DEPARTMENT OF CHEMISTRY
JAHANGIRNAGAR UNIVERSITY
SAVAR, DHAKA.

Curriculum/Syllabus for M.Phil/Ph.D in Chemistry

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

The admission to M.Phil/Ph.D course in chemistry will be in accordance with the ordinance for the degree of master of philosophy of this university. A student admitted to M.Phil/Ph.D course will have to undertake two years full time supervised study in the department under the guidance of a supervisor/supervisors. The department will offer courses of specialization in selected branches of chemistry e.g., Physical, Inorganic, Organic etc. and the degree of M.Phil/Ph.D shall consist of (a) written examination on approved courses, (b) submission of a thesis on an approved topic and (c) an oral examination. The department will offer a number of courses in the first year from which a student will have to take courses covering 200 marks, which will be determined by the respective supervisor/supervisors. There will be an examination on the approved courses at the end of the first year, the pass marks for the courses will be 50%. The M.Phil. students will be required to carry out research on approved topics both in the first and second year and give a minimum of two seminars on topics in his field of research and approved by the supervisor and the full time Ph.D. students will be required to carry out research on specific approved topic for at least 3 years while the minimum research period for part time Ph.D. student will be 5 years. The student will submit a thesis on the approved topic with necessary approval of the supervisor/supervisors and will have to appear at an oral examination provided his thesis is recommended for acceptance by the examiners.

The following courses will be offered for the degree of Master of Philosophy in Chemistry during these sessions.

Course No.	Title of the course	Marks
Chem. 610	Advanced Surface Chemistry	100
Chem. 612	Advanced Electrochemistry	100
Chem. 614	Advanced Polymer Chemistry	100
Chem. 616	Advanced Biophysical Chemistry	100
Chem. 620	Organometallic Chemistry	100
Chem. 622	Coordination Chemistry	100
Chem. 624	Advanced Theory & Spectroscopic Methods in Inorganic Chemistry	100
Chem. 626	Environmental Chemistry	100
Chem. 626	Environmental Chemistry	100
Chem. 630	Physical Organic Chemistry and Spectroscopic Methods in Organic Chemistry	100
Chem. 632	Chemistry of Natural Products and Biosynthesis	100
Chem. 634	Biochemistry	100
Chem. 638	Organic Synthesis	100
Chem. 650	Nuclear and Radiochemistry	100
Chem. 660	Advanced Analytical Chemistry	100

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

Course No. Chem. 610 1 Unit, 4 Credits
Advanced Surface Chemistry 100 Marks

Learning Objectives

Learning objectives of this course are to

- realize the phisico-chemical behavior of colloidal aggregate in solution
- prepare students for advanced studies involving biophysical processes
- attain depth concepts on adsorption, micellization, emulsification, solubilization, stability of colloidal aggregate as well as catalytic behavior of micelle in organic reactions
- achieve knowledge to learn principle of physic-chemical techniques such as electrophoresis, electro osmosis, solubilization etc. and electrokinetic phenomena.

Course Content

1. Introduction: Surface tension, origin of surface tension, surface tension as surface free energy, the Laplace equation, the Kelvin equation, the Young equation, adhesion, cohesion & spreading; measuring surface tension and content angles; surface viscosity; adsorption from solution and its applications; electrocapillarity, auger electric spectroscopy and its application to solid surfaces.

2. Physical adsorption at the gas-solid interfaces: Adsorption isotherms; multilayer adsorption; the BET equation; specific surface area; heats of adsorption; capillary condensation and adsorption.

3. Structures and solution behavior of surfactants: Surfactants, Classification, solution behavior, Micelle; Electrical double layer: Gouy Chapman theory, The diffuse double layer; Micellar structure and shape, Micellar aggregation numbers, Critical Micelle Concentration (CMC), Determination of CMC, Effect of different factors on CMC, Micelle ionization and thermodynamics of micellization; Kraft point, Cloud point temperature (CP), importance of clouding phenomenon, thermodynamics of clouding, Effect of additives on CP; Demicellization, Reverse micelles.

4. Two component and Multi component surfactant systems: Mixed micellization, industrial importance of mixed micellization, Critical Micelle Concentration (CMC), ideal CMC of mixed micelle, mole fractions and interaction parameter of mixed micelles.

5. Stability of colloidal aggregate: Potential energy due to electrical double layers and Vander Waals forces; Total potential energy and Schulze-Hardy rule.

6. Solubilization and micellar catalysis: Solubilization, phase rule and thermodynamics of solubilization, factors determining the extent of solubilization; Micellar catalysis: Effects of micelle on different reactions, micelle-catalyzed reactions, Inhibition in micellar solutions.

7. Detergency and its modification by surface active agents: Detergency, Mechanism of the cleaning process: Removal of soil from substrate, skin Irritation, Dry cleaning; Effect of water hardness: Builders, Lime soap dispersing agents; Fabric softeners, Relation of chemical structure of surfactants to detergency.

8. Emulsification by surfactants : Emulsion and Emulsification; micro-emulsions: Different types, formation, factors determining stability, inversion, Multiple emulsion; Theories of Emulsion Type, Nano emulsions, selection of surfactants as emulsifying agents: HLB, PIT & HLD methods, Demulsification.

Learning Outcomes

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

- describe the methods to determine the surface tension of liquids/ solutions

- understand the type of molecular surfactant aggregate
- describe the nature of bonding in case of the micellization process
- illustrate the effect of different factors on the critical micelle concentration
- use scientific notation for expressing different physico-chemical parameters
- calculate specific surface area of any substance
- understand the solubilization of water insoluble materials by surfactants
- explain the kinetic behavior of micelle-catalyzed reactions
- understand the mechanism of cleaning process
- relate the chemical structure of surfactants to detergency
- prepare emulsion of different categories
- predict the factors influencing the stability of emulsion
- select different surfactants as emulsifying agent in applied fields
- analyze different types of data regarding physical processes.

Suggested Readings

1. Physical Chemistry of Surfaces, Adamson, Wiley, N.Y.
2. Surfactant and Interfacial Phenomena, M. J. Rosen, Wiley, Interscience, New York.
3. Heterogeneous Catalysis, Principles and Application, Bond Clavendon press, Oxford.
4. Micelles - Theoretical and applied aspects, Yoshikiyo Moroi, Plenum press, New York.

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

Course No. Chem. 612 1 Unit, 4 Credits
Advanced Electrochemistry 100 Marks

Learning Objectives
The main learning objective of this course is to teach the students acquiring the knowledge on advanced electrochemistry, electro-chemical techniques and their applications

Course Content

1. Polarization and decomposition potential: Causes of polarization, Explanation of polarization, Demonstration and Remedy of polarization, Decomposition voltage, Measurement, Importance and Significance of decomposition potential.

2. Overvoltage or overpotential: Introduction, Hydrogen evolution reactions, Tafel equation, Factors affecting hydrogen overpotential, Measurement of overpotential, Theories of overpotential, Oxygen evolution reactions, Possible mechanism of anodic oxygen evolution reaction, Importance of overvoltage.

3. Voltammetry and Polarography: Introduction, Principle, Apparatus, Brief description of polarographic measurements, Current voltage relationship, Interpretation of polarographic wave, Equation for the polarographic wave, Half wave potential, Reversible waves, Irreversible waves, Different kinds of currents contributing to the polarographic wave: charging or residual current, migration current, diffusion current; Polarographic cells, the dropping mercury electrode (DME), advantage and limitations, Common Voltammetric Methods: (a.) Direct Current Methods: Linear Sweep Voltammetry, Sampled DC Polarography, Hydrodynamic Voltammetry (b) Pulse Methods: Normal Pulse Voltammetry, Differential Pulse Voltammetry, Square Wave Voltammetry, Cyclic Voltammetry (c) Stripping Methods: Anodic Stripping Voltammetry, Cathodic Stripping Voltammetry, Adsorptive Stripping Voltammetry, (d) Alternating Current Methods, Summary

4. Amperometric Analysis: Instrumentation, Indicator electrodes, Reference Electrodes, Amperometric and potentiometric titrations, Advantages and disadvantages of amperometric titrations, Applications of amperometric titrations.

5. Culometric Analysis: Introduction, general characteristics of coulometric methods, constant current coulometry, Applications of coulometric titrations, Controlled potential coulometric analysis, Experimental conditions, Applications, Determinations of films and coatings, Stripping coulometry, Voltage scanning coulometry, Advantages of coulometry.

6. Electrochemical dissolution and Passivity of metals: Introduction, Anodic dissolution of metals, Chemical and mechanical passivity, Electochemical Passivity, General characteristics of passive state of metals, Theories of passivity.

7. Corrosion: Introduction, Types of corrosion, Chemical corrosion or dry corrosion, Wet or electrochemical corrosion, Factors affecting chemical corrosion, Theories of wet corrosion, Galvanic corrosion, Concentration cell corrosion, Atmospheric corrosion, Open air corrosion, Soil corrosion, Prevention of Corrosion.

Learning Outcomes

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

- understand polarization and overpotential, explain its origin and the measurement of overpotential
- explain modern electrochemical methods such as: voltammetry and polarography, its principle and applications
- describe classical electrochemical methods such as: amperometry, coulometry, etc.
- discuss electrochemical dissolution and passivation of metals.
  understand corrosion and its prevention.

Suggested Readings

1. Electrochemistry, B. K. Sharma, 5Th Edition, GOEL Publishing House, India.
2. Electrochemistry: Fundamentals and Applications, A. J. Bard, John Wiley & Sons Inc
3. Instrumental Analysis, D. A. Skoog, F. J. Holler and S. R. Crouch.
4. Electroanalytical Chemistry, J. Wang, 3rd Edition, John Wiley & Sons Inc., 2006
5. Modern Electrochemistry 2B: Electrodics in Chemistry, Engineering, Biology and Environmental Science, J.O'M. Bockris and A. K. N. Reddy, 2nd Edition, Springer, 2001.

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

Course No. Chem. 614 1 Unit, 4 Credits
Advanced Polymer Chemistry 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. The Interaction of polymers and liquids: Thermodynamics of solutions, the Flory-Huggins treatment, Phase equilibrium of the polymer solution, fractionation crystalline polymers, viscosities of polymer solutions, polyelectrolytes.

2. (a) Determination of molecular weight and size: End group analysis, colligative property measurement. Light scattering, solution viscosity and molecular size, ultracentrifugation. (b) Characterization of polymers: Visible and UV light, infrared spectroscopy, NMR and EPR, X-ray and electron diffraction, thermal analysis of polymers, chromatography.

3. Rheology and the mechanical properties of polymers : Viscous flow, kinetic theory of rubber elasticity, viscoelastic behaviour of amorphous polymers (incompressible viscoelelastic material; time effects, time-temp. equivalence principle, effects of molecular architecture on viscoelastic properties, effect of chemical composition on viscoelastic properties).

4. Chemistry structure and properties of some commercial polymers: Hydrocarbon plastics & elastomers; heterochain thermoplastics, thermosetting resins, cellulose polymers.

5. Polymer processing: (a) Plastic Technology: molding, filters, plasticzeers & other additives; (b) Fiber technology; textile & fabric properties, Fibre spinning, spinning fiber after-treatment; (c) Elastomer Technology: volcanization, reinforcement; (d) Surface finishes: Traditional types of surface finishes, Electrodeposition.

6. Polymers of advanced technologies: (a) Membrane science and technology: Barrier polymers, membrane separations, mechanism of transport, membrane preparation; (b) Biomedical Engineering and Drug delivery: Introduction, Kidney dialysis, control drug delivery; encaptulation (c) Applications in electronics: Electrically conductive polymers, electronic shielding, dielectrics.

7. Engineering and Specialty polymers: (a) Enginnering thermoplastics synthesis and applications of polyamides, polycarbonates, polysulfones, engineering polyesters and fluoropolymers; (b) Specialty polymers: Synthesis and applications of ionic polymers, liquid crystal polymers, conductive polymers, high-performance fibres.

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. Text Book 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. Introduction of Polymer Chemistry (pergamon), D. Margerison; G. C. East.
5. Polymer Chemistry, M. G. Arora, M. Singh.
6. Text Book of Polymer Science (Willey), Fred W. Billmeyer.
7. Introductory Polymer Chemistry, G. S. Misra, Wiley Eastern Limited, India.
8. An Introduction to Polymer Chemistry, H. R. Moore.
9. Polymer Science and Technology, Joel R. Fried.
10. Fundamental Principles of Polymetric Materials; Stephen L. Rosen.

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

Course No. Chem. 616 1 Unit, 4 Credits
Advanced Biophysical Chemistry 100 Marks

Learning Objectives

The learning objectives of this course are to

- examine fundamental physical principles underlying complexbiological systems in order to understand the interactions and behaviors found in biological,biochemical, and physical systems
- know ligand-macromolecule binding equilibrium, dialysis, electrochemical potentials
- realize the enzyme-catalyzed reaction rates of drugs, poisons and hormons as well as kinetics of bacterial growth & decay.
- Understand photochemical processes and there effect on atmosphere and human health

Course Content

1. Biochemical Thermodynamics: The Second Law: Entropy, the direction of spontaneous change,entropy and the second law, the entropy change accompanying - heating, phase transition; Absolute entropies and the third law of thermodynamics;Life and the second law of thermodynamics ; The Gibbs energy of assembly of proteins and biological membranes: (a) The structures of proteins and biological membranes (b) The hydrophobic interaction; Work and the Gibbs energy change; The action of adenosine triphosphate.

2. Chemical Reactions and Equilibrium: Reactions in solution, Binding of Ligands and and Metals Ions to Macromolecules; One and *n* Equivalent binding side per molecule, scatchard plot, cooperative binding, Hell plot, Bioenergetics: The standard state in Biochemistry, ATP- the currency of energy, Macromolecular solubility:donnan equilibrium, dialysis, equilibrium dialysis, "Salting-In and "Salting-Out" effect.

3. Electrolyte Solutions and Electrochemistry: Donnan effect; Biological Membranes, Membrane Transport: simple diffusion, facilitated diffusion, active transport; Biological Oxidation: the chemiosmotic theory of oxidative phosphorylation; Membrane potential: the Goldman equation, action potential.

4. Enzyme kinetics: Enzyme catalysis, Equation of enzyme kinetics, Michaelis-Menten kinetics, Steady state kinetics, significance of Km and Vmax, the catalytic efficiency of enzymes;Multisubstrate systems: sequential mechanism, the non-sequential mechanism; Enzyme inhibition: Reversible inhibition, Irreversible inhibition; pH effects on enzyme kinetics;Pharmacokinetics; Fast events in protein folding;Mechanisms of protein folding and unfolding.

5. Photochemistry and Photobiology: Introduction: Thermal versus photochemical reaction, primary versus secondary processes, quantum yield; Earth atmosphere: Composition of atmosphere, green house effect; Photochemical Smog: Formation of Nitrogen oxides, formation of Ozone, formation of Hydroxyl radical, Harmful effects and prevention of photochemical smog; Photosynthesis: Chloroplast, chlorophyll and other pigment molecules, reaction center; Biological effect of radiation: Sunlight and skin cancer, photomedicine, light activated drug.

Learning Outcomes

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

- explain the physical chemistry of biological systems
- discussthe ligand-macromolecule binding equilibrium, equilibrium dialysis,salting-in and salting-out phenomena
- understand biological oxidation, membrane potential, dissociation of amino acids, maintaining the pH of blood

- understandMichaelis-Menten kinetics, kinetics of bacterial growth and kinetics of drug actions
- explore kinetic data for different biological processes.
- Explain the effect of radiation on human and there prevention and understand photochemical processes

Suggested Readings

1. Physical Chemistryfor Biological and Chemical Sciences,Raymond Chang.
2. Physical Chemistry for the Life Sciences, Peter Atkins and Julio de Paula.

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

Course No. Chem. 620F 1 Unit, 4 Credits
Organometallic Chemistry 100 Marks

Learning Objectives

The learning objectives of this course are to

- impart knowledge on synthesis, structure, bonding, properties and reactivity of main group organometallics, Organotransition metal chemistry and catalytic reactions.
- promote knowledge on the basics of typical Organometallic and cluster compounds.

Course Content

1. General introduction to the types of compounds most frequently encountered; the 18-electron rule and its applicability

2. Preparative, Structural and Bonding aspects (including fluxional behaviour) of Individual Transition Metal Ligand Linkages i.e.
(a) 2-electron donor such as Zeise salt & other mono-olefin complexes;
(b) 3-electron donor, such as π-allyl & π-enyl complexes;
(c) 4-electron donor, such as conjugated diolefin & cyclobutadiene complexes;
(d) 5-electron donors, such as π-cyclopentadienyl complexes;
(e) 6-electron donor such as arene complexes.

3. Stoichiometric Applications of Organometallic Compounds to Organic Synthesis
(a) Main group element compounds: (i) Organomagnesium compounds; (ii) Organosilicon compounds; (iii) Organotin compounds.
(b) Transition metal compounds: (i) Organotitanium compounds; (ii) Organoiron compounds; (iii) Organonickel compounds; (iv) Organocobalt compounds; (v) Oganorhodium compounds; (vi) Organopalladium compounds.

4. Catalytic Applications of Organometallic Compounds
(a) Hydrogenation of unsaturated hydrocarbons: (i) Hydrogenation using $(Ph_3P)_3RhCl$;
(ii) Hydrogenation using other rhodium and iridium catalysis; (iii) Asymmetric hydrogenation.
(b) Reactions involving carbon monoxide: (i) Hydroformylation;(ii) Carbonylation of methanol.
(c) Reactions of unsaturated hydrocarbon involving C-C coupling: (i) Dimerization of alkenes;
(ii) Polymerization of alkenes; (iii) Polymerization of butadiene; (iv) Oligomerization of butadiene; (v) Cyclotrimerization of alkynes; (vi) Isomerization of alkenes.
(d) Application of organometallic complexes in nonlinear optics, metal vapour deposition and other novel materials.

5. Trinuclear Clusters of Osmium, Ruthenium and Iron:
   (a) Historical context and background;
   (b) Synthesis, structure and reactivity of the following starting materials.
   (i) $[M_3(CO)_{12}]$ (M = Os, Ru, Fe); (ii) Clusters $[M_3(CO)_{11}(MeCN)]$ and $[M_3(CO)_{10}(MeCN)_2]$ (M = Os, Ru, Fe); (iii) Cluster $[\mu\text{-}H)_2Os_3(CO)_{10}]$.
   (c) General comparisons between ruthenium and osmium clusters
   (d) Electron counting in triruthenium and triosmium clusters.
   (e) Synthesis, structure and reactivity of some important electron deficient compounds.

Learning Outcomes

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

- explain the 18 –electron rule, that governs the stability of organometallic complexes and its application.
- explain and rationalize the synthesis, structure, bonding, properties and reactivity of both main group and transition metal Organometallic compounds by 2, 3, 4,5 and 6-electron donor ligands.
- describe the applications of organometallic chemistry including catalytic reactions for organic synthesis and polymerization
- interpret and rationalize the synthesis, structure, and reactivity of trinuclear cluster of iron, ruthenium and osmium.

Suggested Readings

1. Principles of Organometallic Chemistry, G. E. Coates, M. L. H. Green, P. Powell and K. Wade, Chapman and Hall publishing, USA.
2. Organometallic Compounds, Vol. 1 & 2 G. E. Coates, M. L. H. Green and K. Wade, Chapman and Hall publishing, USA.
3. Organometallics 1: Complexes with transition metal carbon σ-bonds; M. Bochmann Oxford Science Publications, Macmillan.
4. Organometallics 2: Complexes with transition metal-carbon π-bonds; M. Bochmann Oxford Science Publications, Macmillan.
5. An Introduction to Organometallic Chemistry, A. W. Parkins and R. C. Poller, Macmillan Publishers Ltd, London.
6 Advanced Inorganic Chemistry, 4th edition, F. A. Cotton & G. Wilkinson, John Wiley and Sons.
7. An Introduction to Inorganic Chemistry, K. F. Purcell and J. C. Kotz, Thompson Learning publications.
8. Principles and Applications of Organotransition Metal Chemistry, J. P. Collman & L. S. Hegedus.
9. Metal Clusters, B. F. G. Johnson (ed)., John Wiley and Sons.
10. Introduction to Cluster Chemistry, D. M. P. Mingos and D.I. Wales, Prentice-Hall Int., Inc.

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

Course No. Chem. 622 1 Unit, 4 Credits
Coordination Chemistry 100 Marks

Learning Objectives

The learning objectives of this course are to

- provide students the knowledge of crystal field theory, electronic absorption spectra, structural and thermodynamic effects of inner orbital splitting.
- impart knowledge on molecular orbital theory and inorganic reaction mechanism and synthesis.

Course Content

1. The Electrostatic Crystal Field Theory: The splitting of d orbitals by electrostatic fields, trigonal-bipyramidal complexes: Some consequences and applications of orbital splitting: (Magnetic properties from crystal field theory). Electronic Absorption spectra: (Octahedral and Tetrahedral complexes, spectrochemical series). Structural and thermodynamic effects of inner orbital splitting: Jahn-Teller effects, adjustments to the CFT to allow for covalence. Experimental evidence for metal-ligand orbital overlap. The theoretical failure of an ionic model, ligand field theory. Molecular orbital theory: qualitative principles, quantitative calculations, charge transfer spectra.

2. Inorganic Reaction Mechanism: Mechanism of electron transfer reaction: outer sphere electron transfer reaction & inner sphere electron transfer reaction. Synthesis of compounds using electron transfer reactions. Substitution reactions: Mechanism of square planar substitution reactions. Mechanism of octahedral substitution. Synthesis of coordination compounds by substitution reaction.

Learning Outcomes

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

- understand the key features of coordination compounds, including:
  - the variety of structures
  - oxidation numbers and electronic configurations
  - coordination numbers
  - ligands, chelates
  - bonding, stability of complexes
- understand nomenclature of coordination compounds and to be able to draw the structure of the complexes
- understand isomerism in coordination compounds
- use Crystal Field Theory to understand the magnetic properties (and in simple terms the colour) of coordination compounds
- determine the stability of metal complexes using formation constants and to calculate thermodynamic parameters from them
- Explain some applications of coordination compounds
- calculate oxidation state and number of d electrons for a metal atom in a complex
- understand the factors which determine whether a complex is high or low spin
- understand the reaction mechanism involved in the synthesis of coordination compounds.

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. 624F 1 Unit, 4 Credits
Advanced Theory and Spectroscopic Methods in Inorganic Chemistry 100 Marks

Learning objectives

The learning objectives of this course are to

- impart knowledge on organoboron compounds hydrides and carboranes.
- provide knowledge about metal clusters bonding and structure of polynuclear metal carbonyls.
- promote knowledge about polymeric compounds of boron phosphorus and sulfur.
- convey knowledge on different spectroscopic methods such as UV-Visible, IR NMR spectral data and ESR to elucidate the structure of inorganic compounds
- impart knowledge on mass spectral data and fragmentation pattern to determine the molecular weight and structure.

Course Content

1. Molecular polyhedra: (a) Boron hydrides: structure & bonding, synthesis and reactivity of the boron hydrides, carboranes and metallocarboranes. (b) Metal clusters: bonding and structure of polynuclear metal carbonyls.
2. Inorganic polymers: Chemistry of the polymeric compounds synthesis, reactions and their strutures.
3. Applications of the following spectroscopic methods in inorganic chemistry: (a) Ultraviolet Spectroscopy; (b) Infrared Spectroscopy; (c) Nuclear Magnetic Resonance spectroscopy; (d) Electron Spin Resonance Spectroscopy; (e) Mass Spectrometry.

Learning Outcomes

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

- understand boron polymers and bonding and structure of polynuclear metal clusters
- understand polymeric compounds of Boron phosphorus and sulfur.
- interpret an IR spectrum to find the nature of bonds present in an Inorganic compound.
- use IR spectrum to identify geometric isomers and monitor chemical reactions involving carbonyl compounds.
- analyze the UV-Visible spectrum to find the type of chromophores and purity of the compounds.
- interpret different types of NMR spectra specially ^{1}H, ^{13}C and 2D to determine the structure of a molecule.
- apply mass spectral data 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, H. 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.
4. Organic Spectroscopy, V. R. Dani, Tata McGraw Hill, Delhi.
5. Introduction to Spectroscopy, D. L. Pavia, G. M. Lampman, G. S. Kriz, Cengage Learning India Private Ltd.
6. Spectroscopy of Organic Compounds, 6th edition, P. S. Kalsi, Wiley Eastern Ltd.
7. NMR in Chemistry-A multinuclear Introduction, W. Kemp, MACMILLAN Education Ltd.
8. Modern Inorganic Chemistry, William L. Jolly, 2nd ed., McGraw-Hill International edition.
9. Inorganic Chemistry, D. F. Shriver, P. W. Atkins and C. H. Langford, E. L. B. S.
10. Inorganic Chemistry, Alan G. Sharpe, E. L. B. S and Longman.

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

Course No. Chem. 626F 1 Unit, 4 Credits
Environmental Chemistry 100 Marks

Learning Objectives

The learning objectives of this course are to

- train advanced professionals on scientific research, teaching, environment protection, and environment administration. With emphasis on natural science, humanities and social science, they can have a systematic command of the fundamentals on environment science and can meet the demands of socialist construction.

Course Content

1. Analytical methods for monitoring of many environmental problems from estuary pollution to water supplies and materials from local industry and agriculture.

2. General concept of pollution, pollution of physical environment, pollution caused by nature.

3. Air pollution: Short range and long range transport; Transport and transformations of the air pollutants.

4. Industrial pollution: Chemical treatment of industrial wastes; Waste water treatment.

5. Soil pollution: Chemical treatment of the soil; Biogeochemical studies of the soil; Contamination of soil by various heavy metals including lead.

6. Agrochemicals: Chemical fertilizers and pesticides; Behaviour of pesticides in soil; Mode of action of pesticides; Environment friendly fertilizers and pesticides.

7. Biogeochemical cycles of carbon and sulfur : Carbon cycle and green house effects; Acid rain and sulfur cycle, Interrelationship of sulfur and carbon cycle.

8. Environmental regulations and policy planning social awareness and motivations.

Learning Outcomes

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

- know the analytical techniques for monitoring environmental problems.
- understand the general concept of different pollution like water pollution, air pollution, industrial pollution, soil pollution etc.
- know the behavior of pesticides in soil and the mode of action of pesticides.
- know the environmental regulations and policy.

Suggested Readings

1. Environmental Chemistry, S. Manahan, S, E. Manahan, CRC Press.
2. Handbook of Chemical Technology and Pollution Control, M. B. B. Hocking, Academic Press, USA.
3. Environmental Chemistry, R. W. Raiswell, P. Brimblecombe, D. L. Dent, P. S. Liss, Edward Arnold group, London, UK.
4. Environmental Chemistry, J. W. Moore & E. A. Moore, Academic Press, London, UK.
5. Science, Environment and Disaster, S. S. Ullah.
6. Green Chemistry, The Royal Society of Chemistry, London.
7. National Documentation on the Problems of Arsenic and Farakka, IFC, NY.

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

Course No. Chem. 630 1 Unit, 4 Credits
Physical Organic Chemistry and Spectroscopic Methods in Organic Chemistry 100 Marks

Learning Objectives

Learning objectives of this course are to

- review on electrophilic substitution with special reference to non-benzenoid aromatic compounds and on generation & reactions of C^+, C^-, free radicals.
- impart knowledge on symmetry controlled reactions.
- provide detail concept on photochemistry, conformational analysis & stereochemistry.
- provide in depth knowledge to solve structural problems with spectra/spectral data.
- impart knowledge on correlation of all the spectroscopic data with relevant arguments to a final structure of organic molecules.

Course Content

Group A: Physical Organic Chemistry

1. Aromaticity: The Huckel rule. Review of electrophilic, substitution, non-benzenoid aromatic compounds: azulene, annulenes, tropones etc.
2. Review on generation and reactions of C^+ ,C^- and free radicals.
3. Orbital symmetry and the chemical reaction. Electrocyclic reactions, cycloaddition reactions, sigmatropic reactions.
4. Photochemical reactions: Isomerisation, molecular, rearrangement, Bartom reaction. Thermal reaction: Cycloaddition, Claisen rearrangement, Cope rearrangement.
5. Conformational analysis and stereochemistey. Influence of ring size on the reactivity of substituent groups. Chemistry of small ring, normal rings, medium and large rings, bridged rings and large molecules.

Group B: Applications of the following spectroscopic methods in organic chemistry

1. Ultraviolet spectroscopy: Empirical rules for λmax calculation and differentiation of isomers, study of simple and complex molecules, applications: qualitative and quantitative.
2. Infrared spectroscopy: FTIR and Raman spectroscopy as complimentary methods, study of simple and complex natural products penicillin's, proteins etc.
3. Nuclear Magnetic Resonance spectroscopy: Applications of special pulse sequence in ID NMR:
   J-modulated spin echo experiment SEPT, INEPT, DEPT experiment, 2D-NMR spectroscopy experiments: COSY, TOCSY, HETCOR, application in structural elucidation of organic molecules, ^{13}C-NMR spectroscopy.
4. Mass spectroscopy: Ionization techniques CI, FAB, MALDI TOF, fragmentation patterns, study of protein, carbohydrates by MS.

Learning Outcomes

Upon completion of this course students will be able to

- explain electrophilic substitution reactions of non-benzenoid aromatic compounds.
- discuss symmetry controlled reactions.
- analyze conformations, describe photochemistry and go deep into stereochemistry.

- 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. Advanced Organic Chemistry by J. March, John Wiley & Sons.
2. Organic Chemistry by Morrison and Boyd, Prentice-Hall.
3. Spectroscopy of Organic Compounds, 6th edition by P. S. Kalsi, Wiley Eastern Ltd.
4. NMR in Chemistry by W. Kemp, ELBS with Macmillan.
5. Modern NMR spectroscopy (in Bangla) by M. Rabiul Islam and Mirza Aminul Huque, Ashrafia Boighar, 2nd edition 2007.
6. 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. 632 1 Unit, 4 Credits
Chemistry of Natural Products and Biosynthesis 100 Marks

Learning Objectives

Learning objectives of this course are to

- deliver advanced treatment on the study of different classes of natural products like terpenoids, steroids and alkaloids.
- expose students to photosynthesis of carbohydrates and structure & chemistry of polysaccharides.
- provide knowledge on chemistry on anthocyanines, flavonoids, carotenoids, haemoglobin, chlorophyll and phthalocyanines.
- impart knowledge on biosynthesis of terpenoids, steroids and flavonoids.

Course Content

1. Terpenes: Chemistry of important terpenes from various groups e.g. Juvenile hormone, humulene, germacrone, eudesmol, caryophyllene, longifolene, gibberellic acid, lanosterol, amyrin, lupeol; biosynthesis of terpenoids.

2. Steroids: Spectral properties of steroids; configuration of steroids; some reactions of steroids; synthesis and chemistry of stigmasterol, vitamin D, cephalosporin, steroidal glycosides; saponins and sapogenins; biosynthesis of sterols.

3. Carbohydrates: Structure and chemistry of polysaccharides: Starch and cellulose. Photosynthesis of carbohydrastes..

4. Chemistry and synthesis of anthocyanins, flavonoids and carotenoids. Biosynthesis of carotenoids and flavonoids.

5. Chemistry and synthesis of Haemoglobin, Chlorophyll and phthalocyanines.

6. Alkaloids: Chemistry and synthesis of some important alkaloids with special reference to adrenaline, nicotine, papaverine and heptaphylline.

Learning Outcomes

Upon completion of this course students will be able to

- understand the chemistry of terpenoids from various groups.
- describe the biosynthesis of terpenoids, steroids and flavonoids.

- acquire knowledge about the spectral properties of steroids and chemistry of different steroidal compounds indicated in the contents.
- explain the photosynthesis of carbohydrates and chemistry of polysaccharides.
- know the chemistry of anthocyanines, flavonoids and carotenoids.
- understand the chemistry of haemoglobin, chlorophyll and phthalocyanines.
- discuss the chemistry and synthesis of some important alkaloids.

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. An Introduction to the Alkaloids, G. A. Wawan, Blackwell Scientific.
4. Mono & Sesqui-terpenes, P. de Mayo, Inter Science.
5. Chemistry of the Alkaloids, S. W. Pettetier, von Nostrand Renihold.
6. Natural Products Chemistry, P. S. Kalsi, Kalyani Publishers, New Delhi.

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

Course No. Chem. 634 1 Unit, 4 Credits
Biochemistry 100 Marks

Learning Objectives

Learning objectives of this course are to

- involve students to advance study of different important biomolecules like nucleic acids, proteins, enzymes and hormones.
- render a systematic study on pharmacodynamics and pharmacokinetics of drugs.
- provide knowledge on chemistry and application of some useful drugs.

Course Content

1. Structure, Function & Replication of Informational macromolecules: nucleotides, nucleic acid structure & function; DNA organization & replication; RNA synthesis, processing & metabolism; regulation of gene expression; protein synthesis & the genetic code; role of nucleoproteins in biological systems.

3. Enzymes: general properties, kinetics, mechanism of action, regulation of activities and inhibition.

4. Hormones: Hormone action, Different types with their mode of action: pituitary & hypothalamic hormones, thyroid hormones, sex hormones; Birth control.

5. Drug: Pharmacodynamics, Pharmacokinetics and related topics: Drug absorption, Drug distribution, Drug metabolism, Drug excretion, Drug administration, Drug dosing, Formulation & Drug delivery.

6. Chemistry and application of some important drugs: Sefrad, Omeprazole, Salbutal, Taxol.

Learning Outcomes

Upon completion of this course students will be able to

- explain the structure of DNA, RNA and proteins.
- acquire knowledge about the synthesis, function, replication, regulation of gene expression and genetic code of nucleic acids.
- understand how to synthesize proteins in different methods and biological role of proteins and nucleoproteins.

- know the general properties, kinetics, mechanism of action, regulation of activities and inhibition of enzymes.
- describe the different types of hormone, their sources and functions.
- gather knowledge about drug absorption, drug distribution, drug metabolism, drug excretion, drug administration, drug dosing, drug formulation and drug delivery.
- discuss the chemistry and application of some useful drugs like Sefrad, Omeprazole, Salbutal and Taxol.

Suggested Readings

1. Biochemistry, Lehninger, Kalyani Publishers.
2. Biochemistry, Styer, W. H. Freeman & Company.
3. Out lines of Biochemistry, Cohn & Stumpt, Wiley Eastern Ltd.
4. Harper’s Biochemistry, Robert K. Murray, Daryl K. Granner, Appleton & Lange.
5. An Introduction to Medicinal Chemistry, Graham L. Patrick, Oxford University Press.
6. Foye’s Principles of Medicinal Chemistry, David A. Williams and Thomas L. Lemke, Lippincott Williams & Wilkins. New York.

SESSION: 2017-2018, 2018-2019, 2019-2020, 2020-21

Course No. Chem. 638	1 Unit, 4 Credits
Organic Synthesis	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 achiral type optical active molecules, mechanistic, stereochemical, regiochemical course of such processes.
- lay understanding of key transformations in depth and 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. Synthesis of Biphenyls, Condensed rings with benzenes and heterocycles.

3. Synthetic applications of malonic ester, acetoacetic ester, different condensation reactions, different cyclisation reactions, Baeyer-Villager oxidation, Meerwin-Pondorff-Varley reduction, Clemmenson reduction, Wolff-kishner reduction, birch reduction, hydroboration reaction, sihylation reaction.

4. (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 alhylboron 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 hydroburation-substrate control, reagent control, catalyst control, stereoselective hydrogenation, stereoselective epoxidation, asymmetric dihydro-xylation.

5. 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 Jreen G, Rhodamine B.

6. 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.

7. Koser's Reagents in Modern Synthesis

Introduction to Koser's reagent, Convenient preparation of Koser's reagents, Versatility of Koser's reagents, Hypervalent iodine chemistry, Hydroxy(tosyloxy)iodobenzene (HTIB), Bis(trifluroacetoxy) iodobenzene (BTIB), Diacetoxyiodobenzene (DIB), Carobonyl oxidation with hypoervalent iodine reagents, Scope and limitations of the reaction.

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. Organic Chemistry, I. L. Finar, Longman, Pearson.
6. Organic Chemistry, Clayden, Greeves and Warren, Oxford University Press.

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

Course No. Chem. 650 1 Unit, 4 Credits
Nuclear and Radiochemistry 100 Marks

Learning Objectives

The learning objectives of this course are to

- impart knowledge on nuclear structure in order to understand radioactive decay.
- promote knowledge on the instruments and measurements of activity.
- convey knowledge on radiation effects on matter, radiation biology and radiation hazards; application of radioactive tracers.

Course Content

1. Nuclear Properties and Structure: Nuclear stability and binding energy. Nuclear spins and statistics. Nuclear models: shell model and optical model.

2. Nuclear Reaction and Mechanism: High and low-energy reactions with mechanism, resonance reactions, excitation functions, cross sections.

3. Nuclear Fuel Element Chemistry: Extraction of uranium and thorium from ores. Separation of Uranium, Thorium from irradiated nuclear fuels. Production of transuranium elements.

4. Cyclotron and Its Uses: Production of short-lived radioisotopes, preparation of radio-pharmaceuticals and their uses.

5. Nuclear-analytical Techniques: Nuclear activation analysis: Particle induced X-ray emission (PIXE) analysis. Alpha spectrometric analysis, Isotope dilution methods and radio fraction analysis.

Learning Outcomes

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

- know the nuclear properties, structure and different models.
- know the nuclear reaction and mechanism.
- know how different radionuclide extract from ores.
- know the nuclear analytical technique.

Suggested Readings

1. Introduction to Nuclear and Radiochemistry, Friedlander, Kennedy and Miller, John Wiley & Sons, New York.
2. Nuclear chemistry, Vol. 1, 2, L. Yaffe.
3. Radiation Detection and Measurement, Glenn F. Knoll, John Wiley & Sons, N.Y.
4. Nuclear Chemistry, B. G. Harvey, Prentice-Hall, Inc. Englewood Cliffs, N.J.
5. Essentials of Nuclear Chemistry, H. J. Arnikar, Latest Edition, New age International (p) ltd publisher.
6. Radiochemistry and Nuclear Methods of Analysis, William D. Ehmann, Diane E. Vance, John Wiley & Sons, N.Y.

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

Course No. Chem. 660 1 Unit, 4 Credits
Advanced Analytical Chemistry 100 Marks

Learning Objectives

The learning objectives of this course are to

- provide knowledge regarding solutions and their properties; chromatographic methods for analysis such as Gas chr+omatography (GC), High performance liquid chromatography (HPLC) etc;
- impart knowledge on methods related to analysis of trace element; Sampling and sample preparation and statistical analysis of analytical data.

Course Content

1. Solutions and their properties: Solvent extractions and separation of elements by co-precipitation. Solution equilibria and formation of metal complexes.

2. Chromatographic methods of analysis: Principle and applications of Gas Chromatography, High performance liquid chromatography, Thin layer chromatography and paper chromatography.

3. Trace element chemistry in biology, medicine, industry and agriculture.

4. Instrumental methods in trace element analysis: X-ray spectroscopy: Fluorescence, Absorption and Diffraction methods; Atomic absorption spectrophotometric methods based on flame and electrothermal atomization; Emission spectroscopy based upon Plasma, Arc and Spark atomization; Stripping voltammetry; mass spectrometry; Nuclear activation analysis; Ion-selective electrodes.

5. Sampling and sample preparations: General procedures; collection, preparation and storage of laboratory sample.

6. Statistical treatment of analytical data.

Learning Outcomes

Upon completion of this course the students will be able to

- know solvent, solute, solutions and their properties which are very important for the separation of elements from solution.
- understand chromatographic methods for analysis such as Gas chromatography (GC), High performance liquid chromatography (HPLC) etc. which are vital for the purification and separation of various compounds.
- explain the methods related to the analysis of trace element.
- introduce how to prepare a sample before analysis.
- know the statistical analysis of analytical data.

Suggested Readings

1. Vogel's Textbook of Quantitative Inorganic Analysis, J. Bassett, R. C. Dinney, G. H. Jeffery and J. Mendham, Longman.
2. Analytical Chemistry, G. D. Christian, Wiley.
3. Fundamentals of Analytical Chemistry, D. A. Skoog & D. M. West, Saunders Publishing.
4. Chromatographic Methods, R. Stock and C. B. F. Rice, Chapman and Hall.