B.Sc. (Honours) in Chemistry
Under the Framework of Honours School System
2019-20
OUTLINES OF TESTS

OBJECTIVE OF THE COURSE

To teach the fundamental concepts of Chemistry and their applications at undergraduate level, which will enable to impart comprehensive knowledge in chemistry and its societal applications through a 3 year programme. The syllabi of B.Sc. (Honours) in Chemistry under the framework of honours school system are selected and arranged in such a manner that due importance is given to requisite intellectual and laboratory skills according to UGC module for CHOICE BASED CREDIT SYSTEM (CBCS) pertaining to B.Sc. Honours (Chemistry).

Semester I

CORE COURSE (CHEMISTRY)

Theory Papers:
Core Course-1 (C 1): Inorganic Chemistry-I 100 Marks (4 credits)
Core Course-2 (C 2): Physical Chemistry-I 100 Marks (4 credits)

Practicals:
Core Course-1 Practical (C 1 Lab): Inorganic Chemistry-I 50 Marks (2 credits)
Core Course-2 Practical (C 2 Lab): Physical Chemistry-I 50 Marks (2 credits)

GENERIC ELECTIVE (GE) FOR CHEMISTRY STUDENTS

Each student of Chemistry Department has to opt two Generic Elective Courses from the available options offered by different science, mathematics, computer science and economics departments. However, a student can take only one GE course from one department per semester.

ABILITY ENHANCEMENT COMPULSORY COURSE FOR CHEMISTRY STUDENTS

Each student of Chemistry Department has to opt one Ability Enhancement Compulsory Course of the following:
1. English Communication (2 credits)
2. Environmental Science (2 credits)

GENERIC ELECTIVE (CHEMISTRY)

Theory Paper:
A student from other disciplines may opt following generic elective offered by the Chemistry Department of Panjab University:
Generic Elective -1 (GE-1) 100 Marks (4 credits)

Practicals:
Generic Elective -1 Practical (GE-1 Lab) 50 Marks (2 credits)
Semester II

CORE COURSE (CHEMISTRY)

Theory Papers:
Core Course-3 (C 3): Organic Chemistry-I 100 Marks (4 credits)
Core Course-4 (C 4): Physical Chemistry-II 100 Marks (4 credits)

Practicals:
Core Course-3 Practical (C 3 Lab): Organic Chemistry-I 50 Marks (2 credits)
Core Course-2 Practical (C 4 Lab): Physical Chemistry-II 50 Marks (2 credits)

GENERIC ELECTIVE (GE) FOR CHEMISTRY STUDENTS
Each student of Chemistry Department has to opt two Generic Elective Courses from the available options offered by different science, mathematics, computer science and economics departments. However, a student can take only one GE course from one department per semester.

ABILITY ENHANCEMENT COMPULSORY COURSE FOR CHEMISTRY STUDENTS
Each student of Chemistry Department has to opt one Ability Enhancement Compulsory Course of the following:
1. English Communication (2 credits)
2. Environmental Science(2 credits)

GENERIC ELECTIVE (CHEMISTRY)

Theory Paper:
A student from other disciplines may opt following generic elective offered by the Chemistry Department of Panjab University:
Generic Elective -2 (GE-2) 100 Marks (4 credits)

Practicals:
Generic Elective -2 Practical (GE-2 Lab) 50 Marks (2 credits)

Semester III

CORE COURSE (CHEMISTRY)

Theory Papers:
Core Course-5 (C 5): Inorganic Chemistry-II 100 Marks (4 credits)
Core Course-6 (C 6): Organic Chemistry-II 100 Marks (4 credits)
Core Course-7 (C 7): Physical Chemistry-III 100 Marks (4 credits)

Practicals:
Core Course-5 Practical (C 5 Lab): Inorganic Chemistry-II 50 Marks (2 credits)
Core Course-6 Practical (C 6 Lab): Organic Chemistry-II 50 Marks (2 credits)
Core Course-7 Practical (C 7 Lab): Physical Chemistry-III 50 Marks (2 credits)

SKILL ENHANCEMENT COURSES
Each student of Chemistry Department has to opt one Skill Enhancement Compulsory Course of the following:
1. CHE-SEC1: Industrial Chemistry of Fuels 50 Marks (2 credits)
2. CHE-SEC2: Basic Analytical Chemistry 50 Marks (2 credits)
3. CHE-SEC3: Pesticide Chemistry 50 Marks (2 credits)

**GENERIC ELECTIVE (GE) FOR CHEMISTRY STUDENTS**
Each student of Chemistry Department has to opt one Generic Elective Course from the available options offered by different science, mathematics, computer science and economics departments. However, a student can take only one GE course from one department per semester.

**GENERIC ELECTIVE (CHEMISTRY)**
Theory Paper:
A student from other disciplines may opt following generic elective offered by the Chemistry Department of Panjab University:
Generic Elective -3 (GE-3) 100 Marks (4 credits)
Practicals:
Generic Elective -3 Practical (GE-3 Lab) 50 Marks (2 credits)

**Semester IV**
**CORE COURSE (CHEMISTRY)**
Theory Papers:
Core Course-8 (C 8): Inorganic Chemistry-III 100 Marks (4 credits)
Core Course-9 (C 9): Organic Chemistry-III 100 Marks (4 credits)
Core Course-10 (C 10): Physical Chemistry-IV 100 Marks (4 credits)
Practicals:
Core Course-8 Practical (C 8 Lab): Inorganic Chemistry-III 50 Marks (2 credits)
Core Course-9 Practical (C 9 Lab): Organic Chemistry-III 50 Marks (2 credits)
Core Course-10 Practical (C 10 Lab): Physical Chemistry-IV 50 Marks (2 credits)

**SKILL ENHANCEMENT COURSES**
Each student of Chemistry Department has to opt one Skill Enhancement Compulsory Course of the following:
1. CHE-SEC4: Pharmaceutical Chemistry 50 Marks (2 credits)
2. CHE-SEC5: Chemical Technology & Society 50 Marks (2 credits)
3. CHE-SEC6: Chemistry of Cosmetics & Perfumes 50 Marks (2 credits)

**GENERIC ELECTIVE (GE) FOR CHEMISTRY STUDENTS**
Each student of Chemistry Department has to opt one Generic Elective Course from the available options offered by different science, mathematics, computer science and economics departments. However, a student can take only one GE course from one department per semester.

**GENERIC ELECTIVE (CHEMISTRY)**
Theory Papers:
A student from other disciplines may opt following generic elective offered by the Chemistry Department of Panjab University:
Generic Elective -4 (GE-4) 100 Marks (4 credits)
Practicals:
Generic Elective -4 Practical (GE-4 Lab) 50 Marks (2 credits)
Semester V

CORE COURSE (CHEMISTRY)

Theory Papers:
Core Course-11 (C 11): Organic Chemistry-IV 100 Marks (4 credits)
Core Course-12 (C 12): Physical Chemistry-V 100 Marks (4 credits)

Practicals:
Core Course-11 Practical (C 11 Lab): Organic Chemistry-IV 50 Marks (2 credits)
Core Course-12 Practical (C 12 Lab): Physical Chemistry-V 50 Marks (2 credits)

DISCIPLINE SPECIFIC ELECTIVE COURSES

Theory Papers:
Each student of Chemistry Department has to opt for two Discipline Specific Elective Courses of the following:
1. CHE-DSE1: Green Chemistry 100 Marks (4 credits)
2. CHE-DSE2: Analytical Methods in Chemistry 100 Marks (4 credits)
3. CHE-DSE3: Inorganic Materials of Industrial Importance 100 Marks (4 credits)
4. CHE-DSE4: Polymer Chemistry 100 Marks (4 credits)

Practicals:
1. CHE-DSE1: Green Chemistry 50 Marks (4 credits)
2. CHE-DSE2: Analytical Methods in Chemistry 50 Marks (4 credits)
3. CHE-DSE3: Inorganic Materials of Industrial Importance 50 Marks (4 credits)
4. CHE-DSE4: Polymer Chemistry 50 Marks (4 credits)

Semester VI

CORE COURSE (CHEMISTRY)

Theory Papers:
Core Course-13 (C 13): Inorganic Chemistry-IV 100 Marks (4 credits)
Core Course-14 (C 14): Organic Chemistry-V 100 Marks (4 credits)

Practicals:
Core Course-13 Practical (C 13 Lab): Inorganic Chemistry-IV 50 Marks (2 credits)
Core Course-14 Practical (C 14 Lab): Organic Chemistry-V 50 Marks (2 credits)

DISCIPLINE SPECIFIC ELECTIVE COURSES

Theory Papers:
Each student of Chemistry Department has to opt for two Discipline Specific Elective Courses of the following:
1. CHE-DSE5: Applications of Computers in Chemistry 100 Marks (4 credits)
2. CHE-DSE6: Colloidal Chemistry 100 Marks (4 credits)
3. CHE-DSE7: Strategies in Organic Synthesis 100 Marks (4 credits)
4. CHE-DSE8: Properties of Coordination Compounds & Group Theory 100 Marks (4 credits)

Practicals:
1. CHE-DSE5: Applications of Computers in Chemistry 50 Marks (4 credits)
2. CHE-DSE6: Colloidal Chemistry 50 Marks (4 credits)
3. CHE-DSE7: Strategies in Organic Synthesis 50 Marks (4 credits)
4. CHE-DSE8: Properties of Coordination Compounds & Group Theory 50 Marks (4 credits)
EVALUATION

1. There shall be one Mid Term Examination of 20% Marks in each semester.
2. End-semester examination will be of 80% of total marks.
3. Each practical examination shall be of 3 hours duration.
4. There shall be continuous internal assessment for practicals of 20% marks. The final examination will be of 80% marks.

Pattern of end-semester question paper

(i) Nine questions in all with equal weightage. The candidate will be asked to attempt five questions
(ii) One Compulsory question (consisting of short answer type questions) covering whole syllabus. There will be no choice in this question.
(iii) The remaining eight questions will have Four Units comprising two questions from each Unit.
(iv) Students will attempt one question from each unit and the compulsory question.
PREAMBLE

The B.Sc. (Honours) in Chemistry under the framework of honours school system is a three year, six semester programme of the Chemistry department of PU. The Department of Chemistry was founded by Dr. S. S. Bhatnagar at Lahore in 1925. It is one of the prestigious departments of Panjab University with highly qualified and competent faculty members, whose work has been internationally recognized. Several faculty members are recipients of awards and honours, such as Shanti Swarup Bhatnagar, Jawaharlal Nehru fellowship, Raman and Palit awards. Many faculty members are bestowed with F.N.A., F.A.Sc., F.N.A.Sc., Young Scientist award as well as Visiting Professorship from India and abroad. The department has been selected by the UGC first for COSIST, and then for Special Assistant Programme (SAP) and now it is the Centre for Advanced Studies in Chemistry (CAS) for the last 20 years. The Department of Science and Technology (DST), Government of India has awarded FIST LEVEL-II status to this department.

The department has stimulating undergraduate (3-years) and postgraduate (2-years) teaching programmes in terms if BSc. (Hons.) and MSc (Hons.) programmes besides a vibrant research programme leading to PhD. Frequent symposia, summer schools, refresher and orientation courses are organized for the benefit of University, College and School teachers as well as talented students.

The department has good instrumental facilities such as high resolution 300 MHz NMR, FT-IR, UV-Visible Spectrophotometer, Polarimeter, Photocorrelation Spectrometer, HPLC, Microwave synthesizer etc and good computer facilities for carrying out advanced research. These facilities are often utilized by many Science Department of the Panjab University as well as other Universities, Industries and Institutes in the region. The library of the chemistry department is perhaps one of the best libraries in the subject in Northern India with an excellent collection of books, research journals and monographs.

The department is well known for its research activities and has very well equipped research laboratories. The main areas of research include: Main Group Elements Chemistry, Coordination Chemistry, synthetic Inorganic Chemistry, Organometallic Chemistry, Silicon Chemistry, Non-aqueous solution chemistry, Synthetic Organic Chemistry, Development of New reactions, Photochemistry, Nano-chemistry, Colloidal Chemistry (micelles and microemulsions), Thermodynamics of liquid mixtures as well as electrolyte solutions, Protein Chemistry and Theoretical Chemistry (quantum fluid dynamics, stochastic resonance)
# COURSE STRUCTURE

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<td>C1 CHE-C1: Inorganic Chemistry-I</td>
<td>C3 CHE-C3: Organic Chemistry-I</td>
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<tr>
<td>C2 CHE-C2: Physical Chemistry-I</td>
<td>C4 CHE-C4: Physical Chemistry-II</td>
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<tr>
<td>AECC1 CHE-AECC1: English</td>
<td>AECC2 CHE-AECC2: Environmental Science</td>
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<td>GE1A*</td>
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<td>GE1B*</td>
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<td>C5 CHE-C5: Inorganic Chemistry-II</td>
<td>C8 CHE-C8: Inorganic Chemistry-III</td>
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<td>C7 CHE-C7: Physical Chemistry-III</td>
<td>C10 CHE-C10: Physical Chemistry-IV</td>
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<td>SEC1</td>
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<th>SEMESTER V</th>
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<td>C12 CHE-C12: Physical Chemistry-V</td>
<td>C14 CHE-C14: Organic Chemistry-V</td>
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<td>DSE1</td>
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C: Core Courses; GE: General Elective; AECC: Ability Enhancement Compulsory Courses; SEC: Skill Enhancement Courses; DSE: Discipline Specific Elective

*GE subjects are to be selected by the students from the pool of GE Subjects offered by various Departments of the University.
**SKILL ENHANCEMENT COURSES** (any one per semester in semesters 3-4)**

1. CHE-SEC1: Industrial Chemistry of Fuels  OR  
   CHE-SEC2: Basic Analytical Chemistry  OR  
   CHE-SEC3: Pesticide Chemistry

2. CHE-SEC4: Pharmaceutical Chemistry  OR  
   CHE-SEC5: Chemical Technology & Society  OR  
   CHE-SEC6: Chemistry of Cosmetics & Perfumes

**Courses under these will be offered only if a minimum of 20 students opt for the same**

**DISCIPLINE SPECIFIC ELECTIVE SUBJECTS** (any two per semester in semesters 5-6)**

1. CHE-DSE1: Green Chemistry  OR  
   CHE-DSE2: Analytical Methods in Chemistry  OR  
   CHE-DSE3: Inorganic Materials of Industrial Importance  OR  
   CHE-DSE4: Polymer Chemistry

2. CHE-DSE5: Applications of Computers in Chemistry  OR  
   CHE-DSE6: Colloidal Chemistry  OR  
   CHE-DSE7: Strategies in Organic Synthesis  OR  
   CHE-DSE8: Properties of Coordination Compounds and Group Theory

**Courses under these will be offered only if a minimum of 20 students opt for the same**

**GENERIC ELECTIVE SUBJECTS** (Offered by Chemistry Department) *for students of other departments*

I-Semester  
CHE-GE 1: Atomic structure, bonding, general organic chemistry & aliphatic hydrocarbons

II-Semester  
CHE-GE 2: Chemistry of Main Group Elements & functional organic chemistry

III-Semester  
CHE-GE 3: Chemical Energetics, Equilibria and Transition Metal & Coordination Chemistry, Theories of Acids & Bases

IV-Semester  
CHE-GE 4: Molecules of life, Spectroscopy, states of matter & chemical kinetics

Department will run a particular Generic Elective Course only if the minimum number of students opting for that course is 10.
B.Sc. (Honours) in Chemistry

Under the Framework of Honours School System

1st, 2nd and 3rd Year
Semester I, II, III, IV, V and VI
Objective: The objective of the Inorganic Chemistry is to acquaint the student with the basic phenomenon/concepts of atomic structure and the correlation between structure and properties of materials via chemical bonding.

UNIT-1: Atomic Structure (15 Lectures)

UNIT-2: Periodicity of Elements (15 Lectures)
s, $p$, $d$, $f$ block elements, the long form of periodic table. Detailed discussion of the following properties of the elements, with reference to $s$ and $p$-block. (a) Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table. (b) Atomic radii (van der Waals) (c) Ionic and crystal radii. (d) Covalent radii (octahedral and tetrahedral) (e) Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization energy. Applications of ionization enthalpy. (f) Electron gain enthalpy, trends of electron gain enthalpy. (g) Electronegativity, Pauling’s/ Mulliken’s/ Allred Rachow’s/ and Mulliken-Jaffé’s electronegativity scales. Variation of electronegativity with bond order, partial charge, hybridization, group electronegativity. Sanderson’s electron density ratio.

UNIT-3: Chemical Bonding (15 Lectures)
(i) Ionic bond: General characteristics, types of ions, size effects, radius ratio rule and its limitations. Packing of ions in crystals. Born-Landé equation with derivation and importance of Kapustinskii expression for lattice energy. Madelung constant, Born-Haber cycle and its application, Solvation energy. (ii) Covalent bond: Valence Bond theory (Heitler-London approach). Energetics of hybridization, equivalent and non-equivalent hybrid orbitals. Bent’s rule, Resonance and resonance energy, Molecular orbital theory. Molecular orbital diagrams of diatomic and simple polyatomic molecules $N_2$, $O_2$, $C_2$, $B_2$, $F_2$, $CO$, $NO$, and their ions; $HCl$, $BeF_2$, $CO_2$, (idea of s-p mixing and orbital interaction to be given). Formal charge, Valence shell electron pair repulsion theory (VSEPR), shapes of simple molecules and ions containing lone pairs and bond pairs of electrons, multiple bonding ($\sigma$ and $\pi$ bond approach) and bond lengths.
UNIT-4: Chemical Bonding (15 Lectures)
Covalent character in ionic compounds, polarizing power and polarizability. Fajan’s rules and consequences of polarization. Ionic character in covalent compounds: Bond moment and dipole moment. Percentage ionic character from dipole moment and electronegativity difference.

(Metallic Bond): Qualitative idea of valence bond and band theories. Semiconductors and insulators, defects in solids.

Weak Chemical Forces: van der Waals forces, ion-dipole forces, dipole-dipole interactions, induced dipole interactions, Instantaneous dipole-induced dipole interactions. Repulsive forces, Hydrogen bonding (theories of hydrogen bonding, valence bond treatment). Effects of chemical force, melting and boiling points, solubility energetics of dissolution process. Oxidation-Reduction:
Redox equations, Standard Electrode Potential and its application to inorganic reactions. Principles involved in volumetric analysis to be carried out in class.

Reference Books:

CHE -C1 Lab: (INORGANIC CHEMISTRY-I)
PRACTICALS

Total Lectures: 60 Credits: 2

(A) Titrimetric Analysis
(i) Calibration and use of apparatus
(ii) Preparation of solutions of different Molarity/Normality of titrants

(B) Acid-Base Titrations
(i) Estimation of carbonate and hydroxide present together in mixture.
(ii) Estimation of carbonate and bicarbonate present together in a mixture.
(iii) Estimation of free alkali present in different soaps/detergents

(C) Oxidation-Reduction Titrimetry
(i) Estimation of Fe(II) and oxalic acid using standardized KMnO₄ solution.
(ii) Estimation of oxalic acid and sodium oxalate in a given mixture.
(iii) Estimation of Fe(II) with K₂Cr₂O₇ using internal (diphenylamine, anthranilic acid) and external indicator.

*The experiments may be modified according to the availability of reagents, apparatus, instruments and safety features

Reference Books:
Objective: The objective of the Physical Chemistry is to acquaint the student with the basic phenomenon/concepts of equation of state and properties of liquids and solids. In this module students will learn about chemical equilibrium, its types and the factors affecting the state of equilibrium. In this the lesson you will learn about the equilibria involving ionic species. The equilibria involving acids and bases are critically important for a wide variety of reactions. The use of buffer solutions for pH control is of significance in living systems, agriculture and industrial processes.

UNIT-1: Gaseous state (15 Lectures)
Kinetic molecular model of a gas: postulates and derivation of the kinetic gas equation; deduce gas laws and ideal gas equation from kinetic gas equation; collision frequency; collision diameter; mean free path and viscosity of gases, including their temperature and pressure dependence, relation between mean free path and coefficient of viscosity, calculation of σ from η; variation of viscosity with temperature and pressure.
Maxwell distribution and its use in evaluating molecular velocities (average, root mean square and most probable) and average kinetic energy, law of equipartition of energy, degrees of freedom and molecular basis of heat capacities.
Behaviour of real gases: Deviations from ideal gas behaviour, compressibility factor, Z, and its variation with pressure for different gases. Causes of deviation from ideal behaviour. Van der Waals equation of state, its derivation and application in explaining real gas behaviour, mention of other equations of state (Berthelot, Dietrici) and virial equation of state.

UNIT-2: Liquification of Gas & Liquid state (15 Lectures)
Isotherms of real gases and their comparison with van der Waals isotherms, continuity of states, critical state, relation between critical constants and van der Waals constants, law of corresponding states.
Qualitative treatment of the structure of the liquid state; Radial distribution function; physical properties of liquids; density, refractive index, vapour pressure, surface tension and coefficient of viscosity, and their determination. Effect of addition of various solutes on surface tension and viscosity. Explanation of cleansing action of detergents. Temperature variation of viscosity of liquids and comparison with that of gases.

UNIT-3: Solid state (15 Lectures)
Nature of the solid state, law of constancy of interfacial angles, law of rational indices, Miller indices, elementary ideas of symmetry, symmetry elements and symmetry operations, qualitative idea of point and space groups, seven crystal systems and fourteen Bravais lattices; X-ray Diffraction, Bragg’s law, a simple account of rotating crystal method and powder pattern method. Neutron Diffraction; How do neutrons interact with solids and comparison of X-ray Diffraction and Neutron Diffraction. Defects in crystals. Glasses and liquid crystals.
UNIT-4: Ionic equilibria (15 Lectures)

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect; dissociation constants of mono-, di- and triprotic acids (exact treatment).

Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions; derivation of Henderson equation and its applications; buffer capacity, buffer range, buffer action and applications of buffers in analytical chemistry and biochemical processes in the human body.


Reference Books:

CHE -C1 Lab: PHYSICAL CHEMISTRY-I
PRACTICALS

Total Lectures: 60 Credits: 2

1. Surface tension measurements.
   a. Determine the surface tension by (i) drop number (ii) drop weight method.
   b. Study the variation of surface tension of detergent solutions with concentration.

2. Viscosity measurement using Ostwald’s viscometer.
   a. Determination of viscosity of aqueous solutions of (i) polymer (ii) ethanol and (iii) sugar at room temperature.
   b. Study the variation of viscosity of sucrose solution with the concentration of solute.

3. Density and refractive index measurements
   a. Determination of density and refractive index viscosity of organic solvents at room temperature.

4. pH metry
   a. Study the effect on pH of addition of HCl/NaOH to solutions of acetic acid, sodium acetate and their mixtures.
   b. Preparation of buffer solutions of different pH
      i. Sodium acetate-acetic acid
      ii. Ammonium chloride-ammonium hydroxide
   c. pH metric titration of (i) strong acid vs. strong base, (ii) weak acid vs. strong base.
   d. Determination of dissociation constant of a weak acid.
Reference Books:


SEMESTER I

CHE-GE1: Atomic structure, bonding, general organic chemistry & aliphatic hydrocarbons

**THEORY**

Total Lectures: 60  
Credits: 4

Objective: To teach the fundamental concepts of Chemistry and their applications. The syllabus contents are duly arranged unit wise and contents are included in such a manner so that due importance is given to the requisite intellectual understanding of atomic structure, bonding, general organic chemistry & aliphatic hydrocarbons and laboratory skills.

UNIT-1: Atomic Structure (15 Lectures)

Review of: Bohr’s theory and its limitations, dual behavior of matter and radiation, de Broglie’s relation, Heisenberg Uncertainty principle. Hydrogen atom spectra. Need of a new approach to Atomic structure. What is Quantum mechanics? Time independent Schrödinger equation and meaning of various terms in it. Significance of $\psi$ and $\psi^2$, Schrödinger equation for hydrogen atom. Radial and angular parts of the hydogenic wave functions (atomic orbitals) and their variations for $1s$, $2s$, $2p$, $3s$, $3p$ and $3d$ orbitals (Only graphical representation). Radial and angular nodes and their significance. Radial distribution functions and the concept of the most probable distance with special reference to $1s$ and $2s$ atomic orbitals. Significance of quantum numbers, orbital angular momentum and quantum numbers $ml$ and $ms$. Shapes of $s$, $p$ and $d$ atomic orbitals, nodal planes. Discovery of spin, spin quantum number (s) and magnetic spin quantum number (ms). Rules for filling electrons in various orbitals, Electronic configurations of the atoms. Stability of half-filled and completely filled orbitals, concept of exchange energy. Relative energies of atomic orbitals, Anomalous electronic configurations.

UNIT-2: Chemical Bonding and Molecular Structure (15 Lectures)

Ionic Bonding: General characteristics of ionic bonding. Energy considerations in ionic bonding, lattice energy and solvation energy and their importance in the context of stability and solubility of ionic compounds. Statement of Born-Landé equation for calculation of lattice energy, Born-Haber cycle and its applications, polarizing power and polarizability. Fajan’s rules, ionic character in covalent compounds, bond moment, dipole moment and percentage ionic character. Covalent bonding: VB Approach: Shapes of some inorganic molecules and ions on the basis of VSEPR and hybridization with suitable examples of linear, trigonal planar, square planar, tetrahedral, trigonal bipyramidal and octahedral arrangements. Concept of resonance and resonating structures in various inorganic and organic compounds. MO Approach: Rules for the LCAO method, bonding and antibonding MOs and their characteristics for $s$-$s$, $s$-$p$ and $p$-$p$ combinations of atomic orbitals, nonbonding combination of orbitals, MO treatment of homonuclear diatomic molecules of 1st and 2nd periods (including idea of $s$-$p$ mixing) and
heteronuclear diatomic molecules such as CO, NO and NO$^+$. Comparison of VB and MO approaches.

**UNIT-3: Fundamentals of Organic Chemistry (15 Lectures)**

**UNIT-4: Aliphatic and Aromatic Hydrocarbons (15 Lectures)** Functional group approach for the following reactions (preparations & reactions) to be studied in context to their structure. Alkanes: (Upto 5 Carbons). Preparation: Catalytic hydrogenation, Wurtz reaction, Kolbe’s synthesis, from Grignard reagent. Reactions: Free radical Substitution: Halogenation. Alkenes: (Upto 5 Carbons) Preparation: Elimination reactions: Dehydration of alkenes and dehydrohalogenation of alkyl halides (Saytzeff’s rule); cis alkenes (Partial catalytic hydrogenation) and trans alkenes (Birch reduction). Reactions: cis-addition (alk. KMnO4) and trans-addition (bromine), Addition of HX (Markownikoff’s and anti-Markownikoff’s addition), Hydration, Ozonolysis, oxymecuration-demercuration, Hydroboration-oxidation. Alkynes: (Upto 5 Carbons) Preparation: Acetylene from CaC$_2$ and conversion into higher alkynes; by dehalogenation of tetra halides and dehydrohalogenation of vicinal-dihalides. Reactions: formation of metal acetylides, addition of bromine and alkaline KMnO$_4$, ozonolysis and oxidation with hot alk. KMnO$_4$. Preparation (Case benzene): from phenol, by decarboxylation, from acetylene, from benzene sulphonic acid. Reactions: (Case benzene): Electrophilic substitution: nitration, halogenation and sulphonation. Friedel-Craft’s reaction (alkylation and acylation) (upto 4 carbons on benzene). Side chain oxidation of alkyl benzenes (upto 4 carbons on benzene).

**Reference Books:**

CHE-GE1 LAB: Atomic structure, bonding, general organic chemistry & aliphatic hydrocarbons

PRACTICALS

Total Lectures: 60
Credits: 2

Section A: Inorganic Chemistry - Volumetric Analysis
1. Estimation of sodium carbonate and sodium hydrogen carbonate present in a mixture.
2. Estimation of oxalic acid by titrating it with KMnO₄.
3. Estimation of water of crystallization in Mohr’s salt by titrating with KMnO₄.
4. Estimation of Fe(II) ions by titrating it with K₂Cr₂O₇ using internal indicator.
5. Estimation of Cu(II) ions iodometrically using Na₂S₂O₃.

Section B: Organic Chemistry
1. Detection of extra elements (N, S, Cl, Br, I) in organic compounds (containing upto two extra elements)
2. Separation of mixtures by Chromatography: Measure the Rf value in each case (combination of two compounds to be given)
   (a) Identify and separate the components of a given mixture of two amino acids (glycine, aspartic acid, glutamic acid, tyrosine or any other amino acid) by paper chromatography
   (b) Identify and separate the sugars present in the given mixture by paper chromatography.
3. Purification of organic compounds by crystallization (from water and alcohol) and distillation.
4. Criteria of Purity: Determination of melting point

Reference Books:
Objective: The objective of the Organic Chemistry is to acquaint the student with the basic phenomenon/concepts of stereochemistry of organic compounds and mechanistic aspects of organic reactions. The course is adequate with basic knowledge of hydrocarbons ranging from alkanes to arenes chemistry so they will understand the method of formations and reactions of compounds.

UNIT-1: Structure, Bonding and Mechanism of Organic Reactions: (15 Lectures)
Hybridization, bond lengths and bond angles, bond energy, localized and delocalized chemical bond, van der Waals interactions, inclusion compounds, clatherates, charge transfer complexes resonance, hyperconjugation, aromaticity, inductive and field effects, hydrogen bonding.
Curved arrow notation, drawing electron movements with arrows half-headed and double-headed arrows, hemolytic and heterolytic bond breaking. Types of reagents – electrophiles and nucleophiles. Types of organic reactions. Energy considerations.
Reactive intermediates – carbocations, carbanions, free radicals, carpenes, arynes and nitrenes (with examples). Assigning formal charges on intermediates and other ionic species.
Methods of determination of reaction mechanism (product analysis, intermediates, isotope effects, kinetic and stereochemical studies).


UNIT-2: Alkanes and Cycloalkanes: (15 Lectures)
Stereochemistry of Organic Compounds-I I : Conformational isomerism – conformational analysis of ethane and n-butane; conformations of cyclohexane, axial and equatorial bonds, conformation of mono substituted cyclohexane derivative.
Cycloalkanes – nomenclature, methods of formation, chemical reactions, Baeyer’s strain theory and its limitations. Ring strain in small rings (cyclopropane and cyclobutane), theory of strainless rings. The case of cyclopropane ring; banana bonds.
UNIT-3: Alkenes, Cycloalkenes, Dienes(15 Lectures)

UNIT-4: Alkynes, Arenes and Aromaticity(15 Lectures)


Reference Books:
CHE -C3: ORGANIC CHEMISTRY- I: Basics and Hydrocarbons

PRACTICALS

Total Lectures: 60

1. **Calibration of Thermometer**
   80-82°C (Naphthalene), 113-114°C (acetanilide).

2. **Determination of melting point**
   Naphthalene 80-82°C, Benzoic acid 121.5-122°C Urea,
   132.5-133°C, Succinic acid 184-185°C Cinnamic acid
   132.5-133°C, Salicylic acid 157-158°C Acetanilide
   113-5-114°C, m-Dinitrobenzene 90°C p-
   Dichlorobenzene 52°C. Aspirin 135°C.

3. **Determination of boiling points**
   Ethanol 78°C, Cyclohexane 81.4°C, Toluene 110.6°C, Benzene 80°C.

4. **Mixed melting point determination**

5. **Distillation**

6. **Crystallization**
   Concept of induction of crystallization
   Phthalic acid from hot water (using fluted filter paper and stemless funnel)
   Acetanilide from boiling water
   Naphthalene from ethanol
   Benzoic acid from water.

7. **Decolourisation and crystallization using charcoal**
   Decolourisation of brown sugar (sucrose) with animal charcoal using gravity filtration.
   Crystallization and decolourisation of impure naphthalene (100g of naphthalene mixed with 0.3g of Congo Red using 1g decolorising carbon) from ethanol.

8. **Sublimation(Simple and Vacuum)**

9. **Extraction: The separatory funnel, drying agent:**
   Isolation of caffeine from tea leaves

10. **Steam distillation**
    Purification of aniline/nitrobenzene by steam distillation.

Reference Books

SEMESTER II
CHE –C4: PHYSICAL CHEMISTRY- II: Chemical Thermodynamics and its Applications
THEORY

Total Lectures: 60
Credits: 4

Objective: To develop and systematically upgrade their knowledge of concepts of thermodynamics and to be able to identify and describe energy exchange processes. The student with the knowledge of the thermodynamics will understand and explain scientifically the application of the subject to a wide variety of topics in science and engineering, especially physical chemistry, chemical engineering and mechanical engineering.

UNIT-1: Chemical Thermodynamics (15 Lectures)
Intensive and extensive variables; state and path functions; isolated, closed and open systems; zeroth law of thermodynamics. First law: Concept of heat, $q$, work, $w$, internal energy, $U$, and statement of first law; enthalpy, $H$, relation between heat capacities, calculations of $q$, $w$, $U$ and $H$ for reversible, irreversible and free expansion of gases (ideal and van der Waals) under isothermal and adiabatic conditions.

UNIT-2: Thermochemistry, Second and Third Law of thermodynamics (15 Lectures)
Thermochemistry: Heats of reactions: standard states; enthalpy of formation of molecules and ions and enthalpy of combustion and its applications; calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data, effect of temperature (Kirchhoff’s equations) and pressure on enthalpy of reactions. Adiabatic flame temperature, explosion temperature.
Second Law: Concept of entropy; thermodynamic scale of temperature, statement of the second law of thermodynamics; molecular and statistical interpretation of entropy. Calculation of entropy change for reversible and irreversible processes.
Third Law: Statement of third law, concept of residual entropy, calculation of absolute entropy of molecules.

UNIT-3: Free Energy functions and Systems of Variable Composition (15 Lectures)
Free Energy Functions: Gibbs and Helmholtz energy; variation of S, G, A with T, V, P; Free energy change and spontaneity. Relation between Joule-Thomson coefficient and other thermodynamic parameters; inversion temperature; Gibbs-Helmholtz equation; Maxwell relations; thermodynamic equation of state.
Systems of Variable Composition: Partial molar quantities, dependence of thermodynamic parameters on composition; Gibbs-Duhem equation, chemical potential of ideal mixtures, change in thermodynamic functions in mixing of ideal gases.

UNIT-4: Chemical Equilibrium, Solutions and Colligative Properties (15 Lectures)
Criteria of thermodynamic equilibrium, degree of advancement of reaction, chemical equilibria in ideal gases, concept of fugacity. Thermodynamic derivation of relation between Gibbs free energy of reaction and reaction quotient. Coupling of exoergic and endoergic reactions. Equilibrium constants and their quantitative dependence on temperature, pressure and concentration. Free energy of mixing and spontaneity; thermodynamic derivation of relations.
between the various equilibrium constants $K_p$, $K_c$ and $K_x$. Le Chatelier principle (quantitative treatment); equilibrium between ideal gases and a pure condensed phase. Solutions and Colligative Properties:

Dilute solutions; lowering of vapour pressure, Raoult’s and Henry’s Laws and their applications. Excess thermodynamic functions. Thermodynamic derivation using chemical potential to derive relations between the four colligative properties [(i) relative lowering of vapour pressure, (ii) elevation of boiling point, (iii) Depression of freezing point, (iv) osmotic pressure] and amount of solute. Applications in calculating molar masses of normal, dissociated and associated solutes in solution

Reference Books


CHE –C4: PHYSICAL CHEMISTRY- II: Chemical Thermodynamics and its Applications

PRACTICAL

Total Lectures: 60

Thermochemistry

(a) Determination of heat capacity of a calorimeter for different volumes using change of enthalpy data of a known system (method of back calculation of heat capacity of calorimeter from known enthalpy of solution or enthalpy of neutralization).

(b) Determination of heat capacity of the calorimeter and enthalpy of neutralization of hydrochloric acid with sodium hydroxide.

(c) Calculation of the enthalpy of ionization.

(d) Determination of heat of solution of at least four different salts.

(e) Determination of enthalpy of hydration of copper sulphate.

(f) Study of the solubility of benzoic acid in water and determination of $H$.

Reference Books

SEMESTER II
CHE-GE2: Chemistry of Main Group Elements & functional organic chemistry
THEORY

Total Lectures: 60 Credits: 4
Objective: To teach the fundamental concepts of Chemistry and their applications. The syllabus contents are duly arranged unit wise and contents are included in such a manner so that due importance is given to the requisite intellectual understanding of Chemistry of Main Group Elements & functional organic chemistry and laboratory skills

UNIT-1: s-Block Elements (15 Lectures)
Periodicity in s-block elements with respect to electronic configuration, atomic and ionic size, ionization enthalpy, electron gain enthalpy, and flame color.
General characteristics of s-block metals like density, melting and boiling points, reducing nature. Oxidation states of s-block elements, diagonal relationships and anomalous behavior of first member of each group.
Complex forming tendency of s block elements and a preliminary idea of crown ethers and cryptates, structures of basic beryllium acetate, salicylaldehyde/acetylacetonato complexes of Group 1 metals.
Solutions of alkali metals in liquid ammonia and their properties. Common features, such as ease of formation, solubility and stability of oxides, peroxides, superoxides, sulphates and carbonates of s-block metals.

UNIT-2: p-Block Elements (15 Lectures)
General characteristics of p-block metals like density, melting and boiling points, reducing/oxidizing nature and electronegativity (Pauling scale). Oxidation states of p-block elements, inert-pair effect, and anomalous behavior of first member of each group. Allotropy in C, P and S.
Structure, bonding and properties (acidic/ basic nature, oxidizing/ reducing nature and hydrolysis of the following compounds and their applications in industrial and environmental chemistry wherever applicable: Diborane and concept of multicentre bonding, hydrides of Groups 13 (EH₃), 14, 15, 16 and 17. Oxides of N and P, Oxoacids of P, S and Cl.
Halides and oxohalides of P and S (PCl₃, PCl₅, SOCl₂ and SO₂Cl₂) Interhalogen compounds. A brief idea of pseudohalides
Noble gases: Rationalization of inertness of noble gases, clathrates, preparation and properties of XeF₂, XeF₄ and XeF₆, bonding in these compounds using VBT and shapes of noble gas compounds using VSEPR Theory.

UNIT-3: Alkyl and Aryl Halides, Alcohols and Phenols, Ethers (15 Lectures)
Functional group approach for the following reactions (preparations & reactions) to be studied in context to their structure.
Alkyl Halides (Upto 5 Carbons) Types of Nucleophilic Substitution (SN1, SN2 and SNi) reactions. Preparation: from alkenes and alcohols. Reactions: hydrolysis, nitrite & nitro formation, nitrile & isonitrile formation. Williamson’s ether synthesis: Elimination vs substitution.
Aryl Halides Preparation: (Chloro, bromo and iodo-benzene case): from phenol, Sandmeyer & Gattermann reactions. Reactions (Chlorobenzene): Aromatic nucleophilic substitution (replacement by –OH group) and effect of nitro substituent. Benzyne Mechanism: KNH₂/NH₃
Reactivity and Relative strength of C-Halogen bond in alkyl, allyl, benzyl, vinyl and aryl halides.

**Alcohols:** *Preparation:* Preparation of 1°, 2° and 3° alcohols: using Grignard reagent, Ester hydrolysis, Reduction of aldehydes, ketones, carboxylic acid and esters. *Reactions:* With sodium, HX (Lucas test), esterification, oxidation (with PCC, alk. KMnO₄, acidic dichromate, conc. HNO₃). Oppeneauer oxidation *Diols:* (Upto 6 Carbons) oxidation of diols. Pinacol-Pinacolone rearrangement.


**Ethers (aliphatic and aromatic):** Cleavage of ethers with HI.

**UNIT-4: Carbonyl chemistry, Amines and Diazonium Salts**


**Carboxylic acids:** Carboxylic acids (aliphatic and aromatic) *Preparation:* Acidic and Alkaline hydrolysis of esters. *Reactions:* Hell – Vohlard - Zelinsky Reaction.


**Diazonium salts:** *Preparation:* from aromatic amines. *Reactions:* conversion to benzene, phenol, dyes.

**Reference Books:**
CHE-GE2 LAB: Chemistry of Main Group Elements & functional organic chemistry
PRACTICALS

Total Lectures: 60 Credits: 2

Section A: Inorganic Chemistry
1. Iodometric estimation of potassium dichromate and copper sulphate
2. Estimation of amount of available chlorine in bleaching powder and household bleaches
3. Estimation of dissolved oxygen in water samples.
4. Gravimetric estimation of aluminium as oximato complex
5. Preparation of the following: potash alum, chrome alum, tetraamminecopper(II)sulphate monohydrate, potassium trioxalatoferrate(III) (any two, including one double salt and one complex).

Section B: Organic Chemistry
2. Preparations: Mechanism of various reactions involved to be discussed. Recrystallisation, determination of melting point and calculation of quantitative yields to be done.
   (a) Benzoylation of amines/phenols
   (b) Oxime and 2,4-dinitrophenylhydrazone of aldehyde/ketone

Reference Books
SEGMENT III
CHE –C5: INORGANIC CHEMISTRY-II: MAIN GROUP CHEMISTRY
THEORY

Total Lectures: 60

Credits: 4

OBJECTIVE: The objective of the Inorganic Chemistry is to acquaint the student with the general principle of Metallurgy and to explain certain key introductory concepts in inorganic chemistry i.e. acid, bases and inorganic polymers. In addition, the syllabus contents are duly arranged in such a manner so that due importance is given to the understanding of main group elements, and laboratory skills.

UNIT-1: General Principles of Metallurgy & Acids and Bases (15 Lectures)


Acids and Bases: Arrhenius, Brönsted-Lowry concept of acids and bases, solvent system, relative strength of acids and bases, Lewis acid-base concept, Hard and Soft Acids and Bases (HSAB), Applications of HSAB principle.

UNIT-2: Chemistry of s and p Block Elements-I (15 Lectures)

Inert pair effect, relative stability of different oxidation states, diagonal relationship and anomalous behaviour of first member of each group. Allotropy and catenation. Complex formation tendency of s and p block elements.

Hydrides and their classification ionic, covalent and interstitial. Basic beryllium acetate and nitrate.

UNIT-3: Chemistry of s and p Block Elements-II (15 Lectures)

Study of the following compounds with emphasis on structure, bonding, preparation, properties and uses: Boric acid and borates, boron nitrides, boron hydrides (diborane), carboranes and graphitic compounds, silanes, Oxides and oxoacids of nitrogen, phosphorus and chlorine, Peroxo acids of sulphur, interhalogen compounds, polyhalide ions, pseudohalogens and basic properties of halogens.

UNIT-4: Noble Gases & Inorganic Polymers (15 Lectures)

Noble Gases: Occurrence and uses, rationalization of inertness of noble gases, Clathrates; preparation and properties of XeF₂, XeF₄ and XeF₆; Nature of bonding in noble gas compounds (Valence bond treatment and MO treatment for XeF₂). Molecular shapes of noble gas compounds (VSEPR theory).

Inorganic Polymers: Types of inorganic polymers, comparison with organic polymers, synthesis, structural aspects and applications of polysiloxanes, polyphosphazenes and polysilanes.

Reference Books:

CHE –C5 Lab: (INORGANIC CHEMISTRY-II) 
PRACTICALS

Total Lectures: 60  
Credits: 2

(A) Iodo/Iodimetric Titrations
(i) Estimation of Cu(II) and K₂Cr₂O₇ using sodium thiosulphate solution.
(ii) Estimation of available chlorine in bleaching powder.
(iii) Estimation of antimony in tar-emetic.
(iv) Estimation of iron (Fe) in tablet
(v) Estimation of Cu in brass

(B) Inorganic preparations
(i) Cuprous Chloride, Cu₂Cl₂
(ii) Preparation of Manganese(III) phosphate, MnPO₄H₂O
(iii) Preparation of Aluminium potassium sulphate KAl(SO₄)₂12H₂O (Potash alum) or Chrome alum.
(iv) Synthesis of molecular sieve – zeolite X and cobalt exchange reaction with it.
(v) Preparation and study the linkage isomers complexes of [Co(NH₃)₅(ONO)]Cl₂ and [Co(NH₃)₅(NO₂)]Cl₂

*The experiments may be modified according to the availability of reagents, apparatus, instruments and safety features

Reference Books:

SEMESTER III

CHE–C6: ORGANIC CHEMISTRY-II: Halogenated Hydrocarbons & Functional Groups

THEORY

Total Lectures: 60  
Credits: 4

Objective: The objective of the Organic Chemistry is to acquaint the student with the halogenated hydrocarbons and their comparative studies. The course is adequated with basic knowledge of alcohols, phenols, ethers, carbonyl compounds, carboxylic acids & their derivatives and thiols chemistry so they will understand the method of formations and reactions of compounds

Unit-I: Chemistry of Halogenated Hydrocarbons: (15 Lectures)
Alkyl halides: Methods of preparation, nucleophilic substitution reactions – SN1, SN2 and SNi
mechanisms with stereochemical aspects and effect of solvent etc.; nucleophilic substitution vs. elimination.

* Aryl halides: Preparation, including preparation from diazonium salts. nucleophilic aromatic substitution; SNAr, Benzyne mechanism. Relative reactivity of alkyl, allyl/benzyl, vinyl and aryl halides towards nucleophilic substitution reactions.

Organometallic compounds of Mg and Li – Use in synthesis of organic compounds.

**Unit-II: Alcohols, Phenols, Ethers and Epoxides: (15 Lectures)**

* Alcohols: preparation, properties and relative reactivity of 1°, 2°, 3° alcohols, Bouvaelt-BlancReduction; Preparation and properties of glycols: Oxidation by periodic acid and lead tetraacetate, Pinacol-Pinacolone rearrangement;

* Phenols: Preparation and properties; Acidity and factors effecting it, Ring substitution reactions, Reimer–Tiemann and Kolbe’s–Schmidt Reactions, Fries and Claisen rearrangements with mechanism;

* Ethers and Epoxides: Preparation and reactions with acids. Reactions of epoxides with alcohols, ammonia derivatives and LiAlH₄

**Unit-III: Carbonyl Compounds: (15 Lectures)**

Structure, reactivity and preparation;

Nucleophilic additions, Nucleophilic addition-elimination reactions with ammonia derivatives with mechanism; Mechanisms of Aldol and Benzoin condensation, Knoevenagel condensation, Claisen-Schmidt, Perkin, Cannizzaro and Wittig reaction, Beckmann and Benzil-Benzilic acid rearrangements, haloform reaction and Baeyer Villiger oxidation, α-substitution reactions, oxidations and reductions (Clemmensen, Wolff-Kishner, LiAlH₄, NaBH₄, MPV, PDC and PCC); Addition reactions of unsaturated carbonyl compounds: Michael addition. Active methylene compounds: Keto-enol tautomerism. Preparation and synthetic applications of diethyl malonate and ethyl acetoacetate.

**Unit-IV Carboxylic Acids & their Derivatives & Sulphur containing compounds: (15 Lectures)**

* Carboxylic Acids & their Derivatives: Preparation, physical properties and reactions of monocarboxylic acids: Typical reactions of dicarboxylic acids, hydroxy acids and unsaturated acids: succinic/phthalic, lactic, malic, tartaric, citric, maleic and fumaric acids;

Preparation and reactions of acid chlorides, anhydrides, esters and amides; Comparative study of nucleophilic substitution at acyl group -Mechanism of acidic and alkaline hydrolysis of esters, Claisen condensation, Dieckmann and Reformatsky reactions, Hofmannbromamide degradation and Curtius rearrangement.

* Sulphur containing compounds: Preparation & reactions of thiols, thioethers and sulphonic acids.

**Reference Books:**

CHE –C6 Lab: ORGANIC CHEMISTRY-II
PRACTICALS

Total Lectures: 60 Credits: 2

1. Systematic identification and functional group tests for alcohols, phenols, carbonyl and carboxylic acid group.
2. Organic preparations:
   i. Acetylation of aniline and phenol by any one method:
      a. Using conventional method.
      b. Using green approach
   ii. Benzoylation of aniline and phenol by Schotten-Baumann reaction.
   iii. Oxidation of acetone (Iodoform reaction).
   iv. Nitration of any one of the following:
      a. Acetanilide/nitrobenzene by conventional method
   v. Reduction of p-nitrobenzaldehyde by sodium borohydride.
   vi. Hydrolysis of amides and esters.
   vii. Semicarbazone of any one of the following compounds: acetone, benzaldehyde.
   viii. Aldol condensation using either conventional or green method.
   ix. Benzil-Benzilic acid rearrangement.

The above derivatives should be prepared using 0.5-1g of the organic compound. The solid samples must be collected and may be used for recrystallization, melting point and TLC.

Reference Books

SEMESTER III
CHE –C7: PHYSICAL CHEMISTRY-III: Phase Equilibria, Chemical Kinetics, catalysis & Surface chemistry
THEORY

Total Lectures: 60 Credits: 4

Objective: The objective of the course is to give the students insight into the basics of chemistry in everyday life through the indepth study of topics like concepts of phases, components and degrees of freedom, binary solutions, azeotropes, steam distillation, Nernst Distribution Law, Determination of rate laws of reactions, parallel reactions. Temperature dependence of reaction rates, Physiosorption, Chemisorption. The course will make a better understanding and designing of different research problems based on the study of catalysis and mechanism of catalyzed reactions. The students will be made to practically analyse the theoretical concepts through various practical problems like determination of critical solution temperature and composition of two component system and effect of impurities on them, construction of phase
diagrams using cooling curves, study of kinetics of reactions, verification of different adsorption isotherms.

UNIT-1: Phase Equilibria (15 Lectures)
Concept of phases, components and degrees of freedom, derivation of Gibbs Phase Rule for nonreactive and reactive systems; Clausius-Clapeyron equation and its applications to solid-liquid, liquid-vapour and solid-vapour equilibria, phase diagram for one component systems, with applications.
Phase diagrams for systems of solid-liquid equilibria involving eutectic, congruent and incongruent melting points, solid solutions.

UNIT-2: Phase Equilibria (15 Lectures)
Three component systems, water-chloroform-acetic acid system, triangular plots.
Binary solutions: Gibbs-Duhem-Margules equation, its derivation and applications to fractional distillation of binary miscible liquids (ideal and nonideal), azeotropes, lever rule, partial miscibility of liquids, CST, miscible pairs, steam distillation. Nernst distribution law: its derivation and applications.

UNIT-3: Chemical Kinetics (15 Lectures)
Order and molecularity of a reaction, rate laws in terms of the advancement of a reaction, differential and integrated form of rate expressions up to second order reactions, experimental methods of the determination of rate laws, kinetics of complex reactions (integrated rate expressions up to first order only): (i) Opposing reactions (ii) parallel reactions and (iii) consecutive reactions and their differential rate equations (steady-state approximation in reaction mechanisms) (iv) chain reactions. Temperature dependence of reaction rates; Arrhenius equation; activation energy. Collision theory of reaction rates, Lindemann mechanism, qualitative treatment of the theory of absolute reaction rates.

UNIT-4: Catalysis & Surface chemistry (15 Lectures)
Catalysis: Types of catalyst, specificity and selectivity, mechanisms of catalyzed reactions at solid surfaces; effect of particle size and efficiency of nanoparticles as catalysts. Enzyme catalysis, Michaelis-Menten mechanism, acid-base catalysis, autocatalysis, oscillation reactions.

Reference Books:
CHE –C7 Lab: PHYSICAL CHEMISTRY-III
PRACTICALS

Total Lectures: 60
Credits: 2

I. Determination of critical solution temperature and composition of the phenol-watersystem and to study the effect of impurities on it.

II. Phase equilibria: Construction of the phase diagram using cooling curves or ignitiontube method:
   a. simple eutectic and
   b. congruently melting systems.

III. Distribution of acetic/ benzoic acid between water and cyclohexane.

IV. Study the equilibrium of at least one of the following reactions by the distributionmethod:
   (i) \( I_2(aq) + I^- \rightarrow I_3^+(aq) \)
   (ii) \( Cu^{2+}(aq) + nNH_3 \rightarrow Cu(NH_3)_n \)

V. Study the kinetics of the following reactions.
   1. Initial rate method: Iodide-persulphate reaction
   2. Integrated rate method:
      a. Acid hydrolysis of methyl acetate with hydrochloric acid.
      b. Saponification of ethyl acetate.
   3. Compare the strengths of HCl and H_2SO_4 by studying kinetics of hydrolysis of
      methyl acetate.

VI. Adsorption
   I. Verify the Freundlich and Langmuir isotherms for adsorption of acetic acid on
      activated charcoal.

Reference Books:


SEMESTER III
CHE-SEC1: INDUSTRIAL CHEMISTRY OF FUELS

Total lectures: 30
Credits: 02

Objective: To introduce important energy sources and the industrial processes associated with their production. This paper includes the detailed study of some industrially important chemicals used as energy sources like petroleum, coal and some synthetic fuels. It also provides deep study
of the petrochemicals and clean fuels emphasizing on various processes like refining, distillation and cracking. Further, another industrially important class of chemicals i.e. lubricants is also covered in the paper to enhance the industrial skills.

Unit-I: Energy sources, petroleum and Petrochemical Industry

**General:** Review of energy sources (renewable and non-renewable). Classification of fuels and their calorific value

**Petroleum and Petrochemical Industry:** Composition of crude petroleum, Refining and different types of petroleum products and their applications.

**Petrochemicals:** Vinyl acetate, Propylene oxide, Isoprene, Butadiene, Toluene and its derivatives Xylene.

Unit-II: Coal

**Coal:** Uses of coal (fuel and nonfuel) in various industries, its composition, carbonization of coal. Coal gas, producer gas and water gas—composition and uses. Fractionation of coal tar, uses of coal tar bases chemicals, requisites of a good metallurgical coke, Coal gasification (Hydro gasification and Catalytic gasification), Coal liquefaction and Solvent Refining.

Unit-III: Principles and processes of fuel industry

**Principles and processes:** Fractional Distillation (Principle and process), Cracking (Thermal and catalytic cracking),

**Fuels:** Reforming Petroleum and non-petroleum fuels (LPG, CNG, LNG, bio-gas, fuels derived from biomass), fuel from waste, synthetic fuels (gaseous and liquids), clean fuels.

Unit-IV: Lubricants

**Lubricants:** Classification of lubricants, lubricating oils (conducting and non-conducting) Solid and semisolid lubricants, synthetic lubricants. Properties of lubricants (viscosity index, cloud point, pore point) and their determination

Reference Books:

**SEMESTER III**

**CHE-SEC2: BASIC ANALYTICAL CHEMISTRY**

**THEORY**

**Total Lectures:** 30  
**Credits:** 2

**Objective:** The objective of the Basic Analytical Chemistry is to acquaint the student with the basic understanding of the Analytical Chemistry and Analysis of soil, water & food products.

**UNIT-1:** (7 Lectures)

**Introduction:** Introduction to Analytical Chemistry and its interdisciplinary nature. Concept of sampling. Importance of accuracy, precision and sources of error in analytical measurements. Presentation of experimental data and results, from the point of view of significant figures.

**Analysis of soil:** Composition of soil, Concept of pH and pH measurement, Complexometric titrations, Chelation, Chelating agents, use of indicators
a. Determination of pH of soil samples.
b. Estimation of Calcium and Magnesium ions as Calcium carbonate by complexometric titration.

UNIT-2: (7 Lectures)
**Analysis of water:** Definition of pure water, sources responsible for contaminating water, water sampling methods, water purification methods.
a. Determination of pH, acidity and alkalinity of a water sample.
b. Determination of dissolved oxygen (DO) of a water sample.

**Analysis of food products:** Nutritional value of foods, idea about food processing and food preservations and adulteration.
a. Identification of adulterants in some common food items like coffee powder, asafoetida, chilli powder, turmeric powder, coriander powder and pulses, etc.
b. Analysis of preservatives and colouring matter.

UNIT-3: (8 Lectures)
**Chromatography:** Definition, general introduction on principles of chromatography, paper chromatography, TLC etc.
a. Paper chromatographic separation of mixture of metal ion (Fe$^{3+}$ and Al$^{3+}$).

**Ion-exchange:** Column, ion-exchange chromatography etc.
Determination of ion exchange capacity of anion / cation exchange resin (using batch procedure if use of column is not feasible).

UNIT-4: (7 Lectures)
**Analysis of cosmetics:** Major and minor constituents and their function
a. Analysis of deodorants and antiperspirants, Al, Zn, boric acid, chloride, sulphate.
b. Determination of constituents of talcum powder: Magnesium oxide, Calcium oxide, Zinc oxide and Calcium carbonate by complexometric titration.

**Suggested Applications (Any one):**
a. To study the use of phenolphthalein in trap cases.
b. To analyze arson accelerants.
c. To carry out analysis of gasoline.

**Suggested Instrumental demonstrations:**
a. Estimation of macro nutrients: Potassium, Calcium, Magnesium in soil samples by flame photometry.
b. Spectrophotometric determination of Iron in Vitamin / Dietary Tablets.
c. Spectrophotometric Identification and Determination of Caffeine and Benzoic Acid in Soft Drinks.

**Reference Books:**
SEMESTER III
CHE-SEC3: PESTICIDE CHEMISTRY

Total Lectures: 30  Credits: 02
Objective: To introduce the importance of pesticide chemistry for pest control in agriculture. This paper includes the detailed study of about the classification and synthesis and use of different classes of pesticides.

Unit-I: General introduction  (7 lectures)
Classification based on the basis of use, natural and synthetic pesticides, benefits and adverse effects, changing concepts of pesticides, structure activity relationship.

Unit-II: Chlorinated hydrocarbons and carbamates pesticides  (8 lectures)
Synthesis and use of DDT and its related derivatives, benzenehexachloride, BHC, heptachlor, chlordane, aldrin, carbaryl, propoxur, carbofuran and mexacarbate

Unit-III: Organophosphates and Acaricides  (7 lectures)
Synthesis and use of Malathion, parathion, methylparathion, Chlorpyrifos, Dichlorvos (DDVP), Fenitrothion, chlorfenethol, Dicofol, chlorfensulfide, carbophention, aramite

Unit-IV: Fungicides and Herbicides  (8 lectures)
Synthesis and use of Chloranil, Karathane, dinobuton, Dithianon, 2,4-D, 2,4,5-T, Tomacol, diphenamid

Practicals:
1. Synthesis of plant growth regulator α-naphthoxyacetic acid from α-naphthol and chloroacetic acid.
2. Synthesis of insect repellent N,N-diethyl-m-toluamide (DEET) from m-toulic acid and diethyl amine
Reference Books:

SEMESTER III

CHE-GE3: Chemical Energetics, Equilibria and Transition Metal & Coordination Chemistry, Theories of Acids & Bases

THEORY

Total Lectures: 60
Credits: 4
Objective: To teach the fundamental concepts of Chemistry and their applications. The syllabus contents are duly arranged unit wise and contents are included in such a manner so that due importance is given to the requisite intellectual understanding of Chemical Energetics, Equilibria and Transition Metal & Coordination Chemistry, Theories of Acids & Bases and laboratory skills

UNIT-1: Chemical Energetics
(15 Lectures)

UNIT-2: Chemical Equilibrium & Ionic Equilibria
(15 Lectures)
Free energy change in a chemical reaction. Thermodynamic derivation of the law of chemical equilibrium. Distinction between $G$ and $G_0$, Le Chatelier’s principle. Relationships between $K_p$, $K_c$ and $K_x$ for reactions involving ideal gases.

UNIT-3: Acids and Bases & General Principles of Metallurgy
(15 Lectures)
Acids and Bases: Brönsted–Lowry concept, conjugate acids and bases, relative strengths of acids and bases, effects of substituent and solvent, differentiating and levelling solvents. Lewis acid-base concept, classification of Lewis acids and bases, Lux-Flood concept and solvent system concept. Hard and soft acids and bases (HSAB concept), applications of HSAB process.
UNIT-4: Transition Elements (3d series) and Coordination Chemistry (15 Lectures)
General group trends with special reference to electronic configuration, variable valency, colour, magnetic and catalytic properties, ability to form complexes.

Reference Books:

CHE-GE3 LAB: Chemical Energetics, Equilibria and Transition Metal & Coordination Chemistry, Theories of Acids & Bases
PRACTICALS
Total Lectures: 60 Credits: 2

Section A: Physical Chemistry
Thermochemistry
1. Determination of heat capacity of calorimeter for different volumes.
2. Determination of integral enthalpy of solution of salts (KNO₃, NH₄Cl).
3. Determination of enthalpy of hydration of copper sulphate.
4. Study of the solubility of benzoic acid in water and determination of  H.
Ionic equilibria
pH measurements: Measurement of pH of different solutions like aerated drinks, fruit juices, shampoos and soaps (use dilute solutions of soaps and shampoos to prevent damage to the glass electrode) using pH-meter.
   a) Preparation of buffer solutions:
      (i) Sodium acetate-acetic acid
      (ii) Ammonium chloride-ammonium hydroxide
   b) Measurement of the pH of buffer solutions and comparison of the values with theoretical values.
Section B: Inorganic Chemistry

Semi-micro qualitative analysis (using H₂S or other methods) of mixtures - not more than four ionic species (two anions and two cations, excluding insoluble salts) out of the following:

Cations: NH₄⁺, Pb²⁺, Bi³⁺, Cu²⁺, Cd²⁺, Fe³⁺, Al³⁺, Co²⁺, Ni²⁺, Mn²⁺, Zn²⁺, Ba²⁺, Sr²⁺, Ca²⁺, K⁺

Anions: CO₃²⁻, S²⁻, SO₂⁻, S₂O₃²⁻, NO₃⁻, CH₃COO⁻, Cl⁻, Br⁻, I⁻, NO₃⁻, SO₄²⁻, PO₄³⁻, BO₃³⁻, C₂O₄²⁻, F⁻

1. Estimate the amount of nickel present in a given solution as bis(dimethylglyoximato) nickel(II) or aluminium as oximate in a given solution gravimetrically.
2. Estimation of (i) Mg²⁺ or (ii) Zn²⁺ by complexometric titrations using EDTA.
3. Estimation of total hardness of a given sample of water by complexometric titration.

Reference Books:

OBJECTIVE: To teach the fundamental concepts of Chemistry and their applications. The syllabus contents are duly arranged unit wise and contents are included in such a manner so that due importance is given to the requisite intellectual understanding of coordination chemistry, transition metal & Bio inorganic chemistry.

UNIT-1 Coordination Chemistry-I (15 Lectures)
IUPAC nomenclature of coordination compounds, isomerism in coordination compounds. Stereochemistry of complexes with 4 and 6 coordination numbers, Werner’s theory, Effective Atomic numbers, Stability of complexes, Factors affecting stability of the complexes (Chelate effect), Labile and inert complexes. Valence bond theory (inner and outer orbital complexes), Electroneutrality principle and back bonding.

UNIT-2 Coordination Chemistry-II (15 Lectures)
Crystal field theory, CFSE in weak and strong fields, pairing energies, factors affecting the magnitude of 10 Dq (o, t). The splitting of d-orbitals in different fields (octahedral, tetrahedral, tetragonally distorted octahedral, square planar, trigonal bipyramidal), Consequences and applications of orbital splitting, crystal field stabilization energy magnetic properties, measurement of 10 Dq (o), Factors affecting extent of splitting and spectrochemical series, colour of transition metal complexes. Structural effect of crystal field splitting; ionic radii, Jahn Teller effect in octahedral and tetrahedral complexes. Qualitative aspect of Ligand field and MO Theory.

UNIT-3 Transition Elements: (15 Lectures)
General group trends with special reference to electronic configuration, colour, variable valency, magnetic and catalytic properties, ability to form complexes. Stability of various oxidation states and e.m.f. (Latimer & Ebsworth diagrams). Difference between the first, second and third transition series. Chemistry of Ti, V, Cr Mn, Fe and Co in various oxidation states (excluding their metallurgy).

UNIT-4 Lanthanoids and Actinoids: (15 Lectures)
Electronic configuration, oxidation states, colour, spectral and magnetic properties, lanthanide contraction, separation of lanthanides (ion-exchange method only).

Bioinorganic Chemistry:
Metal ions present in biological systems, classification of elements according to their action in biological system. Geochemical effect on the distribution of metals. Sodium / K-pump, carbonic anhydrase and carboxypeptidase. Excess and deficiency of some trace metals. Toxicity of metal ions (Hg, Pb, Cd and As), reasons for toxicity, Use of chelating agents in medicine. Iron and its application in bio-systems, Haemoglobin; Storage and transfer of iron.
Reference Books:

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CHE –C8 LAB: INORGANIC CHEMISTRY-III
PRACTICAL

Total Lectures: 60
Credits: 2

Gravimetric Analysis:
i. Estimation of nickel (II) using Dimethylglyoxime (DMG).
ii. Estimation of copper as CuSCN
iii. Estimation of iron as Fe₂O₃ by precipitating iron as Fe(OH)₃.
iv. Estimation of Al (III) by precipitating with oxine and weighing as Al(oxine)₃ (aluminiumoxinate).

Inorganic Preparations:
i. Tetraammine copper (II) sulphate, [Cu(NH₃)₄]SO₄.H₂O
ii. Cis and trans K[Cr(C₂O₄)₂. (H₂O)₂] Potassium dioxalatodiaquachromate (III)
iii. Tetraamminecarbonatocobalt (III) ion
iv. Potassium tris(oxalate)ferrate(III)

Chromatography of metal ions
Principles involved in chromatographic separations. Paper chromatographic separation of following metal ions:
i. Ni (II) and Co (II)
ii. Fe (III) and Al (III)

Reference Book:

SEMESTER-IV

CHE–C9: ORGANIC CHEMISTRY-III: Heterocyclic Chemistry & Stereochemical Principles
THEORY

Total Lectures: 60
Credits: 4

Objective: The objective of the Organic Chemistry is to acquaint the student with the heterocyclic chemistry and concepts of stereochemistry of organic compounds. The course is adequated with basic knowledge of nitrogen containing functional groups, heterocyclic & polynuclear compounds, fats, oils, detergents and stereochemical principles so they will understand the method of formations and reactions of compounds
Unit-I: Nitrogen Containing Functional Groups: (15 Lectures)
Preparation and important reactions of nitro and compounds, nitriles and isonitriles Amines: Effect of substituent and solvent on basicity; Preparation and properties: Gabriel phthalimide synthesis, Carbylamine reaction, Mannich reaction, Hoffmann’s exhaustive methylation, Hofmann-elimination reaction; Distinction between 1°, 2° and 3°amines with Hinsberg reagent and nitrous acid. 

Diazonium Salts: Preparation and their synthetic applications.

Unit-II: Heterocyclic Compounds: (15 Lectures)
Classification and nomenclature, Structure, aromaticity in 5-numbered and 6-membered rings containing one heteroatom; Synthesis, reactions and mechanism of substitution reactions of: Furan, Pyrrole (Paal-Knorr synthesis, Knorr pyrrole synthesis, Hantzsch synthesis), Thiophene, Pyridine (Hantzsch synthesis), Pyrimidine, Structure elucidation of indole, Fischer indole synthesis and Madelung synthesis), Structure elucidation of quinoline and isoquinoline, Skraup synthesis, Friedlander’s synthesis, Knorr quinoline synthesis, Doebner-Miller synthesis, Bischler-Napieralski reaction, Pictet-Spengler reaction, Pomeranz-Fritsch Reaction Derivatives of furan: Furfural and furoic acid.

Unit-III: Polynuclear Hydrocarbons and Fats, Oils & Detergents: (15 Lectures)
PolynuclearHydrocarbons:Reactions of naphthalene phenanthrene and anthracene Structure, Preparation and structure elucidation and important derivatives of naphthalene and anthracene; Polynuclear hydrocarbons.
Fats, Oils and Detergents: Natural fats, edible and industrial oils of vegetable origin, common fatty acids, glycerides, hydrogenation of unsaturated oils. Saponification value, iodine value, acid value. Soaps, synthetic detergents, alkyl and aryl sulphonates.

Unit-IV: Stereochemical Principles; conformation, steric and stereoelectronic effects: (15 Lectures)
Enantiomeric relationships, Diastereomeric relationships, Dynamic stereochemistry, Prochiral relationships, Conformations of Acyclic molecules, cyclohexane derivatives, Rings other than six membered. Conformational effects on reactivity, angle strain and its effects on reactivity. Relationship between ring size and facility of ring closure. Torsional strain and related stereo electronic effects.

Reference Books:
- Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Acheson, R.M. Introduction to the Chemistry of Heterocyclic compounds, JohnWelly & Sons (1976).
CHE–C9: ORGANIC CHEMISTRY-III: Heterocyclic Chemistry & Stereochemical Principles

PRACTICAL

Total Lectures: 60  
Credits: 2

1. Qualitative analysis and functional group detection of unknown organic compounds containing nitro, amine and amide functional groups.
2. Qualitative analysis and functional group detection of unknown organic compounds containing multiple functional groups (nitrobenzaldehyde, nitroaniline, aminobenzoic acid)
3. Distinction between 1°, 2° and 3° amines with Hinsberg reagent.
4. Preparation of anthranilic acid from phthalimide.
5. Preparation of a diazonium salt and its synthetic application.

Reference Books

SEMESTER-IV

CHE –C10: PHYSICAL CHEMISTRY-IV: Conductance, Electrochemistry, Electric & Magnetic Properties

THEORY

Total Lectures: 60  
Credits: 4

Objective: The course covers basic ideas of electrostatics, dipole moments, diamagnetism, paramagnetism, concepts of conductivity, equivalent and molar conductivity, Kolrausch Law, ionic velocities, and various applications of conductance measurements such as ionic product of water, conductometric titrations, and hydrolysis constants of salts. The course intends to impart basic knowledge of electrochemistry and its application in industrial and metallurgical processes covering all the important topics such as Faraday's laws of electrolysis, Chemical cells, EMF of cell and its measurement, Application of EMF measurements in determining (i) free energy, enthalpy, and entropy of a cell reaction (ii) equilibrium constants and (iii) pH values using different electrodes. The practical course includes conductometric and potentiometric titrations of different acids and bases and practical determination of cell constant, equivalent conductance, degree of dissociation and dissociation constant of weak acid.
UNIT-1: Conductance (15 Lectures)
Ionic velocities, mobilities and their determinations, transference numbers and their relation to ionic mobilities, determination of transference numbers using Hittorf and Moving Boundary methods.

UNIT-2: Conductance & Electrochemistry (15 Lectures)
Conductance: Applications of conductance measurement: (i) degree of dissociation of weak electrolytes, (ii) ionic product of water (iii) solubility and solubility product of sparingly soluble salts, (iv) conductometric titrations, and (v) hydrolysis constants of salts.

UNIT-3: Electrochemistry (15 Lectures)
Nernst equation; Standard electrode (reduction) potential and its application to different kinds of half-cells. Application of EMF measurements in determining (i) free energy, enthalpy and entropy of a cell reaction, (ii) equilibrium constants, and (iii) pH values, using hydrogen, quinone-hydroquinone, glass and SbO/Sb2O3 electrodes. Concentration cells with and without transference, liquid junction potential; determination of activity coefficients and transference numbers. Qualitative discussion of potentiometric titrations (acid-base, redox, precipitation).

UNIT-4: Electrical & Magnetic Properties of Atoms and Molecules (15 Lectures)
Basic ideas of electrostatics, Electrostatics of dielectric media, Clausius-Mosotti equation, Lorenz-Laurentz equation, Dipole moment and molecular polarizabilities and their measurements. Diamagnetism, paramagnetism, magnetic susceptibility and its measurement, molecular interpretation.

Reference Books:
CHE –C10 Lab: PHYSICAL CHEMISTRY-IV
PRACTICALS

Total Lectures: 60 Credits: 2

Conductometry
I. Determination of cell constant
II. Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid.
III. Perform the following conductometric titrations:
   i. Strong acid vs. strong base
   ii. Weak acid vs. strong base
   iii. Mixture of strong acid and weak acid vs. strong base
   iv. Strong acid vs. weak base

I Perform the following potentiometric titrations:
   i. Strong acid vs. strong base
   ii. Weak acid vs. strong base
   iii. Dibasic acid vs. strong base
   iv. Potassium dichromate vs. Mohr's salt

Reference Books:

SEMESTER-IV
CHE–SEC 4: PHARMACEUTICAL CHEMISTRY
THEORY

Total Lectures: 30 Credits: 2

Objective: The objective of the Pharmaceutical chemistry is to acquaint the student with the basic understanding of the drug discovery, synthesis of drugs of various classes, role of fermentation in pharmaceutical chemistry.

Unit-I: Drugs & Pharmaceuticals-I (8 Lectures)
Drug discovery, design and development; Basic Retrosynthetic approach. Synthesis of the representative drugs of the following classes: analgesics agents, antipyretic agents, anti-inflammatory agents (Aspirin, paracetamol, Ibuprofen); antibiotics (Chloramphenicol); antibacterial and antifungal agents (Sulphonamides; Sulphanethoxazol, Sulphacetamide, Trimethoprim)
Unit-II: Drugs & Pharmaceuticals-II (7 Lectures)
Drug discovery, design and development related to antiviral agents (Acyclovir), Central Nervous System agents (Phenobarbital, Diazepam), Cardiovascular (Glycerol trinitrate), antilaprosy (Dapsone), HIV-AIDS related drugs (AZT- Zidovudine).

Unit-III: Fermentation-I (9 Lectures)
Aerobic and anaerobic fermentation. Production of (i) Ethyl alcohol and citric acid, (ii) Antibiotics; Penicillin, Cephalosporin, Chloromycetin and Streptomycin.

Unit-IV: Fermentation-II (6 Lectures)
Production of Lysine, Glutamic acid, Vitamin B2, Vitamin B12 and Vitamin C.

Practicals
1. Preparation of Aspirin and its analysis.
2. Preparation of magnesium trisilicate (Antacid).

Reference Books:

SEMESTER-IV
CHE-SEC5: CHEMICAL TECHNOLOGY & SOCIETY

Total Lectures: 30 Credits: 2
Objective: The objective of the Chemical Technology & Society is to acquaint the student with the basic understanding of the Chemical Technology & exploration of societal and technological issues from a chemical perspective.

UNIT-1: Chemical Technology (7 Lectures)
Basic principles of distillation, solvent extraction, solid-liquid leaching and liquid-liquid extraction, separation by absorption and adsorption.

UNIT-2: Chemical Technology (8 Lectures)
An introduction into the scope of different types of equipment needed in chemical technology, including reactors, distillation columns, extruders, pumps, mills, emulgators. Scaling up operations in chemical industry. Introduction to clean technology.

UNIT-3: Society (7 Lectures)
Exploration of societal and technological issues from a chemical perspective. Chemical and scientific literacy as a means to better understand topics like air and water (and the trace materials found in them that are referred to as pollutants).
UNIT-4: Society (8 Lectures)
Energy from natural sources (i.e. solar and renewable forms), from fossil fuels and from nuclear fission; materials like plastics and polymers and their natural analogues, proteins and nucleic acids, and molecular reactivity and interconversions from simple examples like combustion to complex instances like genetic engineering and the manufacture of drugs.

Reference Book:

SEMESTER-IV
CHE-SEC 6: CHEMISTRY OF COSMETICS & PERFUMES

Total Lectures: 30  Credits: 02

Objective: Cosmetic and perfume science is a fast moving area. This course introduces the preparation of cosmetics and gives a broad overview of cosmetic ingredients, vehicles and finished products, and the main methodologies used for microbiology, safety and efficacy testing.

Unit-I (7 lectures)
Cosmetics Through the Ages, Formulations of Cosmetics for Everyday Use, A general study including preparation and uses of hair care products: Hair dye, hair spray, shampoo Skin Preparations: creams (cold, vanishing and shaving creams).

Unit-II (8 lectures)
Colouring Materials Used in Decorative Cosmetics and Colour Matching, preparation and uses of decorative products: face powder, lipsticks, talcum powder, nail enamel. Sun Damage and Sunscreen Preparations

Unit-III (7 lectures)

Unit-IV (8 lectures)
Perfumes: Essential oils and their importance in cosmetic industries with reference to Eugenol, Geraniol, sandalwood oil, eucalyptus, rose oil, 2-phenyl ethyl alcohol, Jasmone, Civetone, Muscone.

Hands on exercises:
1. Preparation of shampoo.
2. Preparation of nail polish and nail polish remover

Reference Books:
- *Handbook of Cosmetic Science and Technology* Edited by: Edited by André O. Barel, Marc Paye, Howard I. Maibach, 3rd edition
SEMESTER IV

CHE-GE4: Molecules of life, Spectroscopy, states of matter & chemical kinetics

THEORY

Total Lectures: 60  
Credits: 4

Course Objectives: The course will provide foundational knowledge of the chemistry of life. The syllabus contents are duly arranged unit wise and contents are included in such a manner so that due importance is given to the requisite intellectual understanding of Molecules of life, Spectroscopy, states of matter & chemical kinetics and laboratory skill.

UNIT-1. Amino Acids, Peptides, Proteins and Carbohydrates  (15 Lectures)


Carbohydrates: Classification, and General Properties, Glucose and Fructose (open chain and cyclic structure), Determination of configuration of monosaccharides, absolute configuration of Glucose and Fructose, Mutarotation, ascending and descending in monosaccharides. Structure of disaccharides (sucrose, cellobiose, maltose, lactose) and polysaccharides (starch and cellulose) excluding their structure elucidation.

UNIT-2. Spectra of Organic Molecules  (15 lectures)


UNIT-3: Kinetic Theory of Gases and Liquids  (15 Lectures)

Postulates of Kinetic Theory of Gases and derivation of the kinetic gas equation. Deviation of real gases from ideal behaviour, compressibility factor, causes of deviation. Van der Waals equation of state for real gases. Boyle temperature (derivation not required). Critical phenomena, critical constants and their calculation from van der Waals equation. Andrews isotherms of CO₂. Maxwell Boltzmann distribution laws of molecular velocities and molecular energies (graphic representation – derivation not required) and their importance. Temperature dependence of these distributions. Most probable, average and root mean square velocities (no derivation). Collision cross section, collision number, collision frequency, collision diameter and mean free path of molecules. Viscosity of gases and effect of temperature and pressure on coefficient of viscosity (qualitative treatment only).

UNIT-4: Chemical Kinetics and catalysis


Catalysis: Homogeneous catalysis, Acid-base catalysis and enzyme catalysis (Michaelis-Menten equation). Heterogeneous catalysis. Unimolecular surface reactions.

Reference Books:

SEMESTER IV

CHE-GE4 LAB: Molecules of life, Spectroscopy, states of matter & chemical kinetics

PRACTICALS

Total Lectures: 60 Credits: 2

Section A: Organic Chemistry
1. Separation of amino acids by paper chromatography
2. To determine the concentration of glycine solution by formylation method.
3. Preparation of m-dinitrobenzene from nitrobenzene
4. To determine the saponification value of an oil/fat.
5. To determine the iodine value of an oil/fat
6. Differentiate between a reducing/nonreducing sugar.
7. Aldol synthesis of dibenzalacetone

Section B: Physical Chemistry

Liquids
(I) Surface tension measurement (use of organic solvents excluded).
   a) Determination of the surface tension of a liquid or a dilute solution using a stalagmometer.
   b) Study of the variation of surface tension of a detergent solution with concentration.
(II) Viscosity measurement (use of organic solvents excluded).
a) Determination of the relative and absolute viscosity of a liquid or dilute solution using an Ostwald’s viscometer.
b) Study of the variation of viscosity of an aqueous solution with concentration of solute.

**Chemical Kinetics**

Study the kinetics of the following reactions.

3. Initial rate method: Iodide-persulphate reaction
4. Integrated rate method:
   c. Acid hydrolysis of methyl acetate with hydrochloric acid.
   d. Saponification of ethyl acetate.
   e. Compare the strengths of HCl and H$_2$SO$_4$ by studying kinetics of hydrolysis of methyl acetate.

**Reference Books**

Objective: The objective of the Organic Chemistry-V is to acquaint the student with the basic concepts of UV-vis and IR spectroscopy of organic compounds and their role in identification of simple organic compounds. The course also focuses on basic knowledge of carbohydrates, dyes and electron deficient reaction intermediates.

Unit-I: Oxidation and Reductions (15 lectures)
Oxidation of alcohols to aldehydes, ketones or carboxylic acids; Transition metal oxidants: Cr(VI) Oxidants, MnO₂ and ruthenium tetroxide. Other oxidants: DMSO-DCC, DMSO/Ac₂O, N-chloro-succinimide,. Addition of oxygen at carbon-carbon double bonds. Transition metal oxidants. KMnO₄, OsO₄.
Reduction of Carbonyl group; Addition of hydrogen. Catalytic hydrogenation, Group III hydride-transfer rearrangements. Reduction of carbonyl groups, halides, sulphonates, expoxides, acetylenes; Birch reduction; Group IV hydride donors.

Unit-II: Nucleic Acids, Amino Acids, Peptides and Proteins (15 lectures)
Components of nucleic acids, Nucleosides and nucleotides; Structure, synthesis and reactions of: Adenine, Guanine, Cytosine, Uracil and Thymine; Structure of polynucleotides.

Unit-III: Enzymes (15 lectures)
Introduction, classification and characteristics of enzymes. Salient features of active site of enzymes. Mechanism of enzyme action (taking trypsin as example), factors affecting enzyme action, coenzymes and cofactors and their role in biological reactions, specificity of enzyme action (including stereospecificity), enzyme inhibitors and their importance, phenomenon of inhibition (competitive, uncompetitive and non-competitive inhibition including allosteric inhibition).

Unit-IV: Concept of Energy in Biosystems (15 lectures)
Cells obtain energy by the oxidation of foodstuff (organic molecules). Introduction to metabolism (catabolism, anabolism). ATP: The universal currency of cellular energy, ATP hydrolysis and free energy change.

Reference Books:
CHE-C11: ORGANIC CHEMISTRY-IV (Biomolecules)

PRACTICALS

Total Lectures: 60

Credits: 2

1. Organic reactions describing the fundamental concepts of oxidizing and reducing agents
   (i) Synthesis of Benzil from Benzoin
   (ii) Synthesis of Benzoic Acid from Benzyl Chloride
   (iii) Reduction of m-dinitrobenzene to m-nitro aniline
   (iv) Oxidation of anthracene to anthraquinone
   (v) Schiff base formation by reaction of m-nitrobenzaldehyde and aniline and then reduction to form N-(m-nitrobenzyl) aniline.

2. Estimation of proteins by Lowry’s method.


4. Saponification value of oil or a fat.

5. Determination of Iodine number of an oil/ fat.

6. Determination of Acid value of an oil/ fat.

Reference Books:

SEASON-V
CHE –C12: PHYSICAL CHEMISTRY-V: Quantum Chemistry and Spectroscopy
THEORY

Total Lectures: 60
Credits: 4

Objective: To introduce basic principles of quantum chemistry which are essential for understanding the molecular structure and its spectroscopic characterization.

UNIT-1: Quantum Chemistry-Basic Principles and Model Systems (15 Lectures)
Postulates of quantum mechanics, quantum mechanical operators, Schrödinger equation and its application to free particle and “particle-in-a-box” (rigorous treatment), quantization of energy levels, zero-point energy and Heisenberg Uncertainty principle; wavefunctions, probability distribution functions, nodal properties, extension to two and three dimensional boxes, separation of variables, degeneracy.
Qualitative treatment of simple harmonic oscillator model of vibrational motion: Setting up of Schrödinger equation and discussion of solution and wavefunctions. Vibrational energy of diatomic molecules and zero-point energy, quantum-mechanical tunneling.
Commutators, commutation rules, Angular momentum, quantization of square of total angular momentum and z-component, spherical polar coordinates.
Rigid rotator model of rotation of diatomic molecule: Schrödinger equation, separation of variables, Spherical harmonics, discussion of solution.

UNIT-2: Quantum Chemistry-Atoms and Molecules (15 Lectures)
Quantum-mechanical treatment of hydrogen atom and hydrogen-like ions: setting up of Schrödinger equation in spherical polar coordinates, radial part, quantization of energy (only final energy expression). Average and most probable distances of electron from nucleus.
Setting up of Schrödinger equation for many-electron atoms (He, Li). Need for approximation methods. Statement of variation theorem and application to simple systems (particle-in-a-box, harmonic oscillator, hydrogen atom).
Quantum-mechanical treatment of Molecules & Chemical bonding: Born-Oppenheimer approximation, Covalent bonding, valence bond (VB) and molecular orbital (MO) approaches, LCAO-MO treatment of H$_2^+$ ion (no derivation). Bonding and antibonding orbitals. Qualitative extension to H$_2$.Comparison of LCAO-MO and VB treatments of H$_2$ (only wavefunctions, detailed solution not required), and their limitations. Refinements of the two approaches (Configuration Interaction for MO, ionic terms in VB). Qualitative description of VB and LCAO-MO treatment of other homonuclear and heteronuclear diatomic molecules (HF, LiH), triatomic (BeH$_2$, H$_2$O) molecules.

UNIT-3: Molecular Spectroscopy-Rotational, Vibrational and Raman (15 Lectures)
Interaction of electromagnetic radiation with molecules and various types of spectra; Born-Oppenheimer approximation.
Rotational spectroscopy: Selection rules, intensities of spectral lines, determination of bond lengths of diatomic and linear triatomic molecules, isotopic substitution.
Vibrational spectroscopy: Classical equation of vibration, computation of force constant, amplitude of diatomic molecular vibrations, anharmonicity, Morse potential, dissociation energies, fundamental frequencies, overtones, hot bands, degrees of freedom for polyatomic

**Raman spectroscopy:** Qualitative treatment of Rotational Raman effect, Effect of nuclear spin, Vibrational Raman spectra, Stokes and anti-Stokes lines; their intensity difference, rule of mutual exclusion.

**UNIT-4: Electronic Spectroscopy and Photochemistry** (15 Lectures)

**Electronic spectroscopy:** Franck-Condon principle, electronic transitions, singlet and triplet states, fluorescence and phosphorescence, dissociation and predissociation, calculation of electronic transitions of polyenes using free electron model.

**Electron spin resonance (ESR) spectroscopy:** Its principle, hyperfine structure, ESR of simple radicals.

**Photochemistry:** Characteristics of electromagnetic radiation, Lambert-Beer’s law and its limitations, physical significance of absorption coefficients. Laws, of photochemistry, quantum yield, actinometry, examples of low and high quantum yields, photochemical equilibrium and the differential rate of photochemical reactions, photosensitised reactions, quenching. Role of photochemical reactions in biochemical processes, photostationary states, chemiluminescence.

**Reference Books:**

**CHE -C12 LAB: PHYSICAL CHEMISTRY-V: Quantum chemistry and Spectroscopy**

**PRACTICALS**

**Total Lectures: 60**

**Credits : 2**

**1. Quantum Chemistry***

Numerical solution of the one dimensional time-independent Schrödinger equation, for the following quantum mechanical problems, using either a spreadsheet or computer program for Numerov method:

(i) Determine the lowest three stationary-state energies for a particle of mass \( m \) in a one-dimensional box of length \( L \) with walls of infinite height.

(ii) Determine all the bound-state eigenvalue for a particle of mass \( m \) in a rectangular well of length \( L \) but of finite height described by potentials energy function (a) \( V_0 = 20 \ h^2/mL^2 \) (b) \( V_0 = 50 \ h^2/mL^2 \).

(iii) Determine the ground-state energy of harmonic oscillator.
2. Spectroscopy*
   Colorimetry
   (i) Verify Lambert-Beer’s law and determine the concentration of CuSO$_4$/KMnO$_4$/K$_2$Cr$_2$O$_7$ in a solution of unknown concentration
   (ii) Determine the concentrations of KMnO$_4$ and K$_2$Cr$_2$O$_7$ in a mixture.
   (iii) Study the kinetics of iodination of propanone in acidic medium.
   (iv) Determine the amount of iron present in a sample using 1,10-phenanthroline.
   (v) Determine the dissociation constant of an indicator (phenolphthalein).
   (vi) Study the kinetics of interaction of crystal violet/phenolphthalein with sodium hydroxide.
   (vii) Analysis of the given vibration-rotation spectrum of HCl(g).

*Note: The concerned teacher can modify/replace the proposed experiments as per the availability of chemicals, apparatus, hardware, software and instruments required.

Reference Books

SEMESTER-V
CHE-DSE1: GREEN CHEMISTRY
Total lectures: 60
Credits: 4

Unit-I: Introduction to Green Chemistry, principles and designing a green chemical synthesis-I
What is Green Chemistry? Need for Green Chemistry, Goals of Green Chemistry, Limitations/Obstacles in the pursuit of the goals of Green Chemistry; Twelve principles of Green Chemistry with their explanations.
- Designing a Green Synthesis using these principles; Prevention of Waste/ byproducts; maximum incorporation of the materials used in the process into the final products, Atom Economy, calculation of atom economy of the rearrangement, addition, substitution and elimination reactions.
- Prevention/ minimization of hazardous/ toxic products reducing toxicity. risk = (function) hazard × exposure; waste or pollution prevention hierarchy.
- Green solvents– supercritical fluids, water as a solvent for organic reactions, ionic liquids, fluororous biphasic solvent, PEG, solventless processes, immobilized solvents and how to compare greenness of solvents.
Unit-II: Introduction to Green Chemistry, principles and designing a green chemical synthesis-II (15 Lectures)

- Energy requirements for reactions – alternative sources of energy: use of microwaves and ultrasonic energy.
- Selection of starting materials; avoidance of unnecessary derivatization – careful use of blocking/protecting groups.
- Use of catalytic reagents (wherever possible) in preference to stoichiometric reagents; catalysis and green chemistry, comparison of heterogeneous and homogeneous catalysis, biocatalysis, asymmetric catalysis and photocatalysis.
- Prevention of chemical accidents designing greener processes, inherent safer design, principle of ISD “What you don’t have cannot harm you”, greener alternative to Bhopal Gas Tragedy (safer route to carcarbaryl) and Flixborough accident (safer route to cyclohexanol) subdivision of ISD, minimization, simplification, substitution, moderation and limitation.
- Strengthening/ development of analytical techniques to prevent and minimize the generation of hazardous substances in chemical processes.

Unit-III: Examples of Green Synthesis/ Reactions (15 Lectures)
1. Upjohn Dihydroxylation vs. Woodward cis hydroxylation
2. Microwave assisted reactions in water: Hofmann Elimination, methyl benzoate to benzoic acid, oxidation of toluene and alcohols; microwave assisted reactions in organic solvents Diels-Alder reaction and Decarboxylation reaction
3. Ultrasound assisted reactions: sonochemical Simmons-Smith Reaction (Ultrasonic alternative to Iodine)
4. Photochemical reactions: Boots synthesis of ibuprofen, Norrish Type I&II reactions, 2+2 photocycloaddition reaction
5. Green Synthesis of the following compounds: adipic acid, catechol, disodium iminodiacetate (alternative to Strecker synthesis)

Unit-IV: Real world cases and Future Trends in Green Chemistry (15 Lectures)
1. Surfactants for carbon dioxide – replacing smog producing and ozone depleting solvents with CO₂ for precision cleaning and dry cleaning of garments.
2. Designing of Environmentally safe marine antifoulant.
4. An efficient, green synthesis of a compostable and widely applicable plastic (polylactic acid) made from corn.
5. Healthier Fats and oil by Green Chemistry: Enzymatic Inter esterification for production of no Trans-Fats and Oils

Oxidation reagents and catalysts; Biomimetic, multifunctional reagents; Combinatorial green chemistry; Proliferation of solventless reactions; Green chemistry in sustainable development.

Reference Books:
CHE-DSE1 LAB: GREEN CHEMISTRY

Total lectures: 60  Credits: 02

1. Using renewable resources
   - Preparation of biodiesel from vegetable/waste cooking oil.
   - Preparation of copper nanoparticles using plant extracts.
   - Preparation and characterization of Silver nanoparticles using plant extracts

2. Avoiding waste: Principle of atom economy
   - Acetylation of primary amine (aniline) (Green procedure with acetic acid and zinc dust). Compare with conventional procedure.
   - Bromination of stilbene using hydrobromic acid and hydrogen peroxide in ethanol
   - Bromination of stilbene using sodium bromide and sodium bromate in acetic acid.
   - Diels-Alder reaction between furan and maleic acid

3. Alternative sources of energy, Green Solvents and solvent free synthesis
   - Mechanochemical solvent free synthesis of azomethines
   - Mechanochemical synthesis of Zinc Salen complex
   - Nitration of Phenols Using Cu(NO₃)₂: Green Chemistry Laboratory Experiment
   - Microwave assisted synthesis of copper sulphide nanoparticles in aqueous media.
   - Microwave assisted synthesis of copper oxide nanoparticles
   - CuS/CuO nanoparticles as heterogeneous catalyst in synthesis of xanthenes
   - Quantitative estimation of Nickel in solution using colorimetry
   - Quantitative estimation of Copper in solution using colorimetry

Reference Books:
   - Cann, M. C. & Thomas, P. Real world cases in Green Chemistry, American Chemical Society (2008).
SEMESTER-V
CHE-DSE2: ANALYTICAL METHODS IN CHEMISTRY
(THEORY)

Total Lectures: 60  Credits: 4

Objective: The objective of this paper to enlighten the students about various analytical techniques used for the analysis. These techniques are of utmost importance because of their applications in the real life, industrial processes and environmental analysis. This paper includes detailed description of principles, working and instrumentation of some optical methods, thermal methods and separation techniques. Moreover, some important strategies for the analysis of components are also covered in this paper.

UNIT-1 Qualitative and quantitative aspects of analysis: (15 Lectures)
Sampling, evaluation of analytical data, errors, accuracy and precision, methods of their expression, normal law of distribution if indeterminate errors, statistical test of data; F, Q and t test, rejection of data, and confidence intervals

Optical methods of analysis-I

UV-Visible Spectrometry: Basic principles of instrumentation (choice of source, monochromator and detector) for single and double beam instrument;

Basic principles of quantitative analysis: estimation of metal ions from aqueous solution, geometrical isomers, keto-enol tautomers. Determination of composition of metal complexes using Job’s method of continuous variation and mole ratio method

UNIT-2 Optical methods of analysis-II (15 Lectures)

Infrared Spectrometry: Basic principles of instrumentation (choice of source, monochromator & detector) for single and double beam instrument; sampling techniques. Structural illustration through interpretation of data, Effect and importance of isotope substitution

Flame Atomic Absorption and Emission Spectrometry: Basic principles of instrumentation (choice of source, monochromator, detector, choice of flame and Burner designs. Techniques of atomization and sample introduction; Method of background correction, sources of chemical interferences and their method of removal, Techniques for the quantitative estimation of trace level of metal ions from water samples.

UNIT-3 Thermal methods of analysis (15 Lectures)
Theory of thermogravimetry (TG), basic principle of instrumentation, Techniques for quantitative estimation of Ca and Mg from their mixture.
**Electroanalytical methods:** Classification of electroanalytical methods, basic principle of pH metric, potentiometric and conductometric titrations. Techniques used for the determination of equivalence points, Techniques used for the determination of pKa values

**UNIT-4 Separation techniques (15 Lectures)**
Solvent extraction: Classification, principle and efficiency of the technique, Mechanism of extraction: extraction by solvation and chelation, Technique of extraction: batch, continuous and counter current extractions, Qualitative and quantitative aspects of solvent extraction: extraction of metal ions from aqueous solution, extraction of organic species from the aqueous and nonaqueous media

**Chromatography:** Classification, principle and efficiency of the technique, Mechanism of separation: adsorption, partition & ion exchange, Development of chromatograms: frontal, elution and displacement methods, Qualitative and quantitative aspects of chromatographic methods of analysis: IC, GLC, GPC, TLC and HPLC.

**Stereoisomeric separation and analysis:** Measurement of optical rotation, calculation of Enantiomeric excess (ee)/ diastereomeric excess (de) ratios and determination of enantiomeric composition using NMR, Chiral solvents and chiral shift reagents. Chiral chromatographic techniques using chiral columns (GC and HPLC), Role of computers in instrumental methods of analysis

**Reference Books:**
- Ditts, R.V. *Analytical Chemistry; Methods of separation*, van Nostrand, 1974.

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**CHE-DSE2: ANALYTICAL METHODS IN CHEMISTRY**

**(PRACTICAL)**

**Total Lectures:** 60

**Credits:** 2

**(A) Separation Techniques**

(a) Chromatographic separation of mixtures

- (i) Paper chromatographic separation of Fe$^{3+}$, Al$^{3+}$, and Cr$^{3+}$.
- (ii) Separation and identification of the monosaccharides present in the given mixture (glucose & fructose) by paper chromatography. Reporting the Rf values.

(b) Separate a mixture of Sudan yellow and Sudan Red by TLC technique and identify them on the basis of their Rf values.
(c) Chromatographic separation of the active ingredients of plants, flowers and juices by TLC

(B) Solvent Extractions

(i) To separate a mixture of Ni$^{2+}$ & Fe$^{2+}$ by complexation with DMG and extracting the Ni$^{2+}$-DMG complex in chloroform, and determine its concentration by spectrophotometry.

(ii) Solvent extraction of zirconium with amberliti LA-1, separation from a mixture of iron and gallium.

(C) Real sample analysis

(i) Determine the pH of the given aerated drinks fruit juices, shampoos and soaps.
(ii) Determination of Na, Ca, Li in cola drinks and fruit juices
(iii) Analysis of soil to determine pH, calcium, magnesium, phosphate, nitrate
(iv) To analyse moisture content, water holding capacity, texture and relative salinity of soil samples

(D) Ion exchange:

(i) Determination of exchange capacity of cation exchange resins and anion exchange resins.
(ii) Separation of metal ions from their binary mixture.
(iii) Separation of amino acids from organic acids by ion exchange chromatography.

(E) Spectrophotometry

(i). Determination of pKa values of indicator using spectrophotometry
(ii) Structural characterization of compounds by infrared spectroscopy.
(iii) Determination of dissolved oxygen in water
(iv) Determination of concentration of an unknown sample using Lambert beer’s law.
(v) Determine the composition of the Ferric-salicylate/ ferric-thiocyanate complex by Job’s method.

*The experiments may be modified according to the availability of reagents, apparatus, instruments and safety features*

Reference Books:

Objective: (The objective of this paper is to cover the details of various inorganic materials frequently used for industrial applications. It will give detailed description of glass, ceramics, cement, fertilizers, alloys and batteries etc. Besides, importance of inorganic materials for catalytic purposes and as explosives will also be covered in this paper.

UNIT-1 Silicate Industries (15 Lectures)
Glass: Glassy state and its properties, classification (silicate and non-silicate glasses). Manufacture and processing of glass. Composition and properties of the following types of glasses: Soda lime glass, lead glass, armoured glass, safety glass, borosilicate glass, fluorosilicate, coloured glass, photosensitive glass.

Ceramics: Important clays and feldspar, ceramic, their types and manufacture. High technology ceramics and their applications, superconducting and semiconducting oxides, fullerenes carbon nanotubes and carbon fibre

Cements: Classification of cement, ingredients and their role, Manufacture of cement and the setting process, quick setting cements.

UNIT-2 Fertilizers (15 Lectures)
Different types of fertilizers. Manufacture of the following fertilizers: Urea, ammonium nitrate, calcium ammonium nitrate, ammonium phosphates; polyphosphate, superphosphate, compound and mixed fertilizers, potassium chloride, potassium sulphate.

Surface Coatings

UNIT-3 Batteries (15 Lectures)
Primary and secondary batteries, battery components and their role, Characteristics of Battery, Working of following batteries: Pb acid, Li-Battery, Solid state electrolyte battery, Fuel cells, Solar cell and polymer cell

Alloys
Classification of alloys, ferrous and non-ferrous alloys, Specific properties of elements in alloys, Manufacture of Steel (removal of silicon decarbonization, demanganization, desulphurization dephosphorisation) and surface treatment (argon treatment, heat treatment, nitriding, carburizing). Composition and properties of different types of steels

UNIT-4 Catalysis (15 Lectures)
General principles and properties of catalysts, homogenous catalysis (catalytic steps and examples) and heterogenous catalysis (catalytic steps and examples) and their industrial
applications, Deactivation or regeneration of catalysts, Phase transfer catalysts, application of zeolites as catalysts

**Chemical explosives**

Origin of explosive properties in organic compounds, preparation and explosive properties of lead azide, PETN, cyclonite (RDX). Introduction to rocket propellants

**Reference Books**


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**CHE-DSE3: INORGANIC MATERIALS OF INDUSTRIAL IMPORTANCE (PRACTICAL)**

**Total Lectures: 60**

1. Determination of free acidity in ammonium sulphate fertilizer.
2. Synthesis of calcium ammonium nitrate fertilizer and estimation of calcium in the fertilizer.
3. Estimation of phosphoric acid in superphosphate fertilizer.
4. Determination of composition of dolomite (by complexometric titration).
5. Analysis of solder and brass or synthetic samples.
6. Preparation of pigments; Prussian Blue, chrome yellow, white pigment, malachite, zinc oxide.

*The experiments may be modified according to the availability of reagents, apparatus, instruments and safety features*

**Reference Books:**

Objective: The objective of the course is to acquaint the student with the basic phenomenon/concepts of macromolecules. In this module students will learn polymer nomenclature, degree of polymerization, classification of polymerization reactions, thermodynamic and transport properties of polymer, commercial polymers and their importance. The student with the knowledge of the polymer chemistry will understand and explain scientifically the application of the subject to a wide variety of topics in science and engineering, especially physical chemistry and chemical engineering.

UNIT – I: Introduction to Polymer Science (15 Lectures)
Introduction and history of polymeric materials: Different schemes of classification of polymers, Polymer nomenclature, Molecular forces and chemical bonding in polymers, Texture of Polymers.
Molecular weights of polymers: Number average and weight average molecular weights, Molecular weight distribution and its significance, Polydispersity index, Determination of molecular weights by end group analysis, viscometry, light-scattering and osmotic pressure methods.
Polymer chain flexibility: Configuration and conformation, polymer chain dimensions, end to end distance and radius of gyration, Dimensions of freely joined chain and restricted chains, unperturbed dimensions (no derivations).

UNIT – II: Basic Concept of Polymerization (15 Lectures)
Kinetics of Polymerization: Mechanism and kinetics of step growth, radical chain growth, ionic chain (both cationic and anionic) and coordination polymerizations, Mechanism and kinetics of copolymerization, polymerization techniques.

UNIT – III: Morphology and Physical Chemistry of Polymers (15 Lectures)
Crystallization and crystallinity: Determination of crystalline melting point and degree of crystallinity, Morphology of crystalline polymers, Factors affecting crystalline melting point.
Glass transition temperature (Tg) and determination of Tg, Free volume theory, WLF equation, Factors affecting glass transition temperature (Tg).
Polymer Solution: Criteria for polymer solubility, Solubility parameter, Thermodynamics of polymer solutions, entropy, enthalpy, and free energy change of mixing of polymers solutions, Flory- Huggins theory, Lower and Upper critical solution temperatures.

UNIT – IV: Structures and Properties of Polymers (15 Lectures)
Nature and structure of polymers - Structure Property relationships.
Properties of Polymers (Physical, thermal, Flow & Mechanical Properties): Brief introduction to preparation, structure, properties and application of the following polymers: polyolefins,
polystyrene and styrene copolymers, poly(vinyl chloride) and related polymers, poly(vinyl acetate) and related polymers, acrylic polymers, fluoro polymers, polyamides and related polymers. Phenol formaldehyde resins (Bakelite, Novalac), polyurethanes, silicone polymers, polydiienes, Polycarbonates, Conducting Polymers, [polyacetylene, polyaniline, poly(p-phenylene sulphide polypyrrole, polythiophene)].

**CHE-DSE4 LAB: POLYMER CHEMISTRY**
**PRACTICALS**

**Total Lectures: 60**
**Credits: 2**

**Polymer synthesis:**

1. Free radical solution polymerization of styrene (St) / Methyl Methacrylate (MMA) / Methyl Acrylate (MA) / Acrylic acid (AA).
   a. Purification of monomer
   b. Polymerization using benzoyl peroxide (BPO) / 2,2'-azo-bis-isobutylonitrile (AIBN)
2. Preparation of nylon 6,6/6.
3. Interfacial polymerization, preparation of polyester from isophthaloyl chloride (IPC) and phenolphthalein
   a. Preparation of IPC
   b. Purification of IPC
   c. Interfacial polymerization
4. Redox polymerization of acrylamide.
5. Precipitation polymerization of acrylonitrile.
6. Preparation of urea-formaldehyde resin.
7. Preparations of novalac resin/ resold resin.
8. Microscale Emulsion Polymerization of Poly(methylacrylate).

**Polymer molecular weights determination:**

9. Determination of molecular weight by viscometry:
   a. Polyacrylamide-aq.NaNO2 solution
   b. Poly vinyl propyldiene (PVP) in water
10. Determination of the viscosity-average molecular weight of poly(vinyl alcohol) (PVOH) and the fraction of “head-to-head” monomer linkages in the polymer.
11. Determination of molecular weight by end group analysis: Polyethylene glycol (PEG) (OH group).

**Polymer characterization and instrumental analysis:**

12. Estimation of the amount of HCHO in the given solution by sodium sulphite method.
13. Estimation of the concentration of vinyl monomer by bromination method.
14. Determination of hydroxyl number of a polymer using colorimetric method.
15. Quantitative determination of impurities in given polymer by UV-VIS spectrophotometer.
16. Determination of phase transition in polymers by TGA and DTA.
17. Determination of T_g, T_m and crystallinity by DSC.
18. IR studies of polymers

*at least 7 experiments to be carried out.
**Note: The concerned teacher can modify/replace the proposed experiments as per the availability of chemicals, apparatus, and other instruments required.

Reference Books:

OBJECTIVE: The objective of organometallic chemistry is to disseminate students about the general principles of qualitative analysis and to provide deep insights into the organometallic chemistry with the mechanistic aspects of their reactions. The topics of this paper include detailed description of hydrolysis and redox reactions observed in the tetrahedral and octahedral metal complexes, chemistry of carbonyl compounds and some important organometallic compounds like metal alkyls and ferrocene. Furthermore, the applications of organometallic compounds in industrial processes are also included to highlight the practicality of the organometallic chemistry.

UNIT-1: Organometallic Compounds-I (15 lectures)
Definition and classification of organometallic compounds on the basis of bond type, Concept of hapticity of organic ligands.

**Metal carbonyls:** 18 electron rule, electron count of mononuclear, polynuclear and substituted metal carbonyls of 3d series; General methods of preparation of mono and binuclear carbonyls of 3d series: direct combination, reductive carbonylation, thermal and photochemical decomposition; Structures of mononuclear and binuclear carbonyls of Cr, Mn, Fe, Co and Ni using VBT; π-acceptor behaviour of CO (MO diagram of CO to be discussed), synergic effect and use of IR data to explain extent of back bonding.

UNIT-2: Organometallic Compounds-II (15 lectures)

**Zeise’s salt:** Preparation and structure, evidences of synergic effect and comparison of synergic effect with that in carbonyls.

**Metal Alkyls:** Important structural features of methyl lithium (tetramer) and trialkyl aluminium (dimer), concept of multicentre bonding in these compounds. Role of triethylaluminium in polymerisation of ethene (Ziegler – Natta Catalyst). Species present in ether solution of Grignard reagent and their structures, Schlenk equilibrium.

**Ferrocene:** Preparation and reactions (acetylation, alkylation, metallation, Mannich Condensation), Structure and aromaticity, Comparison of aromaticity and reactivity with that of benzene.

UNIT-3: Reaction Kinetics and Mechanism (15 lectures)
Introduction to inorganic reaction mechanisms, Substitution reactions in square planar complexes, Trans- effect, theories of trans effect, Mechanism of nucleophilic substitution in square planar complexes, Thermodynamic and Kinetic stability, Kinetics of octahedral substitution, Ligand field effects and reaction rates, Mechanism of substitution in octahedral complexes; acid hydrolysis, base hydrolysis, Redox reactions in complexes

UNIT-4: Catalysis by Organometallic Compounds and qualitative chemical analysis lectures (15)

**Catalytic principles and processes:** Study of the following industrial processes and their mechanism: Alkene hydrogenation (Wilkinsons Catalyst), Hydroformylation (Co salts), Wacker
Process, Synthetic gasoline (Fischer Tropsch reaction), Synthesis gas by metal carbonyl complexes.

**Theoretical Principles in Qualitative Analysis (H₂S Scheme):** Basic principles involved in analysis of cations and anions and solubility products, common ion effect, Principles involved in separation of cations into groups and choice of group reagents, Interfering anions (fluoride, borate, oxalate and phosphate) and need to remove them after Group II.

**Reference Books:**
- Cotton, F.A.G.; Wilkinson & Gaus, P.L. *Basic Inorganic Chemistry 3rd Ed.;* Wiley India,
- Sharpe, A.G. *Inorganic Chemistry*, 4th Indian Reprint (Pearson Education) 2005

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**CHE –C13 Lab: (INORGANIC CHEMISTRY-IV) PRACTICALS**

**Total Lectures:** 60  
**Credits:** 2

(A) **Qualitative semimicro analysis**

(i) Qualitative analysis of mixtures containing 3 anions and 3 cations from the following:

CO₃²⁻, NO₂⁻, S₂⁻, SO₃²⁻, S₂O₃²⁻, CH₂COO⁻, F⁻, Cl⁻, Br⁻, I⁻, NO₃⁻, BO₃³⁻, C₂O₄²⁻, PO₄³⁻, NH₄⁺, K⁺, Pb⁺², Cu⁺², Cd⁺², Bi⁺³, Sn⁺², Sb⁺³, Fe⁺³, Al⁺³, Cr⁺³, Zn⁺², Mn⁺², Co⁺², Ni⁺², Ba⁺², Sr⁺², Ca⁺², Mg⁺²

(ii) Qualitative analysis of mixtures containing one interfering anion or insoluble component (preferably BaSO₄, SrSO₄, PbSO₄, CaF₂ or Al₂O₃) or combination of anions (e.g. CO₃²⁻ and SO₃²⁻, NO₂⁻ and NO₃⁻, Cl⁻ and Br⁻, Cl⁻ and I⁻, Br⁻ and I⁻, NO₃⁻ and Br⁻, NO₃⁻ and I⁻)

**Note:** 1. Emphasis should be given to the understanding of the chemistry of different reactions 2. Spot tests should be done whenever possible.

(B) **Preparation of compounds and their spectrophotometric measurements**

(i). Preparation of metal complexes and measurement of 10 Dq by spectrophotometric method
(ii). Preparation of metal complexes with various ligands and verification of spectrochemical series.

(iii). Controlled synthesis of two copper oxalate hydrate complexes: kinetic vs thermodynamic factors.

(iv) Preparation of acetylacetanato complexes of Cu\(^{2+}\)/Fe\(^{3+}\). Find the \(\lambda_{\text{max}}\) of the complex.

(v) Synthesis of ammine complexes of Ni(II) and its ligand exchange reactions (e.g. bidentate ligands like acetylacetone, DMG, glycine) by substitution method.

(vi) Preparation of soap

*The experiments may be modified according to the availability of reagents, apparatus, instruments and safety features*

Reference Books

**SEMESTER-VI**

**CHE-C14: ORGANIC CHEMISTRY-V (Spectroscopy and Chemistry of Carbohydrates, Dyes and Electron Deficient Reaction Intermediates)**

**THEORY**

Total Lectures: 60  
Credits: 4

**Objective:** The objective of the Organic Chemistry-V is to acquaint the student with the basic concepts of NMR, UV-vis and IR spectroscopy of organic compounds and their role in identification of simple organic compounds. The course also focuses on basic knowledge of carbohydrates, dyes and electron deficient reaction intermediates.

**UNIT-I: Organic UV-Vis and IR Spectroscopy**  (15 lectures)

General principles: Introduction to absorption and emission spectroscopy. **UV-vis Spectroscopy:** Types of electronic transitions, \(\lambda_{\text{max}}\), Chromophores and Auxochromes, Bathochromic and Hypsochromic shifts, Intensity of absorption; Application of Woodward Rules for calculation of \(\lambda_{\text{max}}\) for the following systems: \(\alpha,\beta\) unsaturated aldehydes, ketones, carboxylic acids and esters; Conjugated dienes: alicyclic, homoannular and heteroannular; Extended conjugated systems (aldehydes, ketones and dienes); distinction between cis and trans isomers.

**IR Spectroscopy:** Fundamental and non-fundamental molecular vibrations; IR absorption positions of O, N and S containing functional groups; Effect of H-bonding, conjugation, resonance and ring size on IR absorptions; Fingerprint region and its significance; application in functional group analysis.  
Applications of IR, and UV-vis for identification of simple organic molecules.

**UNIT-II:**  (8+7 lectures)

**NMR Spectroscopy:** Basic principles of Proton Magnetic Resonance, chemical shift and factors influencing it; Spin – Spin coupling and coupling constant; Anisotropic effects in alkene, alkyne, aldehydes and aromatics, Interpretation of NMR spectra of simple compounds.

**Photochemistry:** General principles about light absorption, electronic transition, Jablonski diagram, intersystem crossing, singlet and triplet states, Quantum yield, Brief introduction and
description of photochemical reactions of simple carbonyl compounds and alkenes, Barton Reaction, Hofmann-Loffler-Freytag reaction, Photo-Fries rearrangement, Photochemistry of vision.

UNIT-III: Carbohydrates and Dyes (15 lectures)
**Carbohydrates:** Occurrence, classification and their biological importance.
- Monosaccharides: Constitution and absolute configuration of glucose and fructose, epimers and anomers, mutarotation, determination of ring size of glucose and fructose, Haworth projections and conformational structures; Interconversions of aldoses and ketoses; Killiani- Fischer synthesis and Ruff degradation;
- Disaccharides – Structure elucidation of maltose, lactose and sucrose.
- Polysaccharides – Elementary treatment of starch, cellulose and glycogen.

**Dyes:** Classification, Colour and constitution; Mordant and Vat Dyes; Chemistry of dyeing;
- Synthesis and applications of: Azo dyes – Methyl Orange and Congo Red (mechanism of Diazocoupling); Triphenyl Methane Dyes -Malachite Green, Rosaniline and Crystal Violet; Edible Dyes with examples.

UNIT-IV: Electron-deficient intermediates (15 lectures)
**Carbenes:** Structures, generation, reactions, Addition, insertion, rearrangement reactions; Wolff rearrangement and Arndt-Eistert synthesis.

**Nitrenes:** Generation from azides, generation of carboalkoxynitrenes from alkazidoformates.

**Rearrangement of electron-deficient nitrogen compounds:** Beckmann, curtius, Hofmann, Schmidt rearrangements (Bayer-Villiger rearrangement)

**Rearrangement of Carbocations:** Pinacoles, Tiffeneau-Demjanov rearrangement, Carbon-carbon bond formation involving carbocations, Polyolefin cyclisation, and Fragmentation reactions.

**Free radical reactions**: Generation and characterization, characteristics of reaction mechanisms involving and electron transfer reactions.

**Free radical reactions**: Generation and characterization, characteristics of reaction mechanisms involving free radicals and electron transfer reactions.

Reference Books:
- Kemp, W. Organic Spectroscopy, Palgrave.
- Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

CHE-C14: ORGANIC CHEMISTRY-V (Spectroscopy and Chemistry of Carbohydrates, Dyes and Reaction Intermediates)
PRACTICALS

Total Lectures : 60 Credits : 2

2. Qualitative Analysis: To perform qualitative analysis of a given binary mixture
   (i) Separation by ether, sodium hydroxide, sodium bicarbonate and dil. Hydrochloric acid.
   (ii) Test for elements (Other than C,H,O)
   (iii) Functional group determination
   (iv) Melting point, derivative preparation TLC for checking the purity and effectiveness of separation.
   (v) Identification of separated organic compounds by NMR, IR and/or UV-Vis spectroscopy (Spectra to be provided).
3. Preparation of methyl orange.

Reference Books:

SEMESTER-VI
CHE-DSE5: APPLICATIONS OF COMPUTERS IN CHEMISTRY

Theory: 60 Lectures Credits-4

Objectives: To introduce preliminary programming tools and numerical mathematical methods to prepare small computer codes useful for various applications in chemistry as well as in understanding essential concepts for molecular visualization through computers. Pre-requisite: Strong passion for mathematics and computing.

Unit-1: Basics of Computer Programming in Chemistry (15 lectures)
Constants, variables, bits, bytes, binary and ASCII formats, arithmetic expressions, hierarchy of operations, inbuilt functions. Elements of the FORTRAN* language. FORTRAN* keywords and

**Unit-2: Numerical Methods-I**

*(15 lectures)*


*Integral calculus*: Numerical integration (Trapezoidal and Simpson’s rule).

**Unit-3: Numerical Methods-II**

*(15 lectures)*

Probability distributions and mean values.


*Interpolation, extrapolation and curve fitting*: Handling of experimental data.

**Unit-4: Molecular Visualization**

*(15 lectures)*


*Note: The teacher concerned can use any other programming language as per the availability of compiler and necessary software and hardware.*

**Reference Books:**

- Levie, R. de, *How to use Excel in analytical chemistry and in general scientific data analysis*.

**CHE-DSE5 LAB: APPLICATIONS OF COMPUTERS IN CHEMISTRY PRACTICALS**

**60 Lectures**

Credits-2

Computer programs based on numerical methods for:

1. Roots of equations: (e.g. volume of van der Waals gas and comparison with ideal gas, pH of a weak acid).
2. Numerical differentiation (e.g., change in pressure for small change in volume of a van der Waals gas, potentiometric titrations).
3. Numerical integration (e.g. entropy/enthalpy change from heat capacity data), probability distributions (gas kinetic theory) and mean values.
5. Simple exercises using molecular visualization software.

Reference Books:

**SEMESTER-VI**

**CHE-DSE6: COLLOIDAL CHEMISTRY**

**THEORY**

Total Lectures : 60

**Credits : 4**

Objective: The objective of the course is to acquaint the student with the basic phenomenon/concepts of Colloids. In this module students will about basics of colloids and their importance. The main emphasis has been laid on association colloids and their current applications. The student with the knowledge of the colloidal chemistry will understand and explain scientifically the application of the subject to a wide variety of topics in science and engineering, especially physical chemistry and chemical engineering.

**Unit 1: Colloids**


**Unit 2: Surface Chemistry**

Bulk phases and interfacial region, types of interfaces; Surface tension and interfacial tension. Thermodynamics of surfaces, plane interface, curved interface, Laplace and Kelvin equations, the contact angle, capillary rise and surface tension. Electric double layers and thickness of double layer. Surface tension of solutions. Surfactants, Surface films on liquid substrates (surface potential, monomolecular films, Langmuir-Blodgett layers). criteria for spreading in liquid-liquid systems. (Wetting as contact angle and capitary action Phenomenon solid liquid systems).

**Unit 3: Association Colloids-I**

Gibbs adsorption equation and its derivation from thermodynamic considerations. Detergency, surfactants, self-assembly, micelles and vesicles. Surfactant Aggregation Micelles, Surface
active agents, Classification of surface active agents, Micellization, Hydrophobic interaction, Critical micellar concentration (cmc), Factors affecting the concentration of surfactants and micelles, Counter-ion binding of micelle, Thermodynamics of micellization, Phase separation and Mass action models. Solubilization, Applications

Unit 4: Association Colloids-II (15 Lectures)
Emulsions and their types, HLB value of emulsifiers, Introduction to microemulsions, Solubilization Emulsions, Mechanism of formation of microemulsion and their stability, Fishcut and triangular Phase maps (Two component, three component, pseudo-terinary), Physical techniques, Applications of colloid and surface science in petroleum recovery, coating and painting, food, nanotechnology, pharmaceutical and cosmetic industry.

CHE-DSE6 LAB: COLLOIDAL CHEMISTRY

PRACTICAL

Total Lectures : 60 Credits : 2

1. To determine surface excess of solutions of different surface active molecules in water
2. To determine critical micellization concentrations of different surfactants by using conductivity.
3. To study the concentration effect of different micellar solutions on coefficient of viscosity
4. To synthesize nanoparticles using colloidal assemblies.

Reference books

SEMMESTER-VI
CHE-DSE7: STRATEGIES IN ORGANIC SYNTHESIS

THEORY

Total Lectures: 60 Credits: 4
Objective: The objective of this course is to acquaint the student with the various strategies and unique accounts of the synthesis of organic molecules viz-a-viz organometallic reagents, reagents and methods for electrophilic addition to carbon-carbon multiple bond, carbanion and concerted reactions and rearrangements

Unit-I: Organometallic Reagents (15 lectures)
Unit-II: Electrophilic additions to carbon-carbon multiple bond (15 lectures)
Oxymercuration, electrophilic sulfur and selenium reagents, electrophilic substitutions alpha to
 carbonyl groups. Addition to allenes and alkynes. Hydroboration, Synthesis of organoboranes,
 reactions of organoboranes, formation of carbon-carbon bonds via organoboranes, 
Hydroboration of acetylenes. Hydroalumination of alkynes.

Unit-III: Carbanions and other nucleophilic carbon species and their reactions (15 lectures)
Acidity of hydrocarbons, Carbanions stabilized by functional groups, Generation of carbon
 nucleophiles by deprotonations, Regioselectivity, stereoselectivity in enolate formation, other
 methods of enolate generation, alkylation, Alkylation of aldehydes, esters, nitriles, Enamines, 
stork enamine, Michael addition, Aldol condensations, Robinson annulation, Amine catalysed
 condensations, Mannich reactions, acylation of carbanions, wittig and related reaction, sulphur
 ylides Darzen condensation, Stevens wittig and Favorskii rearrangements, Stork-enamine
 reaction, sharpless asymmetric epoxidation.

Unit-IV: Concerted reactions, unimolecular rearrangement and elimination (15 lectures)
Electrocyclic sigmatropic and cycloaddition reactions, Correlation diagrams and FMO theory, 
Diels-Alder reactions, general feature, Dienophiles, Diene (2+2) cycloadditions, Cope and
 Claisen rearrangement, Ene reaction.

Reference Books:
 University Press (2015)
2. Mundy, B.P., Ellerd, M.G. Favaloro, F.G Name Reaction and Reagents in Organic Synthesis 
Wiley Interscience (2005)
3. Carey, F.A. Sundberg, R.J. Advanced Organic Chemistry Part B: Reactions and 
SynthesisSpringer 2007

CHE-DSE7: Strategies in Organic Synthesis
PRACTICALS

Total Lectures : 60 
Credits : 2

1. Synthesis of o-benzoyl benzoic acid by Friedel-Craft acylation of benzene with phthalic
 anhydride and aluminium chloride
2. Synthesis of benzhydrol by sodium borohydride reduction of benzophenone.
4. Synthesis of 3-methyl-1-phenylpyrazol-5-one(antipyrine) by condensation of 
 ethylcetoacetate with phenyl hydrazine.
5. Synthesis of 2-hydroxy-1-naphthaldehyde by Reimer-tiemann formylation of 
naphthol.
6. Preparation of benzopinacol from benzophenone (photoreduction).
7. Preparation of benzopinacolone from benzopinacol (pinacol – pinacolone rearrangement).
8. Preparation of 1,3,5-tribromobenzene from aniline (diazotization, aromatic electrophilic substitution and deamination).
9. Preparation of 2,5-dihydroxy acetophenone/benzophenone from hydroquinone (Fries reaction).
10. Preparation of 3,5-diethoxycarbonyl-2,4-dimethylpyrrole from ethylacetoacetate (Knorr synthesis).

Reference Books:

SEMMESTER-VI
DSE-8: PROPERTIES OF COORDINATION COMPOUNDS AND GROUP THEORY (THEORY)

Total Lectures: 60
Credits: 4

Objective: The objective of this paper is to provide knowledge molecular orbital theory for explaining the structures of coordination compounds. It includes detailed descriptions of electronic spectroscopy and assignment of various electronic transitions with the help of Orgel diagrams and T.S. diagrams. It also provides basic knowledge about symmetry elements and operations, and their applications in bonding and spectroscopy.

UNIT-1 BONDING IN COORDINATION COMPOUNDS (15 lectures)
Overview of bonding theories (VBT and CFT), thermodynamic effects of crystal field splitting, enthalpies of hydration of M$^{2+}$ ions, lattice energies of MCl$_2$ compounds, etc., Evidence of covalence and adjusted crystal field theory, Molecular orbital treatment of octahedral complexes and bonding: complexes with no bonding and complexes with bonding, complexes with sigma and pi bonding, Molecular orbital diagrams for tetrahedral and square planar complexes, Charge transfer spectra

UNIT-2 ELECTRONIC AND MAGNETIC PROPERTIES (15 lectures)
Electronic Spectra of Transition Metal Complexes: Electronic spectra of transition metal complexes: General features, Russell-Saunders coupling scheme, Selection rules, Orgel diagrams; weak field splitting, Intermediate and strong field splitting. Tanabe and Sugano diagrams. Electronic spectra of d$^1$-d$^9$ metal complexes and f type compounds. Calculation of D$_q$, B and $^\prime$ of d$^1$ d$^2$ & d$^8$ configurations
Magnetic properties of transition metal complexes: Types of magnetic behaviour shown by transition elements and inner transition elements and their compounds. Gouy’s method for measuring magnetic susceptibility, importance of magnetic susceptibility measurements in structure determination of transition metal compounds, anomalous magnetic moments, magnetic exchange coupling and spin crossover.
UNIT-3 SYMMETRY AND GROUP THEORY-I (15 lectures)
Concept of symmetry and group theory, symmetry operations, symmetry elements, point groups, identification of point group in molecules of special symmetry, molecules of low symmetry, molecules of high symmetry, notation of point group.

UNIT-4 SYMMETRY AND GROUP THEORY-II (15 lectures)
Definitions of group, subgroup relation between orders of a finite group and its subgroup; group multiplication tables, conjugacy relation and classes, Reducible and Irreducible representation, construction of character table, Matrix representation of symmetry elements and point groups (C2v, C3v and C4v), Symmetry criteria for optical activity, Symmetry restrictions on dipole moment, Hybridization schemes of orbitals

Reference Books

DSE-VIII: PROPERTIES OF COORDINATION COMPOUNDS AND GROUP THEORY (PRACTICAL)
Total Lectures: 60 Credits: 2

(A) Preparation and characterization of acetylacetonato metal complexes and comparison of their spectroscopic properties
(i) Al(acac)₃
(ii) Mn(acac)₃
(iii) Fe(acac)₃
(iv) [Co(acac)₃] and its derivatives
(v) VO(acac)₂
(vi) Cr(acac)₃
(vii) Cu(acac)₂

(B) Study of reactions of the elements of first transition series:
   a. Titanium
   b. Vanadium
   c. Chromium
   d. Manganese
   e. Iron
   f. Cobalt
g. Nickel
h. Copper

(C) Synthesis and spectroscopic characterization of any suitable inorganic/organometallic compounds.

*The experiments may be modified according to the availability of reagents, apparatus, instruments and safety features

Reference Books