a particular branch (Physical/Inorganic/Organic) will have to take two courses from that branch and two other courses from other two branches taking one course from each branch. The courses offered by a particular branch will be decided by that branch. The total marks for the practical courses/research project of General group students will be 200 (2 unit) taking 100 marks (1 unit) from his/her branch of specialization and two 50 marks (½ unit) courses from other branches. A 1 unit (4 credits) practical course will spread over for 7 (seven) weeks with minimum of 15 hours per week. A 0.5 unit (2 credits) practical course will spread over for six weeks with minimum of 9 hours per week and 15 hours per week for 7 weeks for a 1 unit (4-credits) course. A Thesis group student will carry out a research work on a project and submit a dissertation carrying a total marks of 200 (2 unit) for the fulfillment of his/her degree. Students of General group will have a viva voce examination of 50 marks (½ unit) at the end of examination and students of Thesis group will have a viva voce examination of 50 marks (½ unit) at the end of thesis submission, respectively. Assessment of a student in each theoretical and practical course shall be based on marks obtained in the examinations (written, practical) and class works and class attendance. Projects will be evaluated by the examination committee. Marks allotted for class work, termed as tutorial marks, shall be 20% of the total marks and marks for attendance shall be 10% of the total marks earmarked for each of the theoretical and practical courses. For assessment of class works (tutorial) a minimum of three tests for a 1 unit course and two tests for a ½ unit course will be taken. Thus the MS examination in Chemistry shall consist of the following:

General Group

		Units	Marks	Credits
1.	Theoretical courses	4	400	16
2.	Practical courses/project	2 (1.0+0.5+0.5)	200	8
3.	Viva voce	0.5	50	2
	Grand total:	6.5	650	26

Thesis Group

		Units	Marks	Credits
1.	Theoretical courses	4	400	16
2.	Thesis	2	200	8
3.	Viva voce	0.5	50	2
	Grand total:	6.5	650	26

The following courses will be offered for the degree of MS in Chemistry:

A. Physical Chemistry branch

Theoretical

Course No.	Title of the course	Units	Marks	Credits
Chem 510F	Biophysical Chemistry	1	100	4
Chem 511F	Photochemistry and Atmospheric Chemistry	1	100	4
Chem 512F	Electrochemistry and Aquatic Chemistry	1	100	4
Chem 513F	Advanced Chemical Thermodynamics & Kinetics	1	100	4
Chem. 514F	Advanced Polymer Chemistry	1	100	4

Practical

Chem 516LF	Advanced Experiments in Physical Chemistry	1.0	100	4
Chem 517LH	Advanced Experiments in Physical Chemistry	0.5	50	2

B. Inorganic Chemistry branch

Theoretical

Course No.	Title of the course	Units	Marks	Credits
Chem 520F	Material Science	1	100	4
Chem 521F	Advanced Co-ordination Chemistry and Reaction Mechanisms	1	100	4
Chem 522F	Advanced Organometallic Chemistry	1	100	4
Chem 523F	Bio-inorganic Chemistry	1	100	4
Chem 524F	Advanced Analytical Chemistry	1	100	4
Chem 525F	Advanced Environmental Chemistry.	1	100	4

Practical

Chem 526LF	Advanced Inorganic Lab: Synthesis, Structure and Chemical Analysis of Inorganic Compounds	1	100	4
Chem 527LH	Advanced Inorganic Lab: Synthesis, Structure and Chemical Analysis of Inorganic Compounds	0.5	50	2

C. Organic Chemistry branch

Theoretical

Course No.	Title of the course	Units	Marks	Credits
Chem 530F	Advanced Spectroscopy	1	100	4
Chem 531F	Medicinal Chemistry	1	100	4
Chem 532F	Chemistry of Natural Products	1	100	4
Chem 533F	Organic Synthesis	1	100	4
Chem 534F	Food Chemistry	1	100	4
Chem 535F	Fragrance Chemistry	1	100	4

Practical

Chem 536LF	Separation by chemical and Chromatographic methods and Multistep Synthesis	1	100	4
Chem 537LH	Separation by chemical and Chromatographic methods and Multistep Synthesis	0.5	50	2

D. Viva voce

Chem 580VH	Viva voce for general group	0.5	50	2
Chem 585VH	Viva voce for thesis group	0.5	50	2

SESSION: 2017-2018, 2018-2019, 2019-2020, 2020-2021

Course No. Chem. 510F 1 Unit, 4 Credits
Biophysical Chemistry 70+20+10=100 Marks

Learning Objectives

The learning objectives of this course are to promote student knowledge in biophysical chemistry and related fields in order to

- address molecular views of solutions, ionic activity, colligative properties, solution thermodynamics, solubility, partition coefficient
- know ligand-macromolecule binding equilibrium, bioenergetics, glycolysis, electrochemistry involved in biological oxidation, pH of blood
- deal with enzyme kinetics, allosteric interactions, kinetics of bacterial growth, pharmacokinetics, membranes and surfaces in biological systems
- focus on protein stability, DNA fingerprinting and biophysical effects of radiation.

Course Content

1. Solutions: A molecular view of the solution process, Nonelectrolyte solution: Partial molar quantities; The thermodynamics of mixing, Real solutions; Electrolyte solution, Thermodynamics of ions in solution, Ionic activity; Debye-Huckel theory of electrolytes: The salting-in and salting-out effects, Colligative properties of electrolytic solutions: Effect of solute change, Donnan effect; Factors influencing solubility, Hydration and salvation, Structure breaker and structure makers, Hydrophobic hydration, Effects of additives, pH and ionization on solubility, The solubility parameter, Partitioning, Biological activity and partition coefficient.

2. (a) Chemical equilibrium: Binding of ligands and metal ions to macromolecules; one binding site per macromolecule, n equivalent binding sites per macromolecule, The direct plot, the double reciprocal plot and the Scatchard plot, Equilibrium dialysis; (b) Bioenergetics : The standard states in biochemistry, ATP-The currency of energy, Principles of coupled reactions, Glycolysis,, Limitations of thermodynamics.

3. Electrochemistry: (a) Biological oxidation: Chemiosmotic theory of oxidative phosphorylation, Membrane potential, The action potential; (b) Acids and Bases: Amino acids: dissociation of amino acids, isoelectric point, Buffer solutions; Effect of ionic strength and temperature on buffer solution, Maintaining the pH of blood.

4. (a) Enzyme kinetics: Enzyme catalysis, Equation of enzyme kinetics, Michaelis-Menten kinetics, Steady state kinetics, significance of K_m and V_{max}, Chymotrypsin: A case study, multisubstrate system: sequential mechanism, the non-sequential mechanism; Enzyme inhibition: Reversible inhibition, Irreversible inhibition; (b) Allosteric interactions: Immobilized enzyme, oxygen binding to myoglobin and hemoglobin, Hill equation, Concerted model, Sequential model, Conformational changes in hemoglobin induced by oxygen bonding. pH effects on enzyme kinetics; (c) Kinetics of bacterial growth: The Experimental, Lag and Stationary phase. Pharmacokinetics;Time course of drug action; Intake and Elimination of drugs, Theories of drug-effect connection.

5. Membranes and Surfaces in Biological Systems: Biological membranes, Membrane Transport; Simple diffusion, Fascilated diffusion and active transport, Surfactants: Amphipathic compounds. Surface and interfacial properties of surfactants; Gibbs adsorption equation, Application of Gibbs equation to surfactant solutions. Micellisation, Factors affecting critical micelle concentration; Solubilization; Factors affecting solubilization; The structure and properties of water, Hydrophobic interaction, Protein stability, Denaturation, DNA fingerprinting, Biophysical effects of radiation.

Learning Outcomes

Upon completion of this course, the student should be able to

- understand the molecular view of the solution process, solutions of nonelectrolyte and electrolyte, colligative properties, solution thermodynamics, solubility, biological activity and partition coefficient
- realize the binding sites of macromolecule, ligand-macromolecule binding equilibrium, equilibrium dialysis, ATP-The currency of energy, principles of coupled reactions, glycolysis and limitations of thermodynamics
- understand biological oxidation, membrane potential, dissociation of amino acids, maintaining the pH of blood
- understand Michaelis-Menten kinetics, steady state kinetics, significance of kinetic parameters, oxygen binding to myoglobin and hemoglobin and its conformational changes, kinetics of bacterial growth, kinetics of drug actions
- explain membranes and surfaces in biological systems, diffusion, active transport, surfactants and its applications, critical micelle concentration (CMC), solubilization, protein stability, DNA fingerprinting and biological effects of radiation
- interpret data for CMC, surface excess, solubility parameter, binding parameters and thermodynamics of biological processes.

Suggested Readings

1. Physical Chemistry for the Chemical and Biological sciences, Raymond Chang, University Science Books.
2 Bioenergetics, A. L. Lehninger, W. A. Benjamin, N. Y.
3. Principles of Biochemistry, A. L. Lehninger, D. L. Nelson & Michael M. Cox, CBS Publishers and Distributors.
4. Biophysical Chemistry, P. R. Bergethon & F. R. Simons, Springer Verlag N. Y.
5. Physical Biochemistry, Kensal Edward von Halde, Prentice-Hall, N. J.
6. Lippincott's Illustrated Reviews Biochemistry, P. C. Change, R. A. Hervey, F. Velle & M. Cooper, Lippincutt Williams & Wilkins, A Wolter Kluwer Co.
7. Physical Pharmacy, Alfred Martin, B. I. Waverly Pvt Ltd.

SESSION: 2017-2018, 2018-2019, 2019-2020, 2020-2021

Course No. Chem. 511F 1 Unit, 4 Credits
Photochemistry and Atmospheric Chemistry 70+20+10=100 Marks

Learning Objectives

The learning objectives of this course are to

- impart knowledge on the basics of photochemistry and
- teach how to apply these concepts to atmospheric processes.

Course Content

1. Photochemistry of molecules: (a) Term symbol for molecules; Selection rules; Electronic, vibrational and rotational energies; Potential energy curves for iodine molecule; Shapes of absorption band; Frank-condon curves for oxygen molecule; Crossing of potential energy surface; Reaction paths for electronically excited simple molecule; Photochemistry of O_2 and O_3. (b) Notation for excited states of organic molecules; Types of electronic transitions; Molecular orbitals and energy levels in formaldehyde; Photophysical processes of polyatomic molecules; Jablonski diagram of photophysical transitions.

2. Photophysical process: (a) Photophysical kinetics of unimolecular processes; State diagrams; Delayed fluorescence. (b) Photophysical kinetics of bimolecular processes; Kinetic collisions and optical collisions; Bimolecular collisions in gases and vapours; Collisions in solutions; Kinetics of collisional quenching: Stern-Volmer equation; Deviations from Stern-Volmer equation.

3. Photochemical primary processes: Classification of photochemical reactions; Rate constants and lifetimes of reactive energy states – Determination of rate constants of reactions; Types of photochemical reactions: Photodissociation – Gas phase photolysis, Atmospheric photochemistry, Photochemical formation of smog, Mercury photosensitized reactions.

4. Rates and mechanisms of gas-phase reactions: Regions and characteristics of the atmosphere; Reactions in irradiated organic-NO_x-air mixtures: sources of oxidants in the troposphere; Lifetime of typical organics; Reactions of alkanes, alkyl (R), alkylperoxy (RO_2), and alkoxy (RO) radicals; Alkenes; Simple aromatic hydrocarbons; Oxygen- and Nitrogen containing organics; Chemistry of remote regions.

5. Chemistry of the stratosphere: Overview of the chemistry of the stratosphere and global climate change; Statosphere-troposphere exchange (STE); Chapman cycle and NO_x chemistry; Chlorofluorocarbons: Lifetimes and atmospheric fates of CFCs; Gas-phase chemistry in the stratosphere; Antractic "ozone hole", Polar stratospheric clouds.

6. Chemistry of the troposphere: Overview of the air pollution and chemistry of troposphere; Sources, sinks and transport; Dry and wet deposition; The boundary layer; Transport in troposphere; Oxidation and transformation: Photochemical chain initiation, Oxidation steps, Tropospheric ozone production, The importance of NO_x, The reaction OH + CO, The nitrate radical, Reactions with ozone; Compounds of sulphur.

Learning Outcomes

Upon completion of this course, the student will be able to

- describe the term symbols for molecules, selection rules, potential energy curves
- explain the photophysical kinetics of unimolecular and bimolecular processes, kinetics of collisional quenching
- discuss the photochemical primary processes and photodissociation
- understand the rates and mechanism of reactions of alkanes, alkyl, alkylperoxy and also alkoxy radicals
- explain the chemistry of stratosphere and global climate change, Antarctic 'ozone hole'
- discuss the chemistry of troposphere and air pollution, tropospheric ozone production.

Suggested Readings

1. Fundamentals of Photochemistry, K. K. Rohatgi-Mukherjee, Wiley Eastern Ltd.
2. Photochemistry, Jack G. Calvert and James N. Pitts, Jr., John Wiley and Sons, Inc.
3. Upper and Lower Atmosphere, Barbara J. Finlayson-Pitts and James N. Pitts, Jr., Academic Press.
4. Chemistry of Atmosphere, Richard P. Wayne, Oxford University Press.

SESSION: 2017-2018, 2018-2019, 2019-2020, 2020-2021

Course No. Chem. 512F 1 Unit, 4 Credits
Electrochemistry and Aquatic Chemistry 70+20+10=100 Marks

Learning Objectives

The learning objectives of this course are to

- acquire the knowledge on electrochemistry as well as aquatic chemistry

Course Content

1. Atmosphere-water interaction: Gas-water partitioning: Henry's law, gas-water equilibria in closed and open systems, washout of pollutants from the atmosphere, fog, aerosols, acid rain, the volatility of organic substances, gas transfer across water-gas interface.

2. Metal ions in aqueous solution: Ion pairs and complexes, interaction of metal ions with particles, chemical speciation, protons and metal ions, hydrolysis of metal ions, stability of hydrolysis species, chelates: the chelate effects; metal-ion buffers, metal-carbon compounds, conditional constants.

3. Trace metals: cycling, regulation and biological role: Global cycling of metals, metal speciation in natural water, analytical approaches to metal speciation, analytical difficulties, bioavailability and toxicity.

4. Interaction between ions and ionic equilibria: The nature of electrolytes, ion-ion and ion-solvent interaction, dissolution, solvation and heats of solution, chemical and electrochemical potential, efficiency of buffer system, functioning of indicators.

5. Interfacial phenomena: The interphase between conducting phases, electrode double layer, polarized and nonpolarized electrodes, variation of charge with applied potential at a mercury/solution interface, specific adsorption, distribution of charge according to Helmholtz, Gouy & Chapman, and Stern.

6. Applications of electrochemical techniques: (i) Potentiometric methods: ion-selective electrodes, ion-selective microelectrodes, application of ion-selective electrodes to aquatic system. (ii) Voltammetric methods: fundamentals, pulse and stripping techniques, voltammetric methods with microelectrodes, application of voltammetric methods in speciation studies, microelectrodes, chemically modified microelectrodes: gas-sensing electrodes, enzyme electrodes, etc.

7. The exploitation of electrode processes: Corrosion prevention, electrocatalysis and electrosynthesis; electrochemical processes as sources of energy (i) primary cells, (ii) secondary cells & (iii) fuel cells.

Learning Outcomes

Upon successful completion of the course, the students should be able to

- analyze gas-water equilibria in closed and open systems
- explain the interaction of metal ions with particles & metal speciation
- describe trace metals: cycling regulation and biological role
- discuss interfacial phenomena
- understand various electrochemical methods such as potentiometry & voltammetry and various electrochemical processes such as corrosion, electrocatalysis, electrosynthesis, etc.

Suggested Readings

1. Principles and Applications of Electrochemistry, D. R. Crow (4^{th} edition).
2. Introduction to Electrochemistry, J. O'M. Bockriz and A. K. N. Reddy.
3. Aquatic Chemistry: Chemical Equilibria and Rates in Natural waters, Werner Stumm and James J. Morgan (3^{rd} edition).
4. Metal Speciation and Bioavailability in Aquatic Systems, Andre Tessier and David R. Turner (1^{st} edition).

SESSION: 2017-2018, 2018-2019, 2019-2020, 2020-2021

Course No. Chem. 513F 1 Unit, 4 Credits
Advanced Chemical Thermodynamics & Kinetics 70+20+10=100 Marks

Learning Objectives

The main objective of this course is to teach the students acquiring the knowledge on advanced thermodynamics and kinetics including classical & statistical treatment.

Course Content

1. Molecular basis of entropy-introductory concept, Statistical treatment of entropy: entropy and probability, Boltzmann–Planck equation, significance of thermodynamic probability, estimation of entropy of expansion of ideal gas, statistical calculation of entropy, entropy of monoatomic molecule, polyatomic molecules, comparison of third law and statistical entropies.

2. Free energy: free energy and work function, Work function and free energy relationship, isothermal changes in the work function and free energy, Gibbs-Helmholtz equation, free energy and chemical reactions, determination of free energy from thermal data & third law of thermodynamics, from spectroscopic data and statistical mechanics; Statistical mechanics and thermodynamic functions.

3. Partition function: determination of partition function, applications of partition functions, partition function and equilibrium constant, The free energy functions, statistical weigh and entropy; Quantum Statistics-Farmi-Dirac, Bose-Einstein statistics, comparison of three statistics.

4. Transition state theory: equilibrium hypothesis, statistical mechanics and chemical equilibrium, derivations of rate equation; applications of transition state theory, reactions between atoms and molecules, thermodynamic formulation of transition state theory, assumptions and limitations of CTST, Isotope effect on reaction rates, other theoretical treatment-classical treatment, quantum mechanical treatment and non-equilibrium and statistical mechanism.

5. Reactions on surfaces in the solid state-Adsorption, ideal- & non-ideal adsorption, adsorption with dissociation, competitive adsorption, thermodynamics and statistical mechanics of adsorption, Mechanisms of surface reactions-unimolecular surface reactions, bimolecular surface reactions; Some special types of reactions-parahydrogen conversion, combination and formation of atoms at surfaces, exchange reactions, addition of hydrogen to ethylene; Transition-state theory of surface reactions-rates of chemisorption, rates of desorption, unimolecular & bimolecular surface reactions, comparison of homogeneous and heterogeneous reaction rates; Surface heterogeneity; Rate equation for complex reactions-simultaneous and consecutive reactions, chain reactions, comparison of hydrogen-halogen reactions, steady state treatment, decomposition of inorganic compounds, decomposition of organic compounds, principle of microscopic reversibility and detailed balance, production, determination and estimation of atoms & radicals in reaction systems.

6. Homogeneous and heterogeneous catalysis- general catalytic mechanisms, equilibrium treatment, steady-state treatment, activation energies of catalyzed reactions, catalysis by electron and group transfer in solution, acid-base catalysis-mechanism of acid-base catalysis, catalytic activity and acid-base strength, salt effects in acid-base catalysis; catalysis by enzymes-influence of substrate concentration, influence of pH, influence of temperature; enzyme mechanisms, catalysis in gaseous systems, catalysis in chain reactions.

Learning Outcomes

Upon successful completion of the course, the students should be able to

- explain how the statistical mechanics can link microscopic systems with macroscopic systems
- describe the statistical thermodynamics & kinetics
- compute thermodynamic parameters in terms of probability, partition function, etc.
- understand the theories of chemical reaction rates in homogeneous, heterogeneous, solid phase reactions, etc.
- estimate the rates of chemical reactions (catalytic, homogeneous, heterogeneous, biochemical etc.) and study the mechanism of a reaction analyze the basic laws of thermodynamics & kinetics.

Suggested Readings

1. Chemical Kinetics 3rd edition, K. J. Laidler, McGraw-Hill, New Delhi.
2. Thermodynamics for Chemists, Samuel Glasstone, East-West edition, New Delhi.
3. Theoretical Chemistry, Samuel Glasstone, Fourteenth printing, Princetone, New Jersy.
4. Advanced Physical Chemistry, Gurdeep Raj, GOEL Publishing House, Meerul, India.
5. Advanced Concepts in physical Chemistry, E. D. Kaufmann.
6. Reaction Kinetics, M. J. Pilling and P. W. Seakins Oxford Science Publications.

SESSION: 2017-2018, 2018-2019, 2019-2020, 2020-2021

Course No. Chem. 514F 1 Unit, 4 Credits
Advanced Polymer Chemistry 70+20+10=100 Marks

Learning Objectives

The learning objective of this course is to

- provide a general understanding of the advanced topics in polymer chemistry and how to apply the concepts in polymer industries.

Course Content

1. Polymer synthesis: Step-growth polymerization: molecular weight in a step-growth polymerization, step-growth polymerization kinetics; Chain-growth polymerization: free-radical polymerization and copolymerization, ionic polymerization and copolymerization, coordination polymerization; Polymerization techniques: bulk polymerization, solution polymerization, suspension polymerization, emulsion polymerization, solid-state, gas-phase, and plasma polymerization, polymerization in supercritical fluids; Reactions of synthetic polymers: chemical modification, preparation of polymer derivatives.

2. Conformation, solutions, and molecular weight: Polymer conformation and chair dimensions; Thermodynamics of polymer solutions: the Flory-Huggins theory, Flory-Krigbaum and modified Flory-Huggins theory, Equation-of-state theories, phase equilibria, determination of interaction parameter, predictions of solubilities; Measurement of molecular weight: osmometry, light-scattering method, intrinsic viscosity measurements, gel-permeation chromatography.

3. Solid-state properties: Amorphous state: chain entanglements and repetition, the glass transition, secondary-relaxation processes; Crystalline state: ordering of polymer chains, crystalline-melting temperature, crystallization kinetics, techniques to determine crystallinity; Thermal transitions and properties: fundamental thermodynamic relationships, measurement techniques, structure-property relationships, effect of molecular weight, composition, and pressure on T_g; Mechanical properties: mechanisms of deformation, methods of testing.

4. Viscoelasticity and rubber elasticity: Introduction to viscoelasticity: dynamic-mechanical analysis, mechanical models of viscoelastic behaviour, viscoelastic properties of polymer solutions and melts, dielectric analysis, dynamic calorimetry, time-temperature superposition, Boltzmann superposition principle, interrelationships between transient and dynamic processes; Introduction to rubber elasticity: thermodynamics, statistical theory, phenomenological model, recent developments.

5. Polymer degradation and the environment: Polymer degradation and stability: thermal degradation, oxidative and UV stability, chemical and hydrolytic stability, effects of radiation, mechanodegradation; Management of plastics in the environment: recycling, incineration, biodegradation.

6. Additives, blends, and composites: Additives: plasticizers, fillers and reinforcements, other important additives; Polymer blends and interpenetrating networks: polymer blends, toughened plastics and phase-separated blends, interpenetrating network; Introduction to polymer composites: mechanical properties, composite fabrication.

7. Biopolymers, natural polymers, and fibers: Biopolymers and other naturally occurring polymers: Protiens, polynucleotides, polysaccharides, naturally occurring elastomers; Fibers: natural and synthetic fibers, cellulosics, noncellulosics; Fiber-spinning operations.

Learning Outcomes

Upon completion of this course, the student will be able to

- describe the different polymerization processes, polymerization techniques
- explain the thermodynamics of polymer solutions and methods for the determination of molecular weights
- identify amorphous and crystalline state, and mechanical properties
- discuss viscoelasticity and rubber elasticity
- understand stability, degradation and recycling
- explain the preparation and properties of additives, blends, and composites
- identify the structure and properties of biopolymers, natural polymers and fibres.

Suggested Readings

1. Textbook of Polymer Science, Padmal L. Nayak, S. Lenka.
2. Polymer Science, V. R. Gowarker, N. V. Viswanathan and Jayadev Sreadhar.
3. Introduction to Polymer Chemistry (International Student Editions), R. B. Seymour.
4. Polymer Chemistry, M. G. Arora, M. Singh.
5. Text Book of Polymer Science (Willey), Fred W. Billmeyer.
6. Introductory Polymer Chemistry, G. S. Misra, Wiley Eastern Limited, India.

SESSION: 2017-2018, 2018-2019, 2019-2020, 2020-2021

Course Chem. 516LF 1 Unit, 4 Credits
Course Chem. 517LH ½ Unit, 2 Credits
Advanced Experiments in Physical Chemistry/Laboratory Project 35+10+5=50 Marks

Learning Objectives

Learning objectives of this course are to

- acquaint students with some experimental techniques
- impart students skill in using industry based laboratory equipments
- carry out industrial problem based experiment.

Course Content

1. To determine the degree of dissociation of the given acid samples by conductometric method.
2. To determine the equivalent conductance of the given strong electrolyte and hence examine the validity of Onsager equation.
3. To investigate the reaction between potassium persulphate and potassium iodide by colorimetric measurements.
4. Potentiometric titration of phosphoric acid and calculation of the dissociation constant.
5. To determine thermodynamic quantity from e.m.f. measurement.
6. Influence of temperature on the viscosity of a pure liquid and determination of the activation energy of viscous flow.
7 To study the effect of concentration and ionic strength on the viscosity glycerol solution and determination of the radius of glycerol molecule.
8. Determination of molecular weight of a polymer from viscosity measurement.
9. To determine the critical Micelle concentration of sodium lauryl sulphate from conductivity measurement. Also determine thermodynamics of micellization.
10. To determine the binding constant of a dye molecule with polymer spectrophotometrically.

Learning Outcomes

Upon completion of this course, students will be able to

- handle the simple apparatus/equipments safely
- calculate molecular weight of polymer and dissociation constant of weak acid as well as pK_a values of polybasic acid
- determine equivalent conductivity at infinite dilution and verify onsager equation
- determine critical micelle concentration and thermodynamic parameters of surfactant micellization
- compute emf and thermodynamic parameters of a cell
- analyze and interpret tabulated experimental data.

N.B.: Experiments may be added to or omitted from the above list if necessary.

Suggested Readings

1. Practical Physical Chemistry, A. Findlay, Longmans, Green & Co. Ltd.
2. Practical Physical Chemistry, Palit, Science Book Agency.
3. Practical Physical Chemistry, Sharma, Vikas Publishing House, Calcutta.
4. Advanced Practical Physical Chemistry, J. B. Yadav.
5. Advanced Physical Chemistry Experiments, J. N. Gurtu & Amit Gurtu.

SESSION: 2017-2018, 2018-2019, 2019-2020, 2020-2021

Course No. Chem. 520F 1 Unit, 4 Credits
Material Sciences 70+20+10=100 Marks

Learning Objectives

The learning objectives of this course are to

- promote knowledge on synthesis, structure, properties and applications of a range of new materials.
- impart knowledge on inorganic materials involve molecular inorganic superconductors, polymeric coordination complexes, metal containing liquid crystals and precursors for electronic materials.
- convey knowledge on the nanomaterials discussed on metals, carbon based nanomaterials and ceramics with emphasis on structure, synthesis, catalysis and applications.

Course Content

1. Material Chemistry: Definition, Historical Perspectives, Considerations in the Design of New Materials, Critical thinking in designing New Materials.

2. Molecular Inorganic Superconductor Materials: Introduction, conductors and superconductors, Transition metal complex based Conducting systems, Metal Bis-dithiolene Complexes, synthesis, dimensionality and the origin of superconductivity in 1,3-dithiole-2-thione-4,5dithiolate (dmit) based $[M(dmit)_2]$ complexes, band structure calculations.

3. Molecular Inorganic Semiconducting Materials: Semiconductors, properties and types of semiconductors, Moore's Law, Si based semiconductors, band gap, p-n junctions, Integrated circuits (IC), methods for crystal growth and crystal fabrication.

4. Polymeric Coordination Complexes: Examples of polymeric systems, electrochemical characterization of soluble polymeric coordination complexes.

3. Photovoltaic: Principles, Applications: LED, solar cells.

6. Metals in Nanotechnology: Structure and bonding, reduction of size, size dependent properties, synthesis of metal nanoparticles: Gas phase synthesis, Chemical synthesis, arrangement of nanoparticles.

7. Carbon based Nanosystem: Carbon nanotubes, types of carbon nanotubes, synthesis and application of carbon nanotubes; Graphene: Structure, synthesis, properties and application.

8. Ceramics: Introduction, Synthesis: Physical/Aerosol methods, Chemical methods, Bonding and defects, Metal oxides, SiC and SiN, Preparation, Chemical, Physical/Mechanical Properties.

9. Chemical and Catalytic Aspects of Nanocrystals: Chemistry occuring at the nanocrystal surface, nanoparticles size effects in catalysis: electronic effect, support effect, Shape effect, Nanostructured adsorbents, Nanoparticles as chemical reagents, Nanocomposite polymers.

10. Application of Nanocrystals: Nanocrystals as – (i) Structural and mechanical materials, Colorants and pigments, Electronics and magnetic materials, Biomedical applications of nanocrystals.

Learning Outcomes

Upon completion of this course, the student will be able to

- understand the design, synthesis and preparation of functional materials for wide range of applications.
- understand how and why the properties of materials are controlled by structure and bonding at the nanoscale, and by features at the microstructural and macroscopic levels.

Suggested Readings

1. Inorganic Materials, D. W. Bruce and Dermot O′hare (Ed.), 2nd ed., John Wiley & Sons.
2. Nanoscale Materials in Chemistry, Kenneth J. Klabunder (Ed.), John Wiley & Sons.
3. Nanoscale Materials in Chemistry, K. J. Klabunder and R. M. Richards (2nd Ed.), John Wiley & Sons.
4. A Chemical Approach to Nanomaterials, G. A. Ozin & A. C. Arsenault, RSC Publishing.

SESSION: 2017-2018, 2018-2019, 2019-2020, 2020-2021

Course No. Chem. 521F 1 Unit, 4 Credits
Advanced Coordination Chemistry and Reaction Mechanisms 70+20+10=100 Marks

Learning Objectives

The learning objectives of this course are to

- introduce advanced coordination chemistry which includes the 18-electron rule;
- impart knowledge on some special properties of coordination compounds such as paramagnetism, magnetic moment, high-spin-low-spin crossover etc.;
- convey knowledge on kinetics and reaction mechanism of coordination complexes.

Course Content

1. The 18-Electron Rule: Oxidation state ambiguity: nitrosyls, bipyridyl complexes, metal dithienes; polyhedral transition-metal cluster complexes, compounds having metal-metal multiple bonds.

2. Some Special Properties of Coordination Compounds: Paramagnetism; magnetic moment, High-spin-low-spin crossover, orbital angular momentum; Ferromagnetism, ferrimagnetism and anti-ferromagnetism; Jahn-Teller distortions; Ligand field stabilization energy; Structural effects of metal-metal pi bonding; pi-donor bonding and pi- acceptor bonding.

3. Kinetics and reaction mechanisms of coordination complexes: (a) Introduction: Labile and inert complexes; substitution at a metal center: some general considerations; the classification of mechanisms, tests of the intimate mechanism. (b) Substitution Reactions in Octahedral Complexes Rate laws and their interpretations: the Eigen-Wilkins mechanism, the Fuss-Eigen equation, intimate mechanism: leaving group effects, entering group effects, the effect of spectator ligands, steric effects, the effect of overall charge; activation energetics, associative activation; stereochemistry: base hydrolysis; isomerization reactions; stoichiometric mechanisms: the D intermediate. (c) Substitution Reactions in Square-planar Complexes: Intimate mechanisms: effects of entering and leaving groups, the kinetic trans effect, steric effects, stereochemistry, temperature and pressure dependence. (d) The Mechanisms of Redox Reactions: The classification of redox reactions: Inner sphere mechanism and outer sphere mechanism; electron transfer through extended bridges; the theory of redox reactions, Franck-Condon principle, the Marcus equation, inner sphere reactions; oxidative addition, mixed valence compounds, unstable intermediate oxidation states. (e) Photochemical Reactions: Prompt and delayed reactions, d-d and charge transfer reactions, metal-metal bonded systems.

Learning Outcomes

Upon completion of the course students will be able to

- understand the 18-electron rule which is very important to predict structure of cluster compounds.
- explain the oxidation state of transition-metal clusters and compounds having metal-metal multiple bonds.
- explain some special properties of coordination compounds such as paramagnetism, magnetic moment, high-spin-low-spin crossover etc.
- explain the Jahn-Teller distortion, Ligand Field Stabilization Energy (LFSE), Structural effect of metal-metal bonding.
- explain kinetics and mechanism of various types of reactions in coordination chemistry.

Suggested Readings

1. Modern Inorganic Chemistry, William L. Jolly, 2nd ed., McGraw-Hill International edition.
2. Inorganic Chemistry, D. F. Shriver, P. W. Atkins and C. H. Langford, E. L. B. S.
3. Inorganic Chemistry, Alan G. Sharpe, E. L. B. S and Longman.
4. Inorganic Chemistry, Keith F. Purcell and John C. Kotz, W. B. Saunders Company.
5. Inorganic Chemistry, James E. Huheey, 2nd ed., Harper & Row Publishers.

SESSION: 2017-2018, 2018-2019, 2019-2020, 2020-2021

Course No. Chem. 522F 1 Unit, 4 Credits
Advanced Organometallic Chemistry 70+20+10=100 Marks

Learning Objectives

The learning objectives of this course are to

- provide knowledge on the synthesis, structures and bonding in metal-carbene and metal-carbyne complexes.
- impart knowledge on the synthesis, structures and bonding in organometallics cluster compounds and organometallic compounds of fullerenes.
- provide knowledge on spectral analysis and characterization of organometallic complexes.
- convey knowledge on the reactivity of some selected type of organometallic cluster compounds.
- impart knowledge on the applications of Organometallic Chemistry to Organic synthesis.
- convey a general overview of catalysis involving different types of organometallic complexes acting as catalyst.
- provide knowledge on bioinorganic catalysis by various enzymes whose active sites resemble organometallic complexes of clusters.
- convey knowledge about organometallic chemistry of rare earth metals.
- provide knowledge on electrochemistry in metal-fullerene complexes.

Course Content

1. Transition Metal Organometallic Chemistry: Complexes with encapsulated metals; carbene complexes, carbyne complexes; Spectral analysis and characterization of organometallic complexes; problems.

2. Structural and Bonding Aspects of Metal Cluster Chemistry: Important classes of transition metal cluster compound (electron count and structure), Polyhedral skeletal electron pair rules, Exceptions to the rules.

3. Chemistry of Some Selected Type of Metal Clusters: (a) Structures and reactivity of unsaturated clusters with particular emphasis on $[Os_3(\mu\text{-}H)_2(CO)_{10}]$, $[Os_3(\mu\text{-}H)(CO)_8\{Ph_2PCH_2P(Ph)C_6H_4\}]$ and $[Os_3(\mu\text{-}H)(\mu_3\text{-}\eta^2\text{-}L\text{-}H)(CO)_9]$ (L = quinolines, benzothiazoles, quinoxalines), (b) Synthesis, structures and reactivity of μ_3-imidoyl clusters, (c) Osmium-tin and ruthenium-tin bimetallic clusters, (d) Cluster assisted ligand transformations, (e) Spectral analysis and characterization of cluster complexes, (f) Bimetallic clusters as precursors to nanoparticles, (g) Problems.

4. Applications of Organometallic Chemistry to Organic synthesis: (a) Enantioselective Functional group Interconversions (b) Asymmetric Hydrogenation using Rhodium complexes (c) Asymmetric Hydrogenation using Ru-based catalyst (d) Organotransition metal complexes as protecting and activating groups: (i) Use of iron reagents as protecting groups (ii) iron complexes serving as masked functional groups (iii) Palladium η^3-π-allyl complexes: Allyl cation equivalents, (e) Carbon-carbon bond formation via carbonyl and alkene insertion: (i) carbonyl insertions (ii) The Heck reaction (Carbon-carbon double bond insertion) (f) Carbon-carbon bond formation via transmetallation reaction; (i) transmetallation involving Zirconium (ii) transmetallation involving Palladium (g) Carbon-carbon bond formation through cyclization reactions; (i) cyclization involving Fischer –type carbene complexes (ii) cyclization involving Palladium (iii) Cobalt promoted formation of five membered rings (the Pauson-Khand Reaction).

5. Organometallic catalysis and catalytic mechanisms: (a) Detailed mechanistic proofs of CO insertion reaction (alkyl migration); (b) Homogeneous catalysis by mononuclear organometallic complexes: (i) Catalytic deuteration, (ii) Monsanto acetic acid process, (iii) Wacker process; (c)

Organometallic catalysis in biology: (a) Hydrogenase Enzymes: (i) Importance, (ii) Occurrence, (iii) Active site of three types of hydrogenase enzymes, (iv) Electrocatalytic proton reduction by the H-cluster of the active site of [FeFe]-hydrogenase; (b) Nitrogenase enzymes: (i) Importance, (ii) Occurrence, (iii) Active site of nitrogenase and catalytic mechanism for nitrogen fixation.

6. Chemistry of Carbon-Cluster (Fullerene-C_{60})–Metal Metal Clusters: (a) Some basics on fullerene-C_{60}: (i) Discovery of fullerene, (ii) Syntheses and characterization of fullerene, (iii) Structure, bonding and properties of fullerene, (iv) Fullerene – a magic molecule/ligand; (b) Endohedral and Exohedral Metallofullerene: (i) Complexes of fullerene with mononuclear trimetal, (ii) Complexes of fullerene with dinuclear transition metal, (iii) Complexes of fullerene with tri-tetra and pentanuclear clusters, (iv) Bonding of fullerene with transition metal clusters; (c) Electrochemistry of fullerene and metal-fullerene complexes

Learning Outcomes

Upon completion of this course, students will be able to

- understand the structures of metal-carbene and metal-carbyne complexes and the nature of bonding shown by these complexes .
- understand various structural motifs of organometallics cluster compounds and nature of bonding within these clusters.
- understand the importance and applications of organometallic complexes in organic synthesis.
- understand the catalytic application of various organometallic complexes in the synthesis of various types of organic compounds and in polymerization processes.
- understand how organometallic systems operate in nature (living systems).
- understand structure, reactivity and bonding of organometallic compounds containing rare earth metals.
- understand the bonding in metal-fullerene complexes.

Suggested Readings

1. Organometallics 1: Complexes with transition metal carbon σ-bonds, M. Bochmann, Oxford Science Publications, Macmillan.
2. Organometallics 2: Complexes with transition metal-carbon π-bonds, M. Bochmann, Oxford Science Publications, Macmillan.
3. Inorganic Chemistry, G. L. Miessler, P. J. Fischer & D. A. Tarr, Pearson Education Ltd.
4. The Chemistry of Metal Cluster Complexes, Duward F. Shriver, Herbert D. Kaesz, Richard D. Adams, VCH Publishers, NY. USA.
5. Inorganic Chemistry, D. Shriver & P. Atkins, Oxford University Press, UK.
6. Comprehensive Organometallic Chemistry II, Volume 10 and 11, Pergamon Press, USA.
7. An introduction to Organometallic Chemistry, A. W. Parkins and R. C. Pollar, Macmillan Publishers Ltd, London.
8. Principles of Organometallic Chemistry, G. E. Coates, M. L. H. Green, P. Powell and K. Wade, Chapman and Hall publishing, USA.
9. Organometallic Compounds, Vol. 1 & 2, G. E. Coates, M. L. H. Green and K. Wade, Methuen & Company Ltd.
10. Metal Clusters, B. F. G. Johnson (ed.) John Wiley and Sons.
11. Principles of Organometallic Chemistry, P. Powell, Chapman and Hall, New York, USA.

SESSION: 2017-2018, 2018-2019, 2019-2020, 2020-2021

Course No. Chem. 523F 1 Unit, 4 Credits
Bioinorganic Chemistry 70+20+10=100 Marks

Learning Objectives

The learning objectives of this course are to

- provide knowledge of the importance of the role of inorganic elements in biological systems, electron transfer and catalytic reactions of metal containing biological systems.
- systematize the most significant developments of the subject and present important unifying principles.

Course Content

1. Some general principles: Occurrence and availability of inorganic elements in organisms. Biological functions of inorganic elements in organisms. Biological functions of inorganic elements. Biological ligands for metal ions. Coordination by proteins-comments on enzymatic catalysis prophyrin and other macrocycles . Neucleobases, Nucleotides and Nucleic acids (RNA, DNA) as ligands.

2. Cobalamines including vitamin and co enzyme B_{12}: History, Structural characterization, Reactions of the alkylcobalamines, One electron and reduction and oxidation, Co-C bond cleavage, Mutase activity of coenzyme B_{12}, Model systems and the role of apoenzyme.

3. Metals at the center of photosynthesis: Magnesium and Manganese: Volume and total efficiency of photosynthesis primary procession photosynthesis, Light absorption (energy acquisition), Excitor transport (directed energy Transfer) Charge separation and electron transport. Manganese catalyzed oxidation of water to O_2

4. The dioxygen molecule, O_2: Uptake, Transport and Storage of an Inorganic natural product. Molecular and chemical properties of Dioxygen O_2. Oxygen transport and storage through Hemoglobin and Myoglobin. Alternative oxygen transport in some lower animals: Hemerythin and Hemocyanin.

5. Catalysis through Hemo proteins: Electron transfer oxygen activation and Metabolism of Inorganic Intermediates. Cytochromes, cytochrome P-450:oxygen transfer from O_2 to non activated substrates. Peroxidase: Detoxification and utilization of doubly reduced dioxygen controlling the reaction mechanism of oxy heme group-generation and function of oxygen free radicals. Hemeproteins in the partially reduced nitrogen and sulfur compounds.

6. Iron sulfur and other non heme Iron proteins: Biological relevance of the element combination Iron/sulfur. Rubredoxins, Ferredoxins, Polynuclear Iron sulfur clusters: Relevance of the protein environment and catalytic activity Model systems for iron-sulfur proteins. Iron containing Ribonucleotide Reductase (RR). Soluble methane Monooxygenase (MMO) purple acid phosphatase. Mononuclear nonheme iron enzymes.

7. Upake, transport and storage of an essential element as exemplified by Iron: The problem of iron mobilization, oxidation states, Solubility and medical relevance. Iron uptake by microorganisms. Iron uptake by plants. Transport and storage of iron transferring, Ferritin, Hemosiderin.

8. Biological function of the early transition metals: Molybdenum, Tungsten, vanadium and Chromium.Oxygen transfer through tungsten or Molybdenum containing enzymes. Enzymes containing the molybdenum cofactor. Metalo enzymes in biological nitrogencycle: Molybdenum dependent nitrogen fixation. Alternative Nitrogenase. Biological vanadium outside Nitrogenases. Chromium(III) in the Metabolism.

Learning Outcomes

Upon completion of this course, the students will be able to

- understand some general principles like biological functions of inorganic elements in organisms, coordination by proteins-comments etc.
- know the structural characterization, reactions, bond cleavage of Cobalamins including vitamin and Co-enzyme.
- know the molecular and chemical properties, uptake, transport and storage of dioxygen molecule.
- know the uptake, transport and storage of Iron.
- know the biological function of the early transition metals.

Suggested Readings

1. Bioinorganic Chemistry: Inorganic Elements in the Chemistry of Life, An Introduction and Guide Wolfgang Kaim and Brigitte Schwederski, John Wiley and Sons.
2. Inorganic Chemistry, D. F. Shriver and P. W. Atkins, W. H. Freeman and Company.

SESSION: 2017-2018, 2018-2019, 2019-2020, 2020-2021

Course No. Chem. 524F 1 Unit, 4 Credits
Advanced Analytical Chemistry 70+20+10=100 Marks

Learning Objectives

The learning objectives of this course are to

- convey knowledge on modern chemical analytical methods used in material science, environmental study and life science.

Course Content

1. Introduction to Instrumental Methods in Chemical Analysis: Types of instrumental methods, Instruments for analysis, Operational amplifires in chemical instrumentation, signal and noise.

2. Instruments for Optical Spectroscopy: Components of optical instruments, Radiation sources, Wavelength selectors, Sample containers, Radiation detectors, Signal processors and readout, Fiber optics.

3. Atomic Spectroscopy Based upon Flame and Electrothermal Atomization: Sample atomization, Types and sources of atomic spectra, Flame atomization, AAS: Radiation sources, Single beam and Double beam spectrophotometers, Spectral interferences and methods of correction, Analytical techniques; AES: Instrumentation, Interferences, Analytical Techniques; AFS: Instrumentation, Interferences, Application.

4. Emission Spectroscopy Based upon Plasma, Arc and Spark Sources: Spectra from higher energy sources, Emission spectroscopy based on plasma sources, Emission spectroscopy based upon arc and spark sources.

5. X-ray Spectroscopy: Fundamental Principles, Instrument components, X-ray fluorescence method, X-ray absorption method, X-ray diffraction method,

6. Analysis of Surface with Electron Beam: Electron spectroscopy, Scanning Electron Microscopy (SEM).

7. Electrochemical Methods: Potentiometric Stripping Voltametry, Coulometric Methods, Anodic and Cathodic Voltametry, Pulse Polarographic Methods, Square Wave Voltametry.

Learning Outcomes

Upon completion of the Course the students will be able to

- know the components of optical instruments, radiation sources, wavelength selectors, sample containers, radiation detectors, signal processors and readout of optical spectroscopy.
- explain the principle and function of atomic spectroscopy based upon flame and electrothermal atomization.
- know the principle and function of emission spectroscopy based upon plasma.
- understand the fundamental principles, components, fluorescence, absorption and diffraction methods of X-ray spectroscopy.
- know the different electrochemical methods.

Suggested Readings

1. Principles of Instrumental Analysis, Douglas A Skoog and James J Leary.
2. Fundamentals of Analytical Chemistry, D. A. Skoog & D. M. West, Saunders Publishing.
3. Atomic Absorption and Emission Spectroscopy, Ed Metcalfe, John Wiley & Sons.
4. Analytical Chemistry, G. D. Christian, Wiley.
5. Vogel's Textbook of Quantitative Inorganic Analysis, J. Bassett, R. C. Dinney, G. H. Jeffery and J. Mendham, Longman.

SESSION: 2017-2018, 2018-2019, 2019-2020, 2020-2021

Course No. Chem. 525F — 1 Unit, 4 Credits
Advanced Environmental Chemistry — 70+20+10=100 Marks

Learning Objectives

The learning objectives of this course are to

- provide knowledge with the scientific principles, concepts, and methodologies required to understand the interrelationships of the natural world, to identify and analyze environmental problems both natural and human-made, to evaluate the relative risks associated with these problems, and to examine alternative solutions for resolving and/or preventing them.

Course Content

1. The atmosphere and atmospheric chemistry: Importance of the atmosphere, physical characteristics of the atmosphere, chemical and photochemical reactions in the atmosphere, acid-base reaction in the atmosphere, characteristics, sources and biochemical effects of some air pollutants, Ozone in the troposphere and stratosphere, major sources of air pollution in Bangladesh, control of air pollution.

2. Water pollution: Nature and types of water pollution, inorganic and organic pollutants in water, algal nutrient and eutrophication, industrial water pollution, agricultural water pollution, radionuclides in the aquatic environment, waste-water treatment-preliminary, primary, secondary and tertiary treatment, sludge, water disinfection.

3. Hazardous wastes: Introduction, waste reduction and minimization, physical methods of waste treatment, chemical methods, biodegradation, recycling.

4. Trace element pollution: Introduction, essential and non-essential trace elements, environmental levels, Pollution due to some heavy elements in Bangladesh.

5. Toxicological chemistry: Toxicology and toxicological chemistry, dose-response relationship, kinetic and dynamic phase, teratogenesis, mutagenesis, carcogenesis and immune system effects, Biochemical affects of some toxic elements e.g. Pb, Hg, Cd, Cr, As.

6. Noise Pollution: Measurement of noise level, pollution and sources, effects of noise on human health, control of noise pollution.

7. Environmental chemistry of organochlorine and organophosphate compounds: Introduction, chemistry of chlorinated, organic compounds, PCBs, DDT, PAH, PAN, lindane, toxicity of organo-chlorine compounds.

8. Environmental legislations in Bangladesh: Environmental policy-1992, Environment protection regulation on amended in 1997, National water policy 1999, Environment court law 2000, Industrial pollution control law, Air pollution control laws.

Learning Outcomes

Upon completion of the course, the students will be able to

- understand the importance and chemistry of the atmosphere, Sources and biochemical effects of different air pollutants.
- understand the sources and effects of water pollution, treatment methods of waste water.
- know about the different types of solid wastes, the waste treatment methods, waste utilization, waste recycling, waste reduction and minimization.
- know the essential and non-essential trace elements and their pollution.
- know the environmental effects of organochlorine and organophosphorous compounds.
- know the environmental legislations of Bangladesh.

Suggested Readings

1. Fundamentals of Environmental Chemistry, S. E. Manahan, Lewis Publisher, NY.
2. Environmental Chemistry, R. W. Raiswell, Science.
3. Environmental Chemistry, Moore and Moore, Academic Press.
4. Handbook of solid waste management, Frank kreith, McGRAW-HILL.
5. Environmental Chemistry with green chemistry. Asim K. Das. Books and allied (p) Ltd. Kolkata, India.

SESSION: 2017-2018, 2018-2019, 2019-2020, 2020-2021

Course Chem. 526LF 1 Unit, 4 Credits
Course Chem. 527LH ½ Unit, 2 Credits
Advanced Inorganic Lab: Synthesis, Structure and Chemical Analysis of Inorganic Compounds 35 + 10 + 5 = 50 Marks

Learning Objectives

The learning objectives of this course are to

- provide students the knowledge to develop them to be an independent researcher.
- determination of oxygen content in the ground water and tap water
- preparation and characterization of liquid crystalline metal complexes
- preparation of some organometallic compounds

Course Content

1. Synthesis of Copper (II) Acetate Monohydrate.
2. Preparation of Chloropenta(ammine)cobalt(III) chloride, $[CoCl(NH_3)_5]Cl_2$ and conversion into the linkage isomers Nitropenta(ammine)cobalt(III) chloride, $[Co(NO_2)(NH_3)_5]Cl_2$ and Nitritopenta(ammine)cobalt(III) chloride, $[Co(ONO)(NH_3)_5]Cl_2$ and IR investigations.
3. Preparation of Tetraaqua-bis(o-sulfobenzoimido)copper(II) and Tetraaqua-bis(o-sulfobenzoimido) cobalt(II). Characterization of the product using the spectra of IR and UV.

4. Preparation of a Liquid Crystalline Complex Aroylhydrazinatonickel(II).
5. Determination of Dissolve Oxygen (DO).
6. Determination of Chemical Oxygen Demand (COD) of a water sample.

Learning Outcomes

Upon completion of this course, the students will be able to

- synthesize Copper (II) Acetate Monohydrate.
- prepare the Chloropenta(ammine)cobalt(III) chloride.
- prepare Liquid Crystalline Complex.
- determine the DO and COD of a water sample.

Suggested Readings

1. Vogel's Textbook of Quantitative Chemical Analysis, G.H. Jeffery, J. Bassett, J. Mendham & R.C. Denny, Longman and ELBS.
2. Practical Inorganic Chemistry, Preparations, Reactions and Instrumental Methods, G. Pass and H. Sutcliffe, Chapman and Hall, New York.
3. Synthesis and Technique in Inorganic Chemistry, R. J. Angeleci, University Science Books, Sausalito, CA.
4. Microscale Inorganic Chemistry, A Comprehensive Laboratory Experience, Zvi Szafran, R. M. Pike and M. M.Sing, John Willy and Sons, INC. New York,
5. Standard Methods for the Examination of Water and Wastewater, APHA (American Public Health Association, 20^{th} edition, New York, 1998.

SESSION: 2017-2018, 2018-2019, 2019-2020, 2020-2021

Course No. Chem. 530F	1 Unit, 4 Credits
Advanced Organic Spectroscopy	70+20+10=100 Marks

Learning Objectives

Learning objectives of this course are to

- acquire knowledge and understanding of the principles of all spectroscopic methods and instruments.
- provide in-depth knowledge to solve structural problems with spectra/spectral data.
- impart knowledge on correlation of all the spectroscopic data with sufficient arguments to a final structure of organic molecules.

Course Content

1. UV Vis Spectroscopy : Review of Basic principles of UV Vis spectroscopy. Factors affecting the λmax values: conjugation, role of polarity of solvent, conformational effect. Salient features of Woodward Fieser rule in predicting λmax values of dienes and dienones and its application quantitative. Application of UV-VIS in defection of conjugation, distinction of cis/trans isomers, study of tautomeric and conformation of halogenated ketones. Quantitative application of UV-VIS spectroscopy in pharmaceutical industry in drug assay by using Beer-Lambert law.

2. FTIR and Raman Spectroscopy : Review of basic principles of IR and Raman spectroscopy and comparison in application. Factors affecting the stretching vibrations: conjugation, H-bonding, coordination, field effect, mass effect, bond order, ring size etc. Qualitative application in the prediction of functional groups, reaction monitoring, study of conformation, H-bonding, coordination compound, structure elucidation of complex molecules like penicillines, proteins, carbohydrates, steroids distinction of cis/trans isomers, Near IR in medical science.

3. NMR Spectroscopy : Basic principle of NMR spectroscopy of the nuclei ^{1}H, ^{13}C, ^{19}F, ^{31}P. FT-NMR (pulse experiment), special pulse sequence in ID NMR spectroscopy: modulated spin echo (APT), SEPT, INEPT, DEPT experiment, identification of C, CH, CH_2, CH_3 carbons. Factors affecting parameters of chemical shift and coupling constant, Karplus equation and conformation assignment, NOE experiment and its application. Simplification of complex ^{1}H-NMR spectra: decoupling and LSR techniques. Dynamic NMR spectroscopy: temperature dependent spectra.

Empirical rules for calculation of δ_H and δ_{13C}. 2D-NMR: COSY, HETCOR, HSQC, HMBC, INADEQUATE and SECSY, TOCSY experiment. Application of ^{1}H, ^{13}C, ^{19}F and ^{31}P NMR spectroscopy in structure elucidation, medical science, MRI.

4. Mass Spectrometry : Basic principle of ionization techniques of CI, FAB, TOF, GC-MS, LC-MS for chemical analysis. Structural study of simple and complex organic molecules, proteins, carbohydrates. Fragmentation due McLatterty rearrangement ortho-effect, meta-stable ions, retro-Diels-Alder reaction. Problems on structure elucidation, Matrix-assisted laser desorption/ionization (MALDI TOF) technique.

5. Structure elucidation by combined spectra using 1D & 2D-NMR, DEPT, MS, IR and UV-VIS.

Learning Outcomes

Upon completion of this course students will be able to

- discuss the spectral data to establish the structure of unknown molecules.
- use IR spectrum to identify geometric isomers and monitor chemical reactions.
- analyze the UV-Visible spectrum to find the type of chromospheres and purity of drugs.
- analyze NMR of different nuclei (^{1}H, ^{13}C, ^{19}F and ^{31}P) and utilize recent NMR techniques (J modulated spin echo, SEPT, INEPT) to determine the structure of a molecule.
- use of various modern techniques of mass spectrometry (CI, FAB, GC-MS, LC-MS TOF) to find the molecular mass and structure.
- identify unknown molecules using a combination of all the spectroscopic techniques.

Suggested Readings

1. Basic One and Two Dimensional NMR Spectroscopy, Horst Friebolin, 3rd edition, Wiley –VCH.
2. NMR in Chemistry, W. Kemp, Macmillan Education Ltd.
3. Structure Elucidation by Modern NMR, H. Duddeck, W. Dietrich and G. Toth, Spring, Springer – Verlag, New York.
4. Organic Spectroscopy, V. R. Dani, Tata MC Graw Hill, Delhi.
5. Spectroscopy of Organic Compounds, 6th edition, P. S. Kalsi, Wiley Eastern Ltd.
6. Spectroscopy, D. L. Pavia, G. M. Lampman, G. S. Kriz, Ceugage Learning India Private Ltd.
7. Modern NMR spectroscopy (in Bangla), M. Rabiul Islam and Mirza Aminul Huq, Ashrafia Boighar, Dhaka.
8. Modern Mass Spectrometry (in Bangla), Mirza Aminul Huq and M. Rabiul Islam, Bangla Academy, Dhaka.

SESSION: 2017-2018, 2018-2019, 2019-2020, 2020-2021

Course No. Chem. 531F 1 Unit, 4 Credits
Medicinal Chemistry 70+20+10=100 Marks

Learning Objectives

Learning objectives of this course are to

- impart knowledge on physicochemical properties and biological activity of drugs in correlation of structural features.

- provide understanding of drug metabolism and drug design.
- develop in-depth knowledge on the phenomena of cancer, ulcer and on the action of medicines used for the treatment of these diseases.
- make students understand mode of action of opium analgesics.

Course Content

1. Physicochemical Properties and Biological Activity of Drug: Drug-receptor interactions, hydrogen bonding and it's effect, drug absorption and biological membrane, factors affecting the accessibility of the drugs to the active site, drug transport.

2. Structural Features and Pharmacologic Activity: Influence of optical isomerism, influence of geometrical isomerism and conformational isomerism on drug activity.

3. Drug Metabolism: Pathways of metabolism, drug biotransformation pathways (phase 1): aromatic hydroxylation, oxidative deamination of amines, oxidation of alcohol, hydrolysis. Drug conjugation pathways (phase 2): glucoronic acid conjugation, sulfate conjugation and amino acid conjugation.

4. Drug Design: Optimizing target interactions: SAR method, pharmacophore, strategies in drug design: variation of substituents, extension tactics, isosteres & bioisosteres, simplification tactics, rigidification tactics, structure-based drug design & molecular modeling; optimizing access to the target: improving absorption, making drugs resistant to chemical and enzymatic degradation, targeting drugs, prodrug.

5. Anticancer Agents: Definition and cause of cancer, genetic faults leading to cancer, treatment of cancer, drugs acting on nucleic acid, drugs acting on enzymes, antibodies, antibody conjugates and antibody directed therapies.

6. The Opium Analgesics: History of opium, morphine:structure activity relationship; morphine analogues: variation of substituents, extension, simplification and rigidification; opioid receptors and mechanism of actions.

7. Antiulcer Agents: Definition and cause of peptic ulcers, treatment of peptic ulcer, gastric acid release, H_2 antagonists: histamine and histamine receptors, searching for a lead, cimetidine: biological activity, structure and activity, metabolism, ranitidine and its structure activity relationship, traditional and herbal medicines.

8. Introduction to Medicinal Plants: History of medicinal plants and ethonobotany, antifungal plants, fundamentals of phytotherapy, toxic plants and toxicity class, metabolic engineering of plant natural products.

Learning Outcomes

Upon completion of this course students will be able to

- explain the importance of pharmacokinetics, pharmacodynamics and metabolism of drugs.
- discuss the structure-activity relations of a given drug.
- describe mode of action of anticancer and antiulcer drugs.

Suggested Readings

1. An Introduction to Medicinal Chemistry, Graham L. Patrick, Oxford University Press.
2. Foye's Principles of Medicinal Chemistry, David A. Williams and Thomas L. Lemke, Lippincott Williams & Wilkins, New York.
3. Goodmund Gilman's The Pharmacological Basis of Therapeutics, 11^{th} edition, ed. Joel G. Hardman, Lee E. Limbard, McGraw-Hill.
4. An Introduction to Medicinal Plants, Ashwini Dutt, Adhyayan Publishers & Distributors.
5. Introduction to South American Medicinal Plants, Ingrid Roth and Helga Lindorf, Springer, Berlin.

SESSION: 2017-2018, 2018-2019, 2019-2020, 2020-2021

Course No. Chem. 532F 1 Unit, 4 Credits
Chemistry of Natural Products 70+20+10=100 Marks

Learning Objectives

Learning objectives of this course are to

- develop knowledge on extraction, isolation & purification of natural products.
- impart crystal clear understanding of the chemistry of important natural products like terpenoids, alkaloids, natural pigments, steroids and hormones.
- develop knowledge on biosynthesis of natural products and a basic idea about marine natural products.

Course Content

1. Biosynthesis of Natural products: Introduction, biosynthesis of carbohydrates (monosaccharides), terpenoids (Mono-, sesqui-, di- and triterpenoids), alkaloids (Quinoline, isoquinoline, phenanthrene, piperidine and indole alkaloids) and steroids.

2. Terpenoids: Extraction, isolation and purification; Characterization of terpenoids by chemical as well as physical methods (IR,UV, NMR and Mass spectroscopy) and synthesis with special reference to α-pinene and β-amyrin.

3. Alkaloids: Extraction, isolation and purification; Characterization of alkaloids by physical methods (IR,UV, NMR spectroscopy and Mass spectrometry), degradation experiments and synthesis with special reference to cocaine, colchicine and quinine.

4. Natural pigments: Introduction and classification; basic idea about carotenoids, flavonoids, xanthones, porphyrins. Characterization of flavonoids by degradation experiments and synthesis with special reference to quercetin. Synthesis of β-carotene.

5. Steroids and Hormones: Steroids : Introduction, chemistry of cholesterol, stigmasterol and saponins. Basic idea about steroidal alkaloids. Hormones: Introduction; classification; Chemistry of Sex hormones (testosterone), Adrenocortical hormones (cortisone) and plant hormones (gibberellins).

6. Marine Natural Products: General discussion about marine natural products.

Learning Outcomes

Upon completion of this course students will be able to

- understand the steps of biosynthesis of carbohydrates, terpenoids, alkaloids and steroids.
- know the extraction, isolation and purification of different natural products like terpenoids and alkaloids.
- describe the characterization of different terpenoids, carotenoids, flavonoids and alkaloids by chemical as well as physical methods.
- explain the natural pigments like carotenoids, flavonoids, etc.
- discuss the chemistry of different types of steroids, hormones and steroidal alkaloids.
- understand the basics of marine natural products.

Suggested Readings

1. Organic Chemistry, I. L. Finar, Longmans, Vol. 1 & 2, ELBS, Longman.
2. Natural Product Chemistry, K.B.G. Torssell, J. Wiley and sons New York.
3. Natural Products Chemistry, P. S. Kalsi, Kalyani Publishers, New Delhi.
4. An Introduction to the Alkaloids, G. A. Wawan, Blackwell Scientific.
5. Mono & Sesqui-terpenes, P. de Mayo, Inter Science.
6. Chemistry of the Alkaloids, S. W. Pelletier, Van Nostrand Reinhold.

SESSION: 2017-2018, 2018-2019, 2019-2020, 2020-2021

Course No. Chem. 533F 1 Unit, 4 Credits
Organic Synthesis 70+20+10=100 Marks

Learning Objectives

Learning objectives of this course are to

- provide an up-to-date account of modern methods of synthetic organic chemistry.
- go through radical, anion, cation, pericyclic and organometallic mediated processes, gaining new insights into the factors governing the mechanistic, stereochemical and regiochemical course of such processes.
- lay understanding of key transformations in-depth and to utilize them in synthesis.
- cover the strategies employed in the total synthesis of complex type of molecules.
- introduce different modes of energies (microwave, ultrasonic etc.) besides classical heating.

Course Content

1. Synthesis of alicyclic compounds (including fused ring system), Prismane, Basketene, Cubane, Triastaran, Tricyclo [2.2.0.0^{3,5}] hexane, Tricyclo [2.1.1.0^{2,5}] hexane, Tetrahedran and its derivative, Tricyclo [6.3.0.0^{2,6}] Undecane, Rotanes, Cyclophanes.

2. (i) Selectivity: definitions, stereotopic and stereofacial selectivity, Intramolecular symmetry, Topicity and Prochirality, (ii) Stereoselective reactions of carbonyl compounds Nucleophilic addition to carbonyl compounds use of a chiral substrate, Use of a chiral reagent, use of a chiral catalyst, asymmetric conjugate addition, addition of alkylboron derivatives, stereoselectivity of enolate formation alkylation of enolates, the aldol reaction, asymmetric aldol reactions, (iii) Stereoselective reactions of alkenes – The Diels-Alder reaction, chiral dienophiles, chiral dienes, chiral lewis acids, Bulky lewis acids, [2+2] cycloaddition reactions, Sigmatropic rearrangements, stereoselective hydroboration-substrate control, reagent control, catalyst control, stereoselective hydrogenation, stereoselective epoxidation, asymmetric dihydroxylation.

3. Enantioselective opening of epoxides, enantioselective deprotonation of ketones, asymmetric reactions of diketones, diacids and dilactones.

4. Synthesis of dyes: Introduction to dyes, definitions, requisites of a true dye, Era of natural dyes, Nomenclature of dyes Intermediates, nomenclature of dyes, Types of fibres, dyeing, Fastness properties, classification of Dyes, Synthesis of the following dyes: Eriochrome Black T, Eriochrome Black A, Eriochrome Red B, Diamond Black F, Direct Deep Black, Safranine T, Alizarine cyanine G, Rhodamine B.

5. Agrochemicals: Synthesis of organochlorine insecticides-Chlorobenzilate; cyclodiene group insecticides: Aldrin, endrin; organophosphorus insecticides- Dimecron (phospamidon), Azodrin (monocrotophos), Malathion, Ekalux, Fungicides-Ceresan-M, Dazomate, Herbicides: Proximpham, Asulam.

6. Liquid Crystals: Synthesis of liquid crystals – strategies and methods – introduction. Synthetic routes to calamitic liquid crystals, Synthetic routes to chiral liquid crystals, Synthetic routes to discotic mesogens.

Learning Outcomes

Upon completion of this course students will be able to

- appreciate how modern synthetic organic chemistry is conducted.
- propose plausible synthetic strategies or routes to complex organic structures.
- recognize suitable reagents for given transformations.
- suggest mechanistic or strategic rationales for given synthetic routes.

- understand the stereochemical principles on which asymmetric synthesis is based.
- explain the importance and value of total synthesis.
- describe the use of selected heteroelements, both metals and non metals, to facilitate synthetic transformations.
- achieve enough knowledge to make a laboratory based synthetic protocol viable for a commercial or an industrial scale.

Suggested Readings

1. Selectivity in Organic Synthesis, Robest S. Ward, John Wiley & Sons.
2. Stereoselective Synthesis, A Practical Approach, Mihaly Nogradi, VCH, Weinleim.
3. Stereoselective Synthesis in Organic Chemistry, Atta-Ur-Rahman & Zahir Shah Springer, Verlag.
4. Synthetic Dyes, Gurdeep R. Chatwa, Himalaya Publishing House.
5. Principles of Pesticide Chemistry, S. K. Handa, Agrobios (India).
6. Introduction to Liquid Crystals Chemistry and Physics, P. J. Collings and M. Hird, Taylor and Francis Publisher.
7. Organic Chemistry, I. L. Finar, Longman, Pearson.

SESSION: 2017-2018, 2018-2019, 2019-2020, 2020-2021

Course No. Chem. 534F 1 Unit, 4 Credits
Food Chemistry 70+20+10=100 Marks

Learning Objectives

Learning objectives of this course are to

- introduce students with food chemistry.
- provide in-depth knowledge on food additives and food contamination.
- acquaint students with milk & dairy products as well as cereals & cereal products.
- impart knowledge on fruits & fruits products and coffee, tea & cocoa and to create health awareness on the consumption of these type of food.
- expose students to usefulness of spices, salt and vinegar.

Course Content

1. Aromatic Substances: Concept Delineation; Aroma analysis; Aroma isolations; Separation; Chemical structure; Enantioselective analysis. Occurrence & Formation of Individual aroma compounds, e.g. Carbonyl compounds, Pyranones, Furanones Thiols, Thiophenes, Thiazols, Pyrroles, Pyridines, Pyrazine, Phenols, Alcohols, Esters, Lactones, Terpenes. Natural and Synthetic Flavorings.

2. Food Additives: Vitamins; amino acids, minerals, aroma substances; Flavor Enhancer, sugar substitutes; Sweeteners; Food colors; Antioxidants, Acids, bases; Thickening agents, Gel builders, Stabilizers; Humectants, Anticaking agents, Bleaching agents, Clarifying agents, Propellants & Protective gases, Surface-Active Agents e.g. Emulsion (Structure & activity), Synthetic emulsifiers.

3. Food Contamination: Toxic trace elements; Toxic compounds of microbial origin; Pesticides, Veterinary medicines and feed additives; Polychlorinated Biphenyls (PCB's), Polycyclic aromatic hydrocarbons, Nitrosamines, Cleansing agents and Disinfectants.

4. Milk and Dairy Products: Milk: Physical and Physico-chemical Properties; Composition; Processing of milk, Types of Milk, Dairy Products: Production of Fermented milk products, e.g. Sour milk, Yoghurt, Taette milk, Cream, Butter, Condensed milk, Dehydrated milk products, Ice cream, Cheese; Casein; Whey products, Lactose, Aroma of milk and diary products, metabolic process.

5. Cereals and Cereal Products: Introduction, Origin, Chemical composition, Celiac disease; Individual constituents; Role of Enzymes in processing; Cereals-milling; Baked Products & Pasta products (Assay, Additives, Production, Tests).

6. Fruits and Fruit Products: Fruits: Composition, N-containing compounds Carbohydrales, Lipids, Organic acids, Phenolic compounds: Hydroxyaromatic acids, Flavonoid compounds, Anthocyanidins; Aroma compounds in different fruits, Vitamins & minerals in fruits, chemical changes during ripening of fruits, ripening as influenced by chemical agents; Fruit Products: Production and Preservation–Dried fruits, Canned fruits, Deep frozen fruits, Fruits in Sugar Syrups, Fruit juices; fruit Nectars, fruit juice concentrates, Fruit syrups, Fruit powders; Fruit juice beverages, Lemonades; Caffeine containing beverages, analysis.

7. Coffee, Tea, Cocoa: Coffee and coffee substitutes (Harvesting and Processing, Composition, Coffee Products); Tea and Tea-like products (Harvesting and Processing, Composition, reactions involved during processing, Products); Cocoa and Chocolate (Harvesting and Processing, Composition, Reactions during fermentation and drying).

8. Spices, Salt and Vinegar: Spices: Composition, Aroma substances (Biosynthetic pathway), Pigments, Antioxidants, Products, Spices powder, extracts and Concentrates, Blended spices, Preparation, Curry powder, Mustard; Salt: Composition, Occurrence, Production, Special salt, salt substitutes; Vinegar: Production, Microbiological production, Chemical synthesis, Composition.

Learning Outcomes

Upon completion of this course students will be able to

- describe clearly food additives and food contamination.
- explain chemistry and importance of milk & dairy products and cereals.
- analyze fruit & fruit products and coffee, tea, cocoa and know the advantages and disadvantages of these food.
- discuss usefulness of spice, salt and vinegar.

Suggested Readings

1. Food Chemistry, H. D. Belitz and W. Grosch, Springer Verlag, Berlin.
2. Food Flavours: Biology and Chemistry, Carolyn Fisher and Thomas R. Scott, RSC.
3. Flavor Chemistry: Industrial and Academic Research, Edited by Sara J. Risch and Chi-Tang HO, American Chemical Society.

SESSION: 2017-2018, 2018-2019, 2019-2020, 2020-2021

Course No. Chem. 535F 1 Unit, 4 Credits
Fragrance Chemistry 70+20+10=100 Marks

Learning Objectives

Learning objectives of this course are to

- impart an understanding of the principles of chemistry and their vital importance to fragrance technology.
- make them know the ever-evolving technology of essential oil extraction.
- help acquire knowledge of the artisty of blending multiple scents and the growing use of synthetic essences.
- provide knowledge on the complex process of product development from raw materials and ingredients for formulations, applications and finished products.
- acquaint the legal, regulatory and technological standards governing beauty products.

Course Content

1. Introduction: Definition of Fragrance, Human Primary Odours; Odour Classes; Commercial Classes of Fragrance.

2. Structure-Odour Relationships: Regioselectivity, Stereochemistry, Geometry of Unsaturated Compounds; Influence of Substituents, Diestereoselectivity Triaxial Rule, The Bifunctional Unit, Enantioselectivity; QSAR (Quantitative-Structure-Activity-Relationship), Quantitative Odour Perceptions.

3. Natural source of fragrance molecules; essential oils and terpenes; monoterpenes and sesquiterpenes; synthetic derivatives of natural fragrance molecules e.g. α- and β-Pinene, 3,7-Dimethylocta-1,6- diene, myrcene and related compounds.

4. Perfumes of etherial oils: Isolation from natural source & synthetic pathway to Ionones, rose ketones and rose alcohols, patchouli alcohols, Jasminols, violet odourants, Osmanthusols, Drimane and Dinorlabdanes.

5. Fragrance molecules from petro-chemical source, Isoprene, Isobulylene and 3- methyl-1- buten-3-ol as source material.

6. Perfumes of Animal source and the synthetic methods for the followings: Muscon, exalton, zibeton, exaltolid, ambrox, ambraldehyde.

7. Musks : Nitromusks, Polycyclic Musks, Macrocyclic Musks, Perfume ingredients from Benzene, Toluene, Phenol, Naphthalene, Cyclopentanone and Dicyclopentadiene.

8. The Application of Fragrance: Fine Fragrance, Vegetable Soap, Aerosol, Antiperspirant, Shampoo, Shower and Bath Gel, Lipstick, Nailpolish, Toothpaste, Bodylotion, Face powder, Deodorant, Aftershave, Hairspray, Sunscreen.

9. The Safety and Toxicology of Fragrance: Safety Assessment, Skin Irritation, Skin Sensitization, Photoeffets, Neurotoxicity, Reproductive effects etc.

Learning Outcomes

Upon completion of this course students will be able to

- know the natural source of scents as well as can synthesize the fragrance molecules.
- formulate products from raw materials and develop their individual skills in scents production.
- identify scents, categorize it according to essence.
- differentiate the good effects of utilization of cosmetics from its adverse effects.

Suggested Readings

1. Scent and Chemistry: The Molecular World of Odors, Guenther Ohloff, Wilhelm Pickenhagen and Philip Kraft, Verlag Helvetica Chimica Acta, Wiley-VCH, Zurich.
2. The Chemistry of Fragrances, David H. Pybus and Charles S. Sell, RSC, Paperbacks.
3. Chemistry of Fragrant Substances, Paul Jose Teisseire VCH Publishers, Inc. Weinheim.
4. Scent and Fragrances, Wilhelm Pickenhagen & Brian M. Lawrence (Riechstaffe und Geruchssinn, G. Ohloff), Springer-Verlag, Berlin.

SESSION: 2017-2018, 2018-2019, 2019-2020, 2020-2021

Course Chem. 536LF 1 Unit, 4 Credits
Course Chem. 537LH ½ Unit, 2 Credits
Separation by Chemical & Chromatographic Methods and Multistep Synthesis 35+10+5=50 Marks

Learning Objectives

Learning objectives of this course are to

- provide practical knowledge on the separation techniques of the two components from a mixture by chemical and chromatographic methods.
- help the students carrying out extraction of volatile components from plants by steam distillation.
- expose the students to synthesize of chemical compound, spiro-Δ^2-1,2,3,4-thiadiazoline by two steps.

Course Content

Exp. No. 1 : Separation of two components and partial identification.
Exp. No. 2 : Separation of two components mixture by column chromatography.
Exp. No. 3 : Separation of carbohydrate mixture by paper chromatography.
Exp. No. 4 : Extraction of natural products by steam distillation.
Exp. No. 5 : Two step synthesis of spiro-Δ^2-1,3,4-thiadiazoline via thiosemicarbazone of carbonyl compounds.

Learning Outcomes

Upon completion of this course students will be able to

- perform the separation of two compounds from a mixture by chemical method and check their purity by thin layer chromatography.
- identify partially the separated compounds by chemical methods.
- separate the components from a mixture by chromatographic methods.
- extract the volatile components from plants by steam distillation.
- carryout multistep synthesis of chemical compounds and work-up of the products.
- monitor the progress of a reaction and check purity of the product/products by TLC methods.

Suggested Readings

1. Text Book of Practical Organic Chemistry, Vogel's, 5th edition, ELBs with Longman.
2. Laboratory Mannual.
3. Systematic Identification of Organic Compounds, R. L. Shriner, R. C. Fuson and D. Y. Curtin, John Wiley Sons, Inc. New York, London, Sydney, 5th Edition.