**Special Degree Programme: Chemistry**  
**Third year**

**CH 3001 Topics in Analytical Chemistry I (30L, 2C)**  
**Dependencies:** First year and second year chemistry core courses  
**Learning Outcomes:**  
Upon completion of this course students will be able to:  
- Understand the processes involve in chemical separations and electro analytical techniques  
- Apply the underlying principles in qualitative and quantitative analysis  
- Familiarize with the analytical equipment and their usage.  
**Syllabus:**  
**Separational Methods:** (23L) Ion Exchange: Kinetics, Donan Equilibrium, Affinity; Solvent Extraction: Distribution coefficient and distribution ratio, Extraction strategies, Chelating agents for the extraction, Masking; Chromatography: Elution chromatography, Selection of the mobile and stationary phases, Separation mechanisms, Sorption Isotherms, Retention time, Distribution coefficient, Capacity Factor, Selectivity, Efficiency, Resolution, Temperature (solvent strength) programming, Band broadening process, van deemter Equation for GC, H vs u curves for GC and LC, Chromatographic methods for qualitative and quantitative analysis, Instrumentation, GC and HPLC trouble shooting, Size-exclusion chromatography, Supercritical fluids and its applications, Supercritical fluid extraction and Supercritical fluid chromatography.  
**Electro Analytical Techniques:** (7L) Electrophoresis, Applications Electro analytical methods; Coulometry, coulometric titration, electrogravimetry, polarography : dc-, ac-, pulse, differential pulse, stripping voltametry, amperometry, potentiometry, ion and molecular selective electrodes, carbon paste electrodes potentimetric titration, conductometry, conductometric titration.  
**Assessment:** End of semester examination.

**CH 3003 - Industrial Chemistry (30L,2C)**  
**Dependencies:** CH 1006  
**Suggested reading:**  
Polymer Science and Technology, Robert O Ebewele  
**Learning Outcomes:**  
At the end of the lecture series you should be able to;  
- interpret the TGA graph and determine the component constituents.  
- explain the cement manufacture process.
• analyse the given situation and identify the best type of cement for a given set of conditions based on the cement constituent properties.
• differentiate between homogeneous and heterogenous catalyst,
• explain the application of catalyst in the industry.
• Able to identify types of polymerization reactions and mechanisms
• Interpret polymer properties
• Identify structure - end use relationship
• Able to device polymers for particular end use

Syllabus:
Thermal analysis Introduction to Thermal analysis, Thermogravimetric analysis (TGA) – Introduction, instrumentation, interpretation of thermogram, Industrial application of TGA Manufacture of Portland cement, properties of different constituents of cement on setting and hardening, types of cement, weathering of cement, Catalytic terminology, classification of catalyst, differentiate between homogenous and heterogeneous catalysis, application of homogenous and heterogeneous catalysis in industry, Introduction to polymer chemistry, vinyl polymers; mechanism of addition polymerization and introduction of terms and concepts, polymerization of diene monomers, condensation polymerization; polyesters, polyamides, polycarbonates, ladder polymers, formaldehyde resins, ring opening polymerization; polycaprolactam, epoxy resins, poly propylene oxide, cationic polymerization, anionic polymerization, coordination polymerization, bonding and polymer structure, chemical bond and intermolecular forces, configuration, tacticity, crystalline and amorphous structure of polymers, polymer properties, glass transition temperature and crystalline melting point, factors affecting $T_g$ and $T_m$, copolymerization and polymer modification, molecular weight, polymer applications, Persistent Organic Pollutants (POPs), namely PCDDs / PCDFs; PCBs, PAHs, PBDEs, Organochlorine pesticides: What they are, why they are important, how their physico-chemical properties ($K_{ow}$, $K_{OA}$, $W_s$, $K_{OC}$, VP, H, Environmental persistence) govern their environmental fate and behavior, mechanism of action, toxic effects.
Source inventories

CH 3004 Laboratory Management (15L, 1C)
Dependencies: None

Learning Outcomes:
Upon completion of this course students will be able to:
• Demonstrate and understand the basic principles, theories, and regulations related to the laboratory management
• Demonstrate the ability to use appropriate tools to solve issues related to safety and efficiency of laboratory

Syllabus:

Assessment: End of semester examination.

CH 3005 Chemical Technology (30L, 2C)

Dependencies: CH 3003


Learning Outcomes:

At the end of the lectures you should be able to;

- Interpret the E-pH diagrams and identify corrosion control methods using the diagrams
- Analyze the mixed potential theory diagrams and predict the effects of pH, cathodic reaction, reducible species, solution velocity, inhibitors.
- Explain types of corrosion and types of corrosion prevention
- Understand why additives are needed for the stability of polymers and in applications
- Able to differentiate between polymerization methods and their applications
- Selection of reactors for different applications

Syllabus:

Introduction to corrosion, E-pH (Pourbaix) diagram of metals - Fe, Au, Cu, Zn, Al; Strategies for corrosion control from E-pH diagrams; Limitations of using E-pH diagrams on corrosion control
Kinetics of corrosion; Tafel plots of different metals; Polarization – activation, concentration, ohmic polarization, Application of mixed potential theory diagrams – effect of pH, increasing rates of the cathodic reaction, increasing concentration of the reducible species, increasing solution velocity, effect of inhibitors on corrosion of active metals and active-passive metals.

Types of corrosion: Corrosion due to differential aeration, crevice, galvanic, pitting, stress cracking, Corrosion prevention by cathodic protection, anodic protection, inhibitors, sacrificial anode, protective coating.

Polymer stability; Polymer additives: plasticizers, antioxidants, thermal and uv stabilizers, flame retardants; Polymerization methods: bulk, solution, suspension and emulsion polymerization; Polymerization reactors: batch and continuous stirred reactors; Unit operations: extrusion, injection moulding, blow moulding; Applications

Introduction, Recent history of chemical industries, Introduction to chemical technology and chemical industries, Back ground and technical aspects, The economy of scale \[ M = M_0 (Q/Q_0)^n \], \[ C = C_0 (Q/Q_0)^n \], Chemical processing, unit operations, unit process, thermal and mechanical unit operations, Type of reactors, batch, semi-batch, CSTR, multistage CSTR, tubular flow, Conversion and yield, Academic yield, industrial yield, % conversion, Catalysts Homogeneous, heterogeneous and biocatalysis, Production and characterization of catalysts, Deactivation of catalysts, Environmental aspects of chemical technology, pollution, water treatment and waste water management, Green chemistry, Examples of industrial processes

Assessment: End of semester examination.

CH 3006 Computational Chemistry (30L,2C)

Dependencies: First year and second year chemistry core courses

Suggested readings: (i) Quantum chemistry, D.A. Mcquarrie (ii) Molecular modeling: principles and applications, A.R. Leach

Learning Outcomes:
Upon completion of this course students will be able to:

- Predict properties of non-interacting entities using quantum mechanics
- Apply approximate methods to predict properties of complex systems
- Apply quantum mechanics to multi-electron systems
- Apply classical mechanical methods to predict properties of multi-particle systems with many degrees of freedom

Syllabus:
Quantum Mechanics & Computational methods (15 L)
Exactly solvable problems; free particle, harmonic oscillator, 2D and 3D rotational motion, Hydrogen atoms, atomic units, Approximate methods, Many electron systems, Born-Oppenheimer approximation, Pauli exclusion principle, spin and spatial orbitals, Variation and perturbation methods, Huckel molecular orbital theory, Hartree products, Slater determinants, configuration interaction, Hartree-Fock approximation, Coulomb and exchange integrals, Hartree-Fock equations, Orbital energies, Commutation relations, Koopmann theorem, Brillouins theorem, Introduction of a basis, Roothaan equations, orthogonalization of the basis, The self consistency procedure, Semi-empirical and ab-initio calculations.
Molecular Properties & Molecular Dynamics (15 L)
The electric dipole, vector addition of dipole moments, induced dipole moments, Charge-charge interactions, charge-dipole interactions, dipole-dipole interactions, dipole-induced dipole interactions, induced dipole-induced dipole interactions, total attractive interactions, effect of rotation, Axilrod-Teller formula, Mie potential, Lennard-Jones potential, hydrogen bonding interactions, multipoles; Minimum energy structure of a molecule, methods to obtain minimum energy; Molecular dynamics simulation, modeling liquids and solvation.
Assessment: End of semester examination.

CH 3007 - Topics in Analytical Chemistry II (15 L, 1C)
Dependencies: CH 2008, CH 3001 recommended

Learning Outcomes:
Upon completion of this course students will be able to:
- Demonstrate and understand the basics principles, theories, and calculation related to analytical chemistry
- Demonstrate the ability to use appropriate tools and techniques to develop new analytical method
- Understand the recent developments in analytical chemistry.

Syllabus:
Assessment: End of semester examination.

CH 3008 Quality Management (15L, 1C)
Dependencies: None
Learning Outcomes:
Upon completion of this course students will be able to:
• Demonstrate and understand the basics principles, theories, and regulations related to the quality management
• Demonstrate the ability to use appropriate tools to solve issues related to quality in laboratories

Syllabus:
Background on the accreditation of testing and calibration laboratories: ISO/IEC 17025 and ISO 15189, Significance of accreditation and certification for laboratories, Good Laboratory Practice (GPL), An overview to the laboratory accreditation process. Quality Manual: Quality manual contents for ISO/IEC 17025 and main requirements, Use examples to demonstrate how these requirements can be met. Sampling: Type of sampling, Sampling planning, Subsampling, Examples for sampling plans.
Assessment: End of the semester examination

CH 3021 Spectroscopy (45L, 3C)
Dependencies: First year and second year core courses in chemistry
Learning Outcomes: Upon completion of this course students will be able to:
• Explain basic principles underlying the NMR phenomenon in relation to the observed spectra of organic and inorganic compounds
• Elucidate the structures of organic and inorganic molecules using NMR and MS spectroscopic data
• Apply theoretical approach to understand molecular structure and bonding
• Predict rotation, vibration and Raman spectra of molecular systems
• Understand the nature of ESR, NQR and Mossbauer spectroscopy applicable for inorganic molecules and complexes and understand structural information obtain via these spectroscopic methods
• Understand the Atomic Absorption spectroscopy and application of the same to identify and quantify metal ions in a compound
Syllabus:
Introduction to NMR and MS spectroscopy (15L)
NMR Spectroscopy: Magnetic nuclei, CW and Pulsed FT NMR, Signal to noise ratio, Effects of high field, Chemical shift and factors affecting chemical shift. Coupling constants and mechanism of coupling, Chemical equivalence and magnetic equivalence, Homotopic, enantiotopic and diastereotropic nuclei, NOE effect, Protons on hetero atoms, Second order spectra, Shift reagents and chiral resolving agents, \(^{13}\)C NMR spectroscopy, The APT and DEPT experiments, Introduction to 2D NMR, COSY, HETCOR and HMBC spectra, Applications in structure elucidation of organic molecules.
Mass Spectrometry: EI and fragmentation mechanisms, CI, FAB, MALDI, Electrospray ionization, MS/MS in structure elucidation of organic molecules.
Rotation and vibration Spectroscopy (13L)
Microwave spectroscopy of linear polyatomic molecules; Introduction to microwave spectra of symmetric top, spherical top, asymmetric top and molecules. UV- Visible spectra of diatomic and polyatomic molecules; Rotation-vibration spectroscopy of linear triatomic / diatomic molecules; relations with experimental spectra; Raman Spectroscopy: Raman Effect on rotation and vibration spectra, Experimental evidence of Raman Effect.
Inorganic spectroscopic methods (12L)
Inorganic NMR spectroscopy for compounds containing spin \(\frac{1}{2}\) nuclei of \(^{19}\)F, \(^{31}\)P and NMR spectroscopy with spin >1/2 such as \(^{14}\)N, \(^{10}\)B, \(^{11}\)B and NMR signals obtaining for \(^1\)H proton coupled to metal centers such as Rh, and quadrupole nucleuses such as Co. Electron Spin Resonance Spectroscopy (ESR);Electron-electron coupling, Hyperfine couplings and g-factors, Coupling of one electron with several spin active nuclei and ESR spectral pattern of many electron systems (transition metal complexes). Nuclear quadrupole resonance (NQR) and structural information from NQR. Mossbauer spectroscopy for Fe and Sn complexes.
Atomic Spectroscopy (5L)
Assessment: End of semester examination

CH 3023 - Coordination and Organometallic Chemistry (45L, 3C)
Dependencies: First year and second year chemistry core course unites.
Learning Outcomes:
Upon completion of this course students will be able to:

- Compare and contrast transition-metal coordination complexes and organometallic complexes
- Understand the nature of bonding occurs between metal and important π-bonding ligands in stabilizing metal complexes
- Recognize basic reactivity patterns occur in transition metal organometallic complexes and ligand activation
- Understand the involvement of transition metal organometallic complexes as catalysts in very important industrially useful reactions and to realize their mechanisms.
- Predict the mechanism involve for a given catalyst upon given reactants and products
- Understand the inorganic reaction mechanisms and classification of inorganic reactions as substitution, electron transfer and activation of ligands
- Recognize and understand the kinetics laws of substitution reactions occur at square planar, tetrahedral and octahedral metal complexes
- Identify and understand inner sphere and outer sphere mechanisms involve in complexes

Syllabus:

Advanced Coordination Chemistry: (10 L)

Organometallic Chemistry and Catalysis: (22 L)
Introduction to Organometallic Chemistry, Metal-ligand bonding, Introduction to important π-bonding ligands, Dewar-Chatt-Duncanson model, metal-ligand reactivity patterns, reactivity of metal-bound ligands, Homogeneous catalysis, Chemistry of ferrocene, Synthesis, structure and bonding.

Inorganic Reaction Mechanisms: (13 L)
Ligand substitution reactions, classification of substitution reaction mechanism, Substitution reactions of octahedral and square planar and tetrahedral metal complexes, sterochemical changes, isomerization, fluxional behaviour, and electron transfer reactions.

Assessment: End of semester examination

CH 3024 Pharmaceutical Chemistry (30L, 2C)
Suggested readings: (i) Principles of Medicinal Chemistry, William O. Foye, Thomas L. Lemke, David A. Williams (ii) Introduction to Medicinal Chemistry, Patrick Graham (iii) Medicinal Chemistry, Thomas Nogrady, Donald F. Weaver

Learning Outcomes:
Upon completion of this course students will be able to:

- Develop critical thinking skills towards what the body does to the drugs and what the drug does to the body
• Be able to recognize representative anticonvulsant, local anesthetic, anti-inflammatory, diuretics, anti-diabetic, anti-bacterial anti-fungal, anticancer, and antiviral drugs and their respective mechanisms of action.
• Be able to explain structure-activity relationships of some selected drugs.
• Be able to propose routes to some synthetic drugs.
• Be able to explain beta-lactam drug resistance mechanisms.

Syllabus:
Pharmaceutical, Pharmacokinetic, Pharmacodynamic aspect of a drug molecule (5L)
Biopharmaceutical properties of drug substances (Gastrointestinal physiology, Mechanisms of drug absorption, Drug dissolution versus drug absorption), Receptors and drug action (Affinity-the role of chemical bonding, Dose-response relationships, Receptors and biological response), Drug metabolism (Drug biotransformation pathways and Drug conjugation pathways)

Drugs related to the Central Nervous System (4L)
Volatile Anesthetics, Anticonvulsants (Seizures, Anti-convulsants with ureide structure and synthesis, Benzodiazepines, Local Anesthetics (Electrophysiology of nerve membrane and mechanism of action)

Cholesterol lowering drugs and Adrenocorticoids (5 L)
Cholesterol biosynthesis (highlight the connection to anti-fungal agents) and statins, Development of adrenocorticoid drugs (Anti-inflammatory steroids), Introduction to Adrenocorticoid antagonists which will be expanded under diuretics),

Diuretics (2 L)
Osmotic diuretics, Carbonic anhydrase inhibitors, Thiazide diuretics, Loop diuretics, Potassium sparing diuretics

Drugs affecting sugar metabolism (2 L)
Hormonal inter-relationships, Insulin, Oral anti-diabetic agents (Biguanides, sulfonylureas)

Anti-microbial agents (7 L)
General principles and important definitions, Anti-bacterial compounds (Sulfonamides, beta-lactam antibiotics, Aminoglycosides, Tetracyclines), Anti-mycobacterial agents, Anti-fungal agents (Polyenes, Azoles and allylamines), Antiseptics and Disinfectants

Anti-cancer and Anti-viral drugs (5 L)
Anti-neoplastic drugs (Anti-metabolites, Alkylating agents, DNA-intercalating agents, Anti-mitotic agents), Anti-viral agents, Approach to Anti-Aids agents.

Assessment: End of semester examination

CH 3027 – Molecular Biology (30L, 2C)
Dependencies: None
Suggested Readings: Genes VIII (B. Lewin), Watson et al, Recombinant DNA, Drlica, Understanding DNA & gene cloning
Learning outcomes:
Upon completion of this course students will be able to:
• Identify operon, and list its parts.
• Explain how a regulator gene controls transcription of an operon.
• Explain the regulation of the *trp* and *lac* operons.
• Identify different levels at which gene expression in eukaryotes may be regulated
  • Explain how DNA modifications, Chromatin remodeling etc., used in activation and repression of gene expression.
• Describe the different tools used in rDNA technology
• Compare the different strategies used for gene cloning
• Design a PCR assay
• Explain how DNA is characterized and analyzed
• Describe the different applications of rDNA technology

**Syllabus:**
Gene structure; Prokaryotic and eukaryotic gene transcription; Transcription factors, activators and repressors, Mechanism of activation and repression; DNA modifications, Chromatin remodeling. Tools of Molecular Biology; Microorganisms, enzymes & vectors. Cloning; Techniques of cloning; Cutting & joining DNA molecules using enzymes, gene transferring methodologies, Gel Electrophoresis, Blotting techniques (Southern and Northern) DNA Labelling techniques, Nucleic acid Hybridization; Strategies for gene isolation, Construction and screening of genomic & cDNA libraries, DNA sequencing and analysis, Chromosome walking, PCR. Applications of recombinant DNA technology in Medicine, Agriculture and Industry, Recent advances in rDNA technology.

**Assessment:** End of semester examination.

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**CH 3029 - Organic Chemistry (45L, 3C)**

**Dependencies:** CH 1012


**Learning Outcomes:**
Upon completion of this course students will be able to:
• describe the mechanisms of the major classes of organic reactions
• predict the mechanism of simple reactions previously unseen
• describe and predict the reactivities of organic compounds using the principles of physical organic chemistry
• predict the products of or describe the reagents used in organic transformations commonly used in synthesis
• retrosynthetically analyze an organic molecule of interest and propose an efficient synthetic scheme

**Syllabus:**
Reaction Mechanisms (10 L)
Review of reaction mechanisms, use of curved arrows to describe mechanisms; substitution reactions - $S_{N}1$, $S_{N}2$, and $S_{N}i$ mechanisms, neighbouring group participation; the non-classical carbocation; elimination reactions - E1, E2, and E1cb mechanisms; review of electrophilic and other addition reactions of alkenes, electrophilic and nucleophilic aromatic substitutions, and nucleophilic addition reactions of aldehydes and ketones;

**Physical Organic Chemistry (12 L)**
The Hammett equation: applications, free energy diagrams; failures and modifications Hammett equation; Yukawa – Tsuno equation and its applications. Taft equation. steric effects in organic reactions, solvent effects, conformational effects, Curtin-Hammett principle; isotope effects, stereo-electronic effects.

**Organic Synthesis (23 L)**
Retrosynthetic analysis of organic molecules - disconnections and synthons; methods for forming C-C single and C=C double bonds; use of enolates, enamines, organolithium, -magnesium, and -copper compounds; stereoselectivity and regioselectivity; umpolung; 1,2-, 1,3-, 1,4-, and 1,5-dioxygenated systems, aldol and Claisen condensations, and the Michael addition; techniques of forming 3-, 4-, 5-, and 6-membered rings; coupling reactions; synthesis of C-N and C-O bonds; protecting groups; oxidations and reductions; examples of syntheses of somewhat complex molecules.

**Assessment:** End of semester examination

**CH 3030 Advanced Practical Chemistry (240P, 1C)**
Practical conducted in the areas of Organic Chemistry, Inorganic Chemistry and Physical Chemistry.
**Assessment:** End of year examination

**CH 3031 Symmetry in Chemistry (15L, 1C)**

**Dependencies:** None


**Learning Outcomes:**
At the end of the course student should be able to;
- identify symmetry element sand operations of a given molecule
- assign a given molecule into a point group
- apply the theories of irreducible and reducible representation
- identify the Mulliken symbol of a given irreducible representation
- analyze the hybridization of a molecule/ bond by applying the molecular orbital theory
• analyze the molecule given and predict the IR and Raman spectra of the given molecule

**Syllabus:** Introduction to symmetry: Symmetry elements (axis, plane, point) and operations (rotation, reflection, inversion and improper rotation), point groups, Elementary group theory; Matrix representation of symmetry operations, Reducible and irreducible representations, Analysis of IR and Raman spectra. Selection rules for IR and Raman. Symmetrically equivalent coordinates. Molecular orbital diagrams: Symmetry-adapted MO's using projection operators; Linear combination of atomic orbitals. Hückel molecular orbital calculations, σ and π bond formation (hybridization)

**Assessment:** End of semester examination.

**CH 3033 Chemistry of Bio-molecules (45L, 3C)**

**Dependencies:** First year and second year chemistry core courses

**Suggested readings:** Medicinal Natural Products (Paul M Dewick)

**Learning Outcomes:**
Upon completion of this course students will be able to:

• Classify biomolecules based on their biosynthesis
• Propose biosynthetic pathways leading to these natural organic molecules
  • Demonstrate a knowledge of the reactions of simple monosaccharides and the role of carbohydrates in biological systems
  • Identify the use of some of these bio-molecules

**Syllabus:**

**Building blocks and mechanisms in secondary metabolism (04 L)**
Primary and secondary metabolism, enzymes and coenzymes, Construction mechanisms in biological systems such as alklylation, Wagner-Meerwein rearrangement, Aldol and Claisen condensations, Schiff base formation, Mannich reaction, Transamination, reductions and oxidations in biosynthesis

**Fatty acids and polyketides from acetate pathway (05 L)**
Saturated/Unsaturated fatty acids, Prostaglandins, Aromatic polyketides (Cyclization to give simple phenols and Anthraquinones), alkylation and coupling reactions of polyketides, Macrolides and polyethers, Cyclization through Diels-Alder reaction to give statins.

**Aromatic amino acids and phenylpropanoids from shikimate pathway (05 L)**
Aromatic amino acids and simple benzoic acids, Lignans and lignin, Phenylpropanes, Benzoic acids from C₆C₃ compounds, Coumarins

**Terpenoids and steroids from mevalonate pathway (12 L)**
Monoterpenes, Sesquiterpenoids, Diterpenoids, Sesterterpenoids, Triterpenoids, Carotenoids, Steroids. Steroid skeleton, numbering, conformations, main types of steroids and their biological functions, Important reactions and synthesis/partial synthesis of steroids.

**Biosynthesis of Alkaloids from amino acids (07 L)**
Chemical structure, Biosynthesis of alkaloids derived from ornithine, lysine, nicotinic acid, tyrosine, tryptophan, anthranilic acid, and histidine, Important reactions of alkaloids.

**Mixed biogenesis (02 L)**
Flavonoids and stilbenes, Meroterpenoids

**Carbohydrates (10 L)**
Nomenclature and configurational relationship of monosaccharides, Fischer projection and Haworth formula, mutarotation, Reactions of anomeric and non-anomeric carbon atoms, Reactions of the hydroxyl groups, Aminosugars, Reducing and non-reducing sugars, Nature of di-, tri-, and polysaccharides,

**Assessment**: End of semester examination

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**Special Degree Programme: Chemistry**

**Fourth year**

**CH 4001 - Research Project (240P, 8C)**

**Assessment**: End of year evaluation of thesis and viva voce

**CH 4002 - Seminar and Essay (90P, 3C)**

**Assessment**: Seminar- End of the semester evaluation

Essay - End of year evaluation

**CH 4003 - General Paper (45L, 3C)**

**Assessment**: End of year examination

**CH 4004 - Optional Topics (60L, 4C)**

Current topics of interest will be conducted.

**Assessment**: End of semester examination

**CH 4005 - Advanced Organic Chemistry (45L, 3C)**

**Dependencies**: CH 3029


**Learning Outcomes**: Upon completion of this course students will be able to:

- recognise and classify pericyclic reactions
- predict the feasibility and the stereochemical outcome of a pericyclic reaction
- utilize pericyclic and free radical reactions in the synthesis of organic molecules.
- apply basic principles in mechanistic photochemistry
- recognise, classify, and describe the chemical properties of aromatic heterocyclic compounds
- describe methods of synthesis and products of reactions of aromatic heterocyclic compounds.
Pericyclic Reactions (10 L)
Definition and classification of pericyclic reactions; electrocyclic, cycloaddition, sigmatropic, cheletropic and ene reactions; topology of orbital overlap; molecular orbital correlation diagrams; frontier molecular orbital theory, aromatic transition state theory, generalized selection rule for pericyclic reactions; selected examples of applications in organic synthesis.

Organic Photochemistry (18 L)

Free Radical Reactions (5 L)
Structure and reactivity of radicals; generation of radicals; mechanisms of radical reactions; free radical additions, substitutions, and rearrangements; use of radicals in cyclisations; radical oxidations, combustion, oxidative rancidity, etc.; stable radicals and radical scavengers; radicals in carbohydrate and nucleoside chemistry.

Aromatic Heterocycles (12 L)
Review of Hückel's Rules; importance and natural occurrence of heteroaromatic compounds; nomenclature; general principles of heterocyclic synthesis; chemistry of pyridine; diazines; quinoline and isoquinoline; six-membered rings containing O - pyrilliums, pyrones, benzopyriliums and benzopyrones; aromaticity and reactivity of five-membered heterocycles - pyrrole, thiophene, and furan; pyrazole, imidazole, and other azoles; indole and purines; unusual heterocyclic systems - sydnones, etc.

Assessment: End of semester examination

CH 4006 - Biochemistry (45L, 3C )
Dependencies: First year and second year chemistry core courses.
Learning Outcomes:
Upon completion of this course students will be able to:
Syllabus:
Amino acids and proteins, Enzymes as Biological Catalysts, Extraction and Purification of Proteins, Determination of sequence of an protein using Chemical and enzymatic methods, Chemical synthesis of a peptide, Synthesis on a Solid support, Importance of secondary, tertiary and quaternary structure in enzyme catalysis, Enzyme catalysis, Importance of active site residues in enzyme catalysis, Function of Coenzymes, Enzyme Kinetics, Bioenergetics: Application of energy relationships and electrochemistry to biological systems, Role of high energy compounds, Chemical basis for large free energy of “hydrolysis” of ATP, PEP, 1,3-bisphosphoglycerate, Acetyl Coenzyme A. Metabolic pathways, Regulation of pathways, Metabolic disorders and inborn errors of metabolism. Bioinorganic chemistry: Structure and function of oxygen transport and storage proteins (hemoglobin, myoglobin) and electron transfer proteins (cytochromes, iron-sulfur proteins, blue copper proteins) and the related principles of chemistry. The role of zinc in superoxide dismutase and carbonic anhydrase.

**Assessment:** End of semester examination.

**CH 4007 - Advanced Physical Chemistry (45L, 3C)**

**Dependencies:** First year and second year chemistry core course unites


**Learning outcomes:**

Upon completion of this course students will be able to:

- Derive bulk thermodynamic properties from molecular properties
- Derive relevant thermodynamic parameters using different thermodynamic ensembles
- Correlate quantum mechanical results with thermodynamic parameters
- Explain the Third Law of Thermodynamics and calculate third law entropies
- Describe the background of chemical potential
- Analyze thermodynamics of mixing
- Demonstrate how the amount of a solute affect colligative properties of a solvent and perform calculations involving these colligative properties
- Apply advanced kinetics principles in solving problems
- Predict thermodynamic parameters involved in activation of molecules
- Predict quantitatively, rates of reactions using partition functions
- Derive and apply mass transport equations
- Derive Butler-Volmer equation and apply it in problem solving
- Calculate the corrosion rate using appropriate equations


Assessment: End of semester examination.

CH 4008 - Advanced topics in Chemistry(45L, 3C)

Dependencies: First year and second year chemistry core course unites


Learning outcomes:
Upon completion of this course students will be able to:
Demonstrate how an approximate solution of structure is deduced using crystallographic data
Identify problems associated with the crystal structure determination process
Compare and contrast different methods for crystal structure determination
Identify space symmetry in a crystal
Derive the geometry of electron deficient clusters
Explain metal-metal bonding and determine the geometry of metal clusters
Predict synthetic routes and reactivity of clusters
Classify solids into different crystalline systems
Predict electronic and thermal properties of solids
Apply surface analytical techniques to elucidate surface structure and composition

Syllabus:
Clusters and cage molecules (10L): clusters in elemental state. Structure of cluster compounds: classification, nomenclature. Bonding in clusters: molecular orbital theory, frontier molecular orbitals, electron deficient clusters; Lipscomb's Styx rules, Polyhedral skeletal electron pair theory, metal-metal bonds and metal clusters, structure and bonding, isolable principle, synthetic routes to clusters, reactivity of clusters;
Solid state and surface analytical techniques (20L): Crystal growth structure, defects and surfaces. Band theory of solids, Primitive vectors, 2D symmetries, Unit cell, Lattice planes, Miller indices, Surface processes: X-ray photoelectron spectroscopy, Auger spectroscopy, ion scattering spectroscopy, low energy electron diffraction, field emission microscopy, field ionization microscopy, electron microcopy, electron energy loss spectroscopy, atom-probe film, scanning tunneling microscopy, atomic force microscopy.
Assessment: End of semester examination.

CH 4090 – Advanced Molecular Modeling (15L, 1C)
Dependencies: CH 3006 required
Suggested readings: Molecular modeling, A.R. Leach
Learning outcomes:
Upon completion of this course students will be able to:
- Apply advanced molecular modeling techniques to solve molecular level research problems

Syllabus:
Energy minimization: steepest descent method, conjugate gradient method; and related methods for exploring the potential energy surfaces, Non derivative minimization methods, derivative minimization methods, first

**Assessment:** End of semester examination