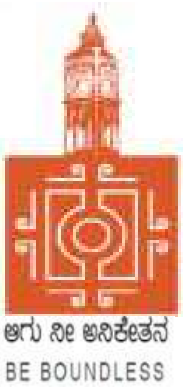

BENGALURU CITY UNIVERSITY

CHOICE BASED CREDIT SYSTEM

(Semester Scheme with Multiple Entry and Exit Options for Under Graduate Course)

Syllabus for B.Sc. Chemistry
(V & VI Semester)

2023-24 onwards

FOREWORD

In continuation of the syllabi already prepared for the I - IV semesters of B.Sc. Chemistry course under NEP, this syllabus has been framed for the current V and VI semesters students, keeping in mind the continuity of the concepts dealt with in the previous semesters and as a stepping stone to further higher education in Chemistry. This BOS has ensured the requisite standard of instruction for the under-graduate students.

The following BOS (full-time and co-opted) members were present for framing the 5th and 6th semester B.Sc. syllabi:

Sl. No.	Name of the BOS Member
1.	Dr. Mahesh Aravind
2.	Dr. Rita Bhattacharjee
3.	Mr. Sivaprakash M
4.	Dr. S Kantharaju
5.	Dr. Prasanna Kumar S. G.
6.	Dr. Ramakrishna Reddy
7.	Dr. Ronald J Mascarenhas
8.	Prof. Hamsini S
9.	Dr Sanjeevarayappa C
10.	Mrs. M R Chaya
11.	Prof. L K Srivatsa
12.	Prof Sujatha M
13.	Prof. Savitha B M
14.	Mr Siddaraju
15.	Chandrima Dutta
16.	Jayashree P
17.	Dr. Ananda Gowda
18.	Dr. V R Devaraj Professor and Chairman, BoS in Biochemistry (UG)
19.	Dr. Hari Prasad. S. Professor and Chairman, BoS in Chemistry (UG)

The Chairman places on record, thanks to the teachers, involved in the preparation of this syllabus.

Discipline Core Course

V - Semester

Course Title: DSC 5: Paper V (Inorganic chemistry - III & Organic chemistry - III)	
Course Credits	**4**
Total Contact Hours	**56**
Formative Assessment Marks: 40	**Summative Assessment Marks: 60**
Duration of ESA/Exam	**2½ Hours**

INORGANIC CHEMISTRY – III (28 Hours)

Coordination Compounds 10 hours

Coordination compounds- the difference between double salts and complex salts with examples. Ligands - definition and their classification (*mono-, bi-, tri-, tetra-, penta- and hexa-* dentate ligands*;* ambidentate ligands), with examples for each class.

Coordination number- definition with examples. Nomenclature of coordination compounds in detail.

Theories of structure and bonding: explanation for the formation of complexes by Werner's theory and its limitations. EAN rule- statement with illustrations.

Valence bond theory: postulates, low spin and high spin complexes with examples, limitations of VBT.

Crystal field theory: (octahedral-, tetrahedral- and square-planar complexes). Crystal field splitting and crystal field stabilization energies- definition and illustrations with examples. Limitations of CFT. Magnetic properties of $[CoF_6]^{3-}$, $[Co(NH_3)_6]^{3+}$, $Fe(CN)_6]^{4-}$, $[Fe(CN)_6]^{3-}$. Spectral properties of $[Ti(H_2O)_6]^{3+}$, $[Co(H_2O)_6]^{3+}$, $[CoCl_4]^{2-}$. Isomerism in complexes: Structural isomerism - ionization, linkage, hydrate and coordination isomerism with examples. Stereoisomerism- geometrical and optical isomerism of coordination compounds with coordination numbers 4 and 6 with examples.

Organometallic Compounds 4 hours

Organometallic compounds - ligands, classification (hapticity). Synthesis and structure of $K[PtCl_3(\eta^2\text{-}C_2H_4)]$ and $[Fe(\eta^5 - C_5H_5)_2]$.

Metal carbonyls: Structures of $Cr(CO)_6$, $Co_2(CO)_8$, $Mn_2(CO)_{10}$; eighteen electron rule and its deviations with examples. Applications of coordination/organometallic compounds: cis-platin in cancer therapy, Na_2Ca EDTA in the treatment of heavy metal (Pb, Hg) poisoning, Wilkinson's

Catalyst in alkene hydrogenation, Monsanto acetic acid process.

Nuclear and Radiochemistry 8 hours

Review of the properties of radioactivity, types of radiations and their properties, atomic number and mass number, isotopes and isobars.

Nucleus – nucleons, nuclear force, nuclear density, stability - explanation using meson theory, n/p ratio, n versus p graph. Mass defect; Binding energy - definition, Binding energy curve, graph, calculation of binding energy to show that 1 *amu* = 931 MeV. Explanation of the instability of the nuclei. Problems.

Radioactive decay law, derivation of $N = N_0 e^{-\lambda t}$, half-life period of a radioisotope, relationship between half-life and decay constant, numerical problems. Radioactive equilibrium - explanation, introduction of the terms parent and daughter elements. Group displacement law - statement and explanation - with examples; radioactive series - U, Th, Ac and Np series (mention of the first and last stable elements, number of α- and β- particles. Type of series: *viz.,* 4n, (4n+1), (4n+2) and (4n+3).

Artificial radioactivity: Rutherford's first artificial transmutation, induced radioactivity; nuclear reactions – differences between chemical and nuclear reactions; reason for the large amount of Qvalue; symbolic representation of a nuclear reaction, (Bethe's notation) introduction of the term projectile, comparison of neutron, proton, α, γ and deuteron as projectiles. Examples of nuclear reaction induced by γ-radiation, α, n, p and deuteron. Nuclear fission - explanation with an example, chain reaction, principle of atomic bomb, calculation of energy liberated, fissionable isotopes. Nuclear fusion - explanation with an example, thermonuclear reaction, advantages and disadvantages of fusion over fission, the principle of a hydrogen bomb. Nuclear reactors - principle, working of a thermal reactor, diagram, and explanation of the terms like nuclear fuel, control rods, moderators and coolant. Breeder reactors- a brief explanation of their functioning. Atomic energy program in India. Use of radioisotopes in tracer technique - agriculture (phosphorous in agriculture research), medicine (phosphorous to check crack in bones, sodium/iodine to detect clots in blood vessels), food preservation.

Carbon dating - formation of radioactive carbon in the atmosphere. Explanation of the determination of age of wood/peat or fossil. Numerical problems on carbon dating.

Steel and Alloys 6 Hours

Manufacture of steel by Bessemer process. (Removal of silicon, decarbonisation,demanganisation, desulphurisation, dephosphorisation) and surface treatment (argon treatment, heat treatment, nitriding, carburizing). Composition and properties of different types of steels (role of Ni, Cr, Mo, Si, Mn, V, W, Al).

Classification of alloys - ferrous alloys (iron base alloys - cast iron and steel, tool steel) and non-ferrous alloys (copper, lead and tin alloys – composition of brass, bronze, cupro-nickel, manganin, constantan, antifriction bearing, solders, Pb-Sn, Pb-Sb). Specific properties of elements in alloys

(role of Ti in Al and Mg alloys, Ni in copper and iron alloys, Sn and Cu in lead base alloys).

ORGANIC CHEMISTRY – III (28 Hours)

Aldehydes and Ketones 5 hours

Nomenclature: Relative reactivity of aldehydes and ketones towards nucleophilic addition reactions. General mechanism of condensation with ammonia and its derivatives (NH_2−R; R = −NH_2, −OH, −NH−CO−NH_2).

Mechanisms of: Acetal formation, Claisen condensation, Knoevenagel condensation and Benzoin condensation reactions. Reductions by $LiAlH_4$ and $NaBH_4$. Mechanism of Clemmensen and Wolff-Kishner reductions.

Carboxylic acids and their Derivatives 7 hours

Nomenclature of *di-* and *tri-* carboxylic acids: action of heat on dicarboxylic acids (oxalic-, malonic-, succinic-, glutaric- adipic- and pimelic- (OMSGAP) acids).

Hydroxy acids: Reactions of tartaric acid and citric acid – (i) action of heat and (ii) reduction with HI.

Reactions of acid chlorides (example: acetyl chloride) - hydrolysis, reaction with alcohol, ammonia and lithium dialkylcuprates.

Reactions of acid anhydrides - hydrolysis, reaction with alcohol, ammonia.Reactions of amides - hydrolysis, reduction.

Reactions of esters - alkaline hydrolysis, ammonolysis and alcoholysis. Mechanism of ester hydrolysis - acid and base catalyzed (acyl O-cleavage: $B_{AC}2$, $A_{AC}2$; alkyl O-cleavage: $A_{AL}1$ mechanisms).

Amines 7 hours

Classification, nomenclature, preparation of alkyl and aryl amines - reductive amination of carbonyl compounds (ethanamine and 2-propanamine), Gabriel phthalimide synthesis (ethanamine), reduction of nitrobenzene, Hoffmann's bromamide reaction. Relative basicity of amines in aqueous solution. Explanation using inductive, resonance, steric and solvation effects [(a) ammonia, methylamine, dimethylamine and trimethylamine; (b) methylamine and aniline].

Reactions - amines as nucleophiles (methylation and acylation), formation of quaternary ammonium salts (reaction of tertiary amine and alkyl halide), distinguishing reactions of primary-, secondary- and tertiary amines (reactions with equations for Hinsbergs test).

Diazotization: formation of benzene diazonium chloride.

Synthetic applications of benzenediazonium chloride in the preparation of (i) chlorobenzene, bromobenzene and benzonitrile by Sandmeyer's reaction (ii) phenol (iii) phenylhydrazine

and aniline by reduction reaction and (iv) p-hydroxyazobenzene and 1- phenylazo-2-naphthol by coupling reaction.

Tautomerism and Enolates 4 hours

Tautomerism in carbonyl compounds – keto-enol tautomerism; oxime-nitroso tautomerism. Acidity of α-hydrogen atoms in aldehydes-, ketones- and active methylene compounds (example: diethyl malonate, ethyl acetoacetate and acetyl acetone).

Preparation of diethyl malonate from acetic acid and synthetic applications of diethyl malonate (preparation of monocarboxylic acids - butanoic acid, dicarboxylic acid - adipic acid, unsaturated acids: cinnamic- and crotonoic- acids; ketones - butanone, cyclic compounds - barbituric acid).

Preparation of ethyl acetoacetate (from ethyl acetate). Synthetic applications of ethyl acetoacetate (preparation of monocarboxylic acids - butanoic acid; dicarboxylic acid - succinic acid, unsaturated acids- crotonic acid and cinnamic acid, ketones - butanone).

Rearrangements 5 hours

Mechanisms of: Wagner - Meerwein, Fries, Beckmann, Hoffmann, benzil - benzilic acid, Favorskii rearrangements and Baeyer - Villiger oxidation.

Course Title: DSC 6: Paper VI (Physical chemistry - III & Spectroscopy - I)	
Course Credits	**4**
Total Contact Hours	**56**
Formative Assessment Marks: 40	**Summative Assessment Marks: 60**
Duration of ESA/Exam	**2½ Hours**

PHYSICAL CHEMISTRY - III (42 Hours)

Chemical Dynamics 8 hours

Macroscopic and microscopic kinetics. Review of theories of reaction rate- collision theory and transition state theory. Comparison of collision theory with transition state theory. Arrhenius equation- characteristics. Significance of energy of activation, temperature coefficient and its evaluation. Thermodynamical formulation of reaction rates (Wynne-Jones and Eyring treatment), Reaction between ions in solutions - Influence of ionic strength on reaction rates (primary and secondary salt effects). Numerical problems.

Concept of Steady state kinetics, Chain reactions - chain length and chain inhibition, comparison of photochemical and thermal reactions.

Photochemistry 6 hours

Laws of photochemistry (Grotthus-Draper and Stark-Einstein laws). Quantum yield (definition, Einstein and its significance). Comparison of thermal and photochemical reactions. Mechanisms of thermal and photochemical reactions between (i) hydrogen-bromine and (ii) hydrogen-chlorine. Actinometry (explain uranyl oxalate actinometer for measurement of the energy of radiation absorbed). Examples of low and high quantum yields (examples for $\phi = 1$, $\phi < 1$ and ϕ very high): Photochemical combination of (i) H_2 and Cl_2 (ii) H_2 and Br_2 (iii) dissociation of HI. Photochemical equilibrium (statement). Photosensitized reactions (explanation taking example), quenching (explanation taking example). Singlet and triplet states. Fluorescence and phosphorescence (explanation using Jablonski diagram). Role of photochemical reactions in biochemical processes (bioluminescence), photo stationary states, chemiluminescence (definition and with example).

Phase Equilibria 7 hours

Phases, components and degrees of freedom of a system (explanation of the terms taking suitable examples), criteria of phase equilibrium (thermal, mechanical and chemical). Gibb's Phase Rule and its thermodynamic derivation.

Phase diagrams of one-component systems (water and sulphur systems - phase diagram, explanation of the various equilibria, triple point, application of phase rule to various phases, effect of external pressure on transition temperatures, calculation of the degrees of freedom). Two component systems (condensed phase rule) involving eutectics, congruent and incongruent melting points (lead-silver system- phase diagram, the effect of impurity elements on the melting point, calculation of the degrees of freedom, eutectic mixture - definition, composition and applications, cooling of molten mixtures and Pattinson's process. Phase diagram of $FeCl_3$ - H_2O system. Freezing mixture - definition and applications. Phase diagram o f Na - K system.

Ionic Equilibria — 6 Hours

Common ion effect: statement and example (ammonium hydroxide - ammonium chloride and acetic acid - sodium acetate). Buffers: types and examples. Buffer action and buffer capacity. pH of buffers- Henderson's equation and its derivation for acidic and basic buffers. Problems in calculating the pH of buffers. Solubility product and ionic product - definitions and their applications in the precipitation of II and IV group basic radicals in the qualitative analysis of simple salt mixtures. Analytical and biological applications of buffers.

Theories of indicators (Mentioning the different theories). Acid-base theory by taking phenolphthalein and methyl orange as examples.

Electrochemistry - II — 9 Hours

Reversible and irreversible cells (definition and examples. Introduction of an electrochemical cell and explanation taking suitable examples). Concept of EMF of a cell (origin of EMF in an electrochemical cell, oxidation and reduction reactions, single electrode potential, reduction and oxidation potentials and formula for EMF). Measurement of EMF of a cell (compensation method, mention of standard cell-Weston cadmium cell). Nernst equation (derivation from free energy concepts for a cell and then for a single electrode) and its importance. Numerical problems. Types of electrodes [examples and their applications (i) metal/metal ion electrode - Zn/Zn^{2+} and Cu/Cu^{2+}; (ii) metal/insoluble salt/anion electrode-calomel and Ag/AgCl electrodes; (iii) metal/gas-ion electrode- hydrogen electrode; (iv) inert metal/ organic compound electrode- quinhydrone electrode; (v) Glass electrode and (vi) Red-ox electrode]. Standard electrode potential (definition, explanation of the importance of electrodes. Mention of primary-SHE and secondary reference electrodes -calomel electrode, convention of representing a cell, differences between standard reduction potential and standard oxidation potential). Electrochemical series and its applications (definition, standard reduction potential, SRP values of common reference electrodes, uses). Thermodynamics of a reversible cell (equations depicting the relationship between free energy change, enthalpy change, entropy change, equilibrium constant and EMF). Calculation of thermodynamic properties: ΔG, ΔH and ΔS from EMF data. Numerical problems. Calculation of equilibrium constant from EMF data (Numerical problems). Concentration cells with transference and without transference (definition and examples). Liquid junction potential (definition) and salt bridge (significance). pH determination using hydrogen electrode, Glass and quinhydrone electrodes (setting up of a suitable electrochemical cell, measurement of EMF and calculation of

pH). Numerical problems.

Quantum Mechanics - II 6 hours

Concepts of Operators: Laplacian, Hamiltonian, Linear and Hermitian operators. Angular Momentum operators and their properties. Commutation of operators. Solutions of Schrödinger wave equation for a particle in a three-dimensional box (no derivation). Quantum mechanical degeneracy, tunneling (no derivation). Application of Schrödinger equation to harmonic oscillator and rigid rotator (*Equations to be assumed*). Eigen functions and eigen values of angular momentum. Ladder operator method for angular momentum.

Solutions to Schrödinger equation in spherical polar co-ordinates (no derivation). Θ, Φ, R equation. Total wave functions of a hydrogen atom. Quantum numbers and their characteristics.

SPECTROSCOPY - I (14 Hours)

Molecular Spectroscopy 3 hours

Interaction of electromagnetic radiation with molecules (emission and absorption spectra, electromagnetic spectrum in terms of wave length/wave number,difference between atomic and molecular spectra and molecular energy levels) and various types of spectra (UV, IR, MW, Raman, and NMR and mention of the region), Born - Oppenheimer approximation (statement and explanation).

Rotation Spectroscopy

(Expressions for energy of diatomic rigid rotor in terms of *joule* and m^{-1}, rotational constant, reduced mass, moment of inertia and spacing between rotational levels) Selection rules [statement, expression for frequency for transition between J to (J+1), condition for absorption and spacing between spectral lines], intensities of spectral lines (explanation based on populations of energy levels), determination of bond lengths of diatomic molecules. Numerical problems.

Vibrational Spectroscopy 4 hours

Classical equation of vibration (mention of expression for frequency/wave number for diatomic (S H O), computation of force constant (definition of force constant, significance and statement of Hooke's law) amplitude of diatomic molecular vibrations (potential energy curve for diatomic SHO, expression for vibrational energy (from solutions to Schrödinger wave equation), zero point energy, selection rule, condition for absorption and fundamental vibrational frequency). Anharmonicity (difference in potential energy curves for SHO and others), Morse potential (energy expression for anharmonic oscillator, selection rules), dissociation energies, fundamental frequencies, overtones (compare the intensities), hot bands, degrees of freedom for polyatomic molecules (linear and non-linear – explanation taking suitable examples), modes of vibration (stretching and bending vibrations – types, comparison of frequencies, sketching of vibrational

modes for CO_2 and H_2O), concept of group frequencies. Vibration-rotation spectroscopy – (pure vibrational spectra in liquids and mixing of vibration and rotational levels) diatomic vibrating rotator (expression for energy, selection rule and expression for energy change), P, Q, R branches explanation using diagram).

Raman Spectroscopy 2 hours

(Raman scattering, Rayleigh scattering, polarizability and Raman shift) Qualitative treatment of rotational Raman effect (selection rule, expression for energy difference of a rigid diatomic rotor); Vibrational Raman spectra (selection rule) Stokes and anti-Stokes lines (explanation using diagram); their intensity difference, rule of mutual exclusion (explanation using molecules such as CO_2, O_2, N_2 etc.).

Electronic Spectroscopy 3 hours

(Complexity of electronic spectra), Franck-Condon principle (statement and demonstration using potential energy *vs*. internuclear distance plot), electronic transitions (HOMO, LUMO, bonding, antibonding and non-bonding orbitals, energy level diagram, examples for $\sigma \rightarrow \sigma^*$, $\pi \rightarrow \pi^*$, $n \rightarrow \sigma^*$ and $n \rightarrow \pi^*$ transitions). Dissociation and pre-dissociation (chemical reactions and non-radiative transitions), calculation of electronic transitions of polyenes using free electron model (qualitative explanation of electronic spectra of conjugated systems using free electron molecular orbital theory and formula for calculation of frequency of electronic transition taking butadiene as an example).

Nuclear Magnetic Resonance (NMR) Spectroscopy 2 hours

Principles of NMR spectroscopy. Fundamental NMR equation. Nuclear spin, examples for half integral, zero and integral values. Magnetic moment, orientations in an external magnetic field and absorption of radiofrequency and magnetic resonance. Relationship between applied magnetic field and frequency. Larmor precession.

V Semester B.Sc., Practical

Practical 5 – Inorganic chemistry

I. Volumetric analysis

1. Volumetric estimation of Zinc.
2. Volumetric estimation of Magnesium.
3. Volumetric estimation of Nickel.
4. Volumetric estimation of iron haematite.
5. Volumetric estimation of calcium in lime stone.
6. Volumetric estimation of copper in brass

II. Preparation and quantitative analysis of inorganic complexes

1. *Cis*- and *trans*- potassium dioxalatodiaquachromium(III) complex [analysis of oxalate and chromium]
2. Hexamminecobalt(III) chloride [analysis of cobalt]
3. Preparation of pentamminechlorocobalt(III) chloride.

III. Gravimetric analysis

1. Gravimetric determination of Fe in iron ore as Fe_2O_3.
2. Gravimetric determination of Ni in Cu and Ni solution.
3. Gravimetric determination of Fe in Fe and Cr solution.

Practical 6 – Organic Chemistry and Physical Chemistry

I. Preparation (one stage)

1. Cannizarro reaction: Benzaldehyde.
2. Sandmeyer reaction: 4-Chlorotoluene from 4-toluidine.
3. Pechmann reaction: Resorcinol and ethylacetoacetate.
4. Oxidation of Cyclohexanol.
5. Synthesis of 2,4,6-tribromoaniline.

Chemical kinetics Experiments

1. Study the hydrolysis of methyl acetate in presence of two different concentrations of HCl and report the relative strength.
2. Analysis of a binary mixture of two miscible liquids and to determine the composition of the given unknown mixture.
3. Evaluation of Arrehenius parameter for the reaction between $K_2S_2O_8$ versus KI (first order).
4. Study the hydrolysis of methyl acetate in the presence of HCl at different temperatures and report the energy of activation.
5. Study of variation of viscosity of a liquid with temperature, determine the constant A and B.

Discipline Core Course

VI - Semester

Course Title: DSC 7: Paper VII (Inorganic chemistry - IV & Physical chemistry - IV)	
Course Credits	**4**
Total Contact Hours	**56**
Formative Assessment Marks: 40	**Summative Assessment Marks: 60**
Duration of ESA/Exam	**2½ Hours**

INORGANIC CHEMISTRY – IV (28 Hours)

Industrial Materials- I 6 Hours

Refractories: Definition**.** Properties of a good refractory, classification, determination of PCE values.

Abrasives: Definition and classification with examples, applications, hardness-definition and magnitude of hardness, manufacture and importance of carborundum and tungsten carbide.

Glass: Properties, types, manufacture of soda glass. Composition and applications of borosilicate,metallic glass, optical glasses and polycarbonate glass, safety glass, fire and bullet proof glasses.

Ceramics: Raw materials and their roles, varieties of clay, production of ceramic ware, glazing, ceramic insulators.

Cement: Raw materials, manufacture of Portland cement (by wet process), setting of cement, role of water and gypsum.

Industrial Materials - II 7 Hours

Paints and Varnishes: Constituents of oil and emulsion paints and their role. Constituents of varnishes.

Fuels: Characteristics, calorific value - definition and its determination using bomb calorimeter.

Coal – varieties. Gaseous fuels- advantages, constituents and their significance. Production of Coal gas. Composition of LPG. Octane number-definition and significance.

Explosives: Classification, preparation of dynamites and TNT.

Propellants: Characteristics, classification and their applications.

Fertilizers 4 Hours

Types of fertilizers (definition and examples). Classification based on agrochemical nature (direct

and indirect): based on number of basic nutrients (simple, double/triple, micro and complex); and based on application (Single and mixed fertilizers)

Manufacture of the following fertilizers (method, drying and finishing)

Urea (Sindri method), Ammonium nitrate (Production-Prilling process, drying- Stengel process; Finishing- Nitrochalk / parting agents), Calcium ammonium nitrate (From ammonia. nitric acid and limestone), Ammonium phosphates and polyphosphate (from ammonia and phosphoric acid), Superphosphate (from rock phosphate and sulphuric acid), Potassium chloride (Manufacture from Carnallite, Sylvinite), Potassium sulphate (Manufacture from Kainite).

Chemistry of Newer Materials 11 Hours

Nanomaterials: Overview of nanostructures and nanomaterials (introduction, nanostructures - types with examples}. Nano materials- size, shape, specific surface area, crystallinity, solubility and surface morphology; reasons for special properties attributed to materials with nano- size) Classification of nanomaterials based on dimensions & type of material - organic, inorganic. Preparation of gold and silver metallic nanoparticles (Turkevich method), self-assembled nanostructures (definition, types of synthesis). Carbon nanotubes (definition, SWCNT & MWCNT, brief structure & applications) and inorganic nanowires (examples).

Conducting polymers: Introduction, definition and examples- polyaniline, polyacetylene. Mechanism of conduction. Qualitative treatment of doping. Properties: elasticity with high electrical conductivities. Engineering and biological applications.

Superconductors: Introduction, definition, type-1, type-2 and atypical. Preparation of high temperature superconductor- $Y_1Ba_2Cu_3O_{x\pm\delta}$. BCS theory (qualitative treatment only) and general applications of high temperature superconductors.

Fullerenes: Introduction, definition, preparation and isolation of C_{60}. Structure and chemical reactions (redox reactions, electrophilic aromatic substitution and bromination) of C_{60}. Commercial uses of C60.

PHYSICAL CHEMISTRY – IV (28 Hours)

Electroanalytical Methods 12 Hours

Introduction. Classification of electroanalytical methods: Potentiometry, Coulometry and Voltametry (explanation of the principle of each technique). Discussion of the principle of pH meter, conductomete and potentiometer). Potentiometric (acid base and redox, calibration, choice of electrodes) and conductometric titrations. (acid base - 4 types, conductivity cell, cell constant and its determination). Techniques used for the determination of equivalence points (comparison of use of indicator and graphical method). Techniques used for the determination of pK_a values (conductometry and potentiometry). Advantages of conductometric and potentiometric methods.

Voltametry: Polarography – Type of mercury electrodes (dropping mercury electrodes, hanging

drop mercury electrode, static mercury drop electrode, mercury thin film electrode). Linear scan polarography. Types of mass transport – Faradaic and non-Faradaic currents. Polarogram – sign conventions. Ilkovic equation and its applications. Half wave potential and its significance.

Principles of different voltammetric techniques: linear scan voltammetry, normal pulse voltammetry and differential pulse voltammetry.

Cyclic voltametry: Principle – explanation of electro-oxidation and electro-reduction based on frontier and molecular orbitals. Current – potential relation. Excitation response signal in CV and their significance. Electrochemical reversible and irreversible and quasi-reversible electrochemical processes and diagnostic criteria. Explanation of a typlical electrochemical reversible process using the potassium ferricyanide system as an example.

Thermal methods of analysis: (Introduction to gravimetry) Theory of thermogravimetry (TG), basic principle of instrumentation. Techniques for quantitative estimation of Ca and Mg.

Thermodynamics 8 Hours

Gibb's-Helmholtz equation - derivation from dG = VdP – SdT. Concepts of partial molar properties - partial molar free energy, chemical potential, partial molar volume and its significance. Derivation of Gibbs-Duhem equation.

Concept of fugacity: Determination of fugacity by graphical method. Activity and activity coefficient and its significance.

Derivation of van't Hoff reaction isotherm, van't Hoff reaction isochore and Clausius-Clapeyron equation. The application of Clausius-Clapeyron equation to the determination of ΔT_b and ΔT_f (in detail with derivations). Numerical problems. Nernst heat theorem (qualitative treatment only).

Flame Atomic and Absorption Spectrometry 4 Hours

Simple atomization techniques: flame atomization and electrochemical atomization. Processes occurring during atomization. Basic principles of instrumentation (choice of source, monochromator, detector, choice of flame and burner designs). Single beam and double beam instruments. Sample introduction. Correction methods: two line and continuum source correction methods. Sources of chemical interferences and their method of elimination.

Physical Properties and Molecular structures 4 Hours

Dipole moment (a brief review). Polarization and orientation of dipoles in an electric field. Clausius-Mossotti equation (derivation). Electrical properties of solids: types of solids-metals, insulators and semiconductors. Pyroelectricity, piezoelectricity, ferroelectricity, inverse piezoelectricity. Definition and examples. Thomson effect, Seebeck effect and Peltier effect - definitions with examples.

Course Title: DSC 8: Paper VIII (Organic chemistry - IV & Spectroscopy - II)	
Course Credits	**4**
Total Contact Hours	**56**
Formative Assessment Marks: 40	**Summative Assessment Marks: 60**
Duration of ESA/Exam	**2½ Hours**

ORGANIC CHEMISTRY – IV (42 Hours)

Heterocyclic Compounds 5 Hours

Introduction: Nomenclature of heterocyclic compounds. Aromaticity of pyrrole, furan, thiophene and pyridine. Comparison of their aromaticity and with benzene Structure, reactivity, synthesis and reactions of: pyrrole, furan, thiophene, pyridine. Structures of indole, pyrimidine and purine.

Chemistry of Natural Products 12 Hours

Carbohydrates: Introduction and classification (based on number of monosaccharide units; sugars and non-sugars) with examples. Monosaccharides: Definition with examples, classification of monosaccharides (based on functional group).

Aldoses: Structures of D-aldohexoses (glucose, galactose and mannose). Open and Haworth structures. Epimers (Example: D-galactose and D-glucose, D-glucose and D-mannose). Elucidationof open chain structure of D-glucose. Limitations of open chain structure of glucose. Mechanism of mutarotation and anomeric effect.

Elucidation of ring structure and size of D-glucose by oxidation with HIO_4 and HNO_3.

Ketoses: Structure of fructose- (pyranose and furanose forms). Inter-conversion of glucose and fructose. Disaccharides: Definition with examples. Formation of glycosidic bond with examples. Haworth and conformational structures of maltose, lactose and sucrose.

Terpenes and terpenoids: Occurrence, isoprene rule and classification (on the basis of number of isoprene units, acyclic and cyclic). Elucidation of structure and synthesis of citral (from methyl heptenone) and zingiberene (from methylheptenone and *p*-methoxyphenylmagnesium bromide). Structures and uses of limonene, menthol, α-terpineol, and camphor.

Alkaloids: Introduction, classification (based on heterocyclic ring present) and general characteristics. Structural elucidation and synthesis of nicotine (from succinimde). Structures and uses of ephedrine, caffeine, cocaine, atropine, quinine and morphine.

Polymers 4 Hours

Brief introduction (definition of polymers and polymerization); preparation, structure,

properties and application of the following polymers: *polyolefins* – polystyrene and styrene copolymers (BUNA-S), polyvinyl acetate. *Acrylic polymers* – polyacrylonitrile. *Fluoropolymers* - Teflon, Polyamides - nylon-6,6. *Phenol formaldehyde resins* – Bakelite. *Polyurethanes*. Silicone polymers and Polycarbonates.

Pharmaceutical Chemistry 4 Hours

Chemotherapy. Drugs: classification of drugs (i) drugs used for the treatment of diseases due to infection (antimalarial, sulpha drugs, antibiotics and antiseptic drugs with examples) (ii) drugs used for the treatment of diseases not due toinfection (antipyretics, analgesics, anesthetics, tranquilizers and hypnotics, narcotics, anticonvulsants, cardiac or cardiovascular and diuretics drugs with examples**).** Synthesis of (i) aspirin (from phenol), (ii), paracetamol (from phenol), (iii) chlorophenaramine, (iv) sulphanilamide (from acetanilide). Structure and uses of (i) Penicillin and (ii) cephalosporin.

Green Chemistry 2 Hours

Introduction. Principles of Green chemistry with examples - special emphasis on atom economy, reducing toxicity and green solvents. Green chemistry and catalysis (taking the synthesis of ibuprofen as an example).

Lipids 4 hours

Introduction, Classification - simple, complex and derived with examples.

Fatty acids: definition, classification as saturated and unsaturated with examples and structure (lauric, myristic, palmitic, stearic, oleic, linoleic, linolenic and arachidonic acids). Essential fatty acids - definition with examples.

Triglycerides: Structure of simple and mixed glycerides. Properties of triglycerides- acid and alkali hydrolysis, saponification number; iodine number and their significance. Rancidity (oxidative and hydrolytic), causes and prevention. Biological importance of triglycerides.

Phosphoglycerides: General structure of 3-Sn–phosphatidic acid, lipid bilayer (as in cell membrane), micelles, liposomes and its applications, structure and biological importance of lecithin, cephalin, phosphatidylserine, phosphatidylinositol.

Cholesterol: structure, biological importance and clinical significance.

Amino acids & Proteins 5 Hours

L-α-Amino acids: Introduction, structure, classification on the basis of polarity of R – groups; essential and non-essential amino acids. Preparation of glycine by Gabriel method. Zwitter ionic property of amino acids. Reaction of amino acids with Ninhydrin. The peptide bond. Sanger's- and Edman's- degradation reactions with their significance.

Proteins: levels of organization of proteins: primary-, secondary-, tertiary- and quaternary-structures with examples (α - helix, β - pleatedsheet, triple helix and the structure of haemoglobin). Denaturation and renaturation of proteins. Anfinsen's experiment; separation of proteins by PAGE.

Enzymes 4 hours

Introduction, holoenzyme (apo-enzyme and co-enzyme). Active site, specificity (Group, absolute and stereoselectivity with examples). Classification of enzymes (EC code number not required) with examples. Enzyme substrate interaction- Fischer and Koshland models.

Enzyme kinetics - factors affecting rate of enzymatic reactions - enzyme concentration, substrate concentration (mention M. M. equation), pH and temperature. Allosteric enzymes - definition and example. Enzyme inhibitions - Competitive, noncompetitive and uncompetitive inhibition with one example foreach.

Vitamins 2 Hours

Classification. Biological importance and deficiency symptoms of Vitamins A, Vitamin B1 (thiamine), Vitamin B6 (pyridoxine), folic acid, pantothenic acid, riboflavin, Vitamin C, Vitamin E (α-tocopherol), Vitamin H (biotin), Vitamins K_1 and K_2.

SPECTROSCOPY – II: Organic Spectroscopy (14 Hours)

UV Spectroscopy 4 Hours

Introduction. Types of electronic transitions, λ_{max}, Chromophores and auxochromes. Bathochromic and hypsochromic shifts. Beer-Lambert's law. Woodward – Fieser rules for calculation of λ_{max} of conjugated dienes and α,β-unsaturated carbonyl compounds. Influence of extended conjugation on the λ_{max} absorptivity in UV-Visible region. Comparison of UV spectra of acetone and methyl vinyl ketone. Graphical representation of spectra of 1,3-butadiene, benzene and lycopene. Applications of UV-Visible spectroscopy.

IR Spectroscopy 4 Hours

Introduction. Basic principles of IR spectroscopy. Conditions for organic compounds to become IR active. Stretching and bending modes of vibrations. Factors affecting the position of IR absorption peak (atomic and force constant-electronic effects and hydrogen bonding). Regions of IR in the electromagnetic spectrum- (functional group region and finger print regions). Explanation of stretching frequencies of –OH (free and H-bonded), alkyl C–H, alkenyl C–H, alkynyl C–H stretch frequencies. Group frequencies of C–C, C = C, C–O and C = O functionalities. IR spectra of benzene, ethanol, phenol, acetaldehyde, acetone and acetic acid and their individual identification. Applications of IR spectroscopy.

Nuclear Magnetic Resonance spectroscopy 6 hours

Basic principles of proton magnetic resonance: Nuclear magnetic spin quantum number I, influence of the magnetic field on the spin of nuclei, spin population, saturation using radio frequency. Nuclear magnetic resonance. Chemical shift (δ values). Internal standard - uses of TMS as reference. Nuclear shielding and de-shielding effects. Equivalent and non-equivalent protons. Effect of: (i) electronegativity of adjacent atoms (ii) magnetic induction by pi (π-) electrons-.

Magnetic anisotropy on chemical shift values. Spin-spin splitting and spin-spin coupling (qualitative treatment only). ^{1}H-NMR spectra of: (i) methane (ii) $CH_3{-}Cl$ (iii) CH_2Cl_2 and (iv) $CHCl_3$. Discussion of chemical shift (δ) based on $-I$ effect. First order splitting rules. Spectra of: (i) dichloroacetaldehyde (ii) 1,1,2-trichloroethane and (iii) ethyl chloride.

Practical 7 – Physical chemistry

I. Determination of percentage of sodium chloride by finding the CST of phenol-water system.

II. Potentiometric Experiments

1. $K_2Cr_2O_7$ versus FAS.
2. Determination of dissociation constant of H_3PO_4 using potentiometric method. Acid mixture versus NaOH.
3. Titration of weak acid against a strong base using quinhydrone electrode and calculation of pK_a and K_a of the weak acid.

III. pH metric Experiments

1. Determination of pK_a value of phosphoric acid by pH meter.
2. Determination of pH of acetic acid with sodium acetate buffer by pH metry method.
3. Determination of degree of hydrolysis of aniline hydrochloride at room temperature and calculation of dissociation constant of the base by pH metry.
4. To determine the acidic and basic dissociation constant of an amino acid and determination of isoelectric point by pH metry.

IV. Conductometric Experiments

1. Conductometric titration of weak acid versus weak base.
2. Acid mixture versus NaOH.
3. Weak acid with salt versus NaOH.
4. Strong acid with salt versus NaOH.
5. Determination of pH of a buffer by using quinhydrone electrode and comparison of the pH values obtained with glass electrode.

Practical 8 – Organic chemistry

I. Qualitative analysis of bifunctional organic compounds

(*p*-aminobenzoic acid, *p*-chlorobenzoic acid, *p*-chloroaniline, salicylamide, methyl salicylate)

II. Quantitative analysis

1. Titrimetric estimation of amino acids.
2. Saponification value of oil.
3. Estimation of glucose by Fehling's method.
4. Estimation of keto group.
5. Estimation of phenols.
6. Iodine value of oil (chloramine-T method).

III. Qualitative Test for Carbohydrates and Proteins

IV. Preparation (Two / three stages)

1. 2,4-Dinitrophenylhydrazine from chloronitrobenzene.
2. Anthranilic acid from phthalic acid.
3. Benzanilide from benzophenone.
4. Benzilic acid from benzoin.

Recommended Books

Analytical Chemistry

1. Willard, H.H., Merritt, L.L., Dean, J. &Settle, F.A. Instrumental Methods of Analysis, 7th Ed. Wadsworth Publishing Company Ltd., Belmont, California, USA, 1988.
2. Christian, G.D; Analytical Chemistry, 6th Ed. John Wiley & Sons, New York, 2004.
3. Harris, D. C. Exploring Chemical Analysis, Ed. New York, W.H. Freeman, 2001.
4. Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age, International Publisher, 2009.
5. Skoog, D.A. Holler F.J. &Nieman, T.A. Principles of Instrumental Analysis, Cengage Learning India Ed., 2023.

Biochemistry

1. Concise Text Book of Biochemistry T. N. Pattabhiraman, All India Publishers,2000.
2. Biochemistry by A. L. Lehninger, CBS, 2000.
3. A Text Book of Biochemistry A. V. S. S. Rama Rao, UBSPD, 1998.
4. Biochemistry P. C. Champe and R. A. Harvey, J. B. Lipincott& Co, 1982.
5. Fundamentals of Biochemistry J. L. Jain, S. Chand & Co., 1983.
6. Outlines of Biochemistry Conn E. E and Stumpf P. K., John Wiley & Sons, 1978.
7. General Biochemistry Weil J. H., Wiley Eastern.
8. Biochemistry Campbell M. K., Harcourt Brace & Co**.**

Industrial Chemistry

1. C. A. Heaton, An Introduction to Industrial Chemistry, Springer Science and Business Media, 1996.
2. Vandana Meshram, A text book of Industrial Chemistry, Educational Publisher and Distributor, 2017.
3. B. K. Sharma, Industrial Chemistry Part-1, Krishna Prakashan, 2023.
4. R. M. Felder, R. W. Rousseau: Elementary Principles of Chemical processes, Wiley Publishers, New Delhi.
5. W. D. Kingery, H. K. Bowen, D. R. Uhlmann: Introduction to Ceramics, Wiley publishers, New Delhi.

Inorganic Chemistry

1. Lee J D, Concise Inorganic Chemistry, 5 th Edition, 5th Edition, Wiley India Pvt Ltd, 2014.

2. Huheey, J.E., Keiter, E.A., Keiter, R.L. & Medhi, O.K. Inorganic Chemistry: Principles of Structure and Reactivity, Pearson Education India, 2006.

3. Glasstone S, Source Book on Atomic Energy, Affiliated East West Press Pvt. Ltd. New Delhi, 1967.

4. Cotton F A and Wilkinson G, Manfred B & Russel N S Inorganic Chemistry a Comprehensive Text, 6th Edition, Wiley Inter Science Publishers, 1999.

5. Shriver D, Weller M, Overton T, Rourke J and Armstrong F, Inorganic Chemistry, 6th Edition, W H Freeman and Company, New York, USA.

6. Mark Weller, Tina Overton, Jonathan Rourke, Fraser Armstrong, Inorganic Chemistry International Edition, Oxford University Press, 7th edition, 2018.

7. Housecroft C E and Sharpe A. G, Inorganic Chemistry, 5 th Edition, Pearson Education Limited, Essex, 2018.

8. R. C. Mehrotra, Organometallic Chemistry, New Age International (P) Ltd. Publishers, 2nd edition, 2004.

9. Jens-Volker Kratz, Karl Heinrich Lieser, Nuclear and Radiochemistry: Fundamentals and Applications, 1st edition, 2013.

10. Friedlander G, Macias E S, Kennedy J W and Miller J M, Nuclear and Radiochemistry, 3rd Edition, John Wiley and Sons Inc., 1981.

11. Arniker H J, Essentials of Nuclear Chemistry, New Age International Publishers, 4th edition, 2011.

12. Kotz, J, C., Treichel, P.M. & Townsend, J.R. General Chemistry Cengage Learning India Pvt Ltd., New Delhi (2009).

13. Mahan, B.H. University Chemistry 3rd Ed. Narosa (1998). D Petrucci, R.H. General Chemistry 5th Ed. Macmillan Publishing Co.: New York.

14. Petrucci, R.H. General Chemistry, 5th Ed., Macmillan Publishing Co.: New York.

Nano chemistry

1. Geoffrey A. Ozin , Andre C. Arsenault, Ludovico Cademartiri, Chad A. Mirkin, Nano chemistry: A Chemical Approach to Nanomaterials, 2nd edition, Royal Society of Chemistry, 2003.

2. Charles P. Poole, Frank J Owens, Introduction to Nanotechnology, Wiley-Interscience, 2008.

3. T. Pradeep, Text book of Nanoscience and Nanotechnology, McGraw Hill Education, 2017.

4. Poore, C.P. & Owens, F.J. Introduction to Nanotechnology John Wiley & sons, 2003.

Organic Chemistry

1. Carey F A, Sundberg R J, Advanced Organic Chemistry, Part A: Structure and mechanisms, 5th Edition, Springer (India) Pvt Ltd. New Delhi, 2007.
2. Carey F A, Sundberg R J, Advanced Organic Chemistry, Part B: Structure and Mechanisms, 5th Edition, Springer (India) Pvt Ltd. New Delhi, 2007.
3. Finar, I.L. Organic Chemistry (Vol. I & II), E.L.B.S. • Morrison, R.T. & Boyd, R.N. Organic Chemistry, Pearson, 2010.
4. Graham Solomon, T.W., Fryhle, C.B. & Dnyder, S.A. Organic Chemistry, John Wiley & Sons, 2014.
5. McMurry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.
6. Sykes, P. A Guidebook to Mechanism in Organic Chemistry, Orient Longman, New Delhi, 1988.
7. Nasipuri D, Stereochemistry of Carbon Compounds, 2nd Edition, New-Age International Publishers, New Delhi, 1996.
8. Bruckner R, Organic Mechanisms - Reactions, Stereochemistry and Synthesis, SpringerVerlag, Berlin, Heidelberg, 2010.
9. Clayden J, Greeves N, and Warren S, Organic Chemistry, 2nd Edition, Oxford University Press, New York, 2012.
10. Smith M B, and March J, March's Advanced Organic Chemistry, 6th Edition, John-Wiley and Sons, New York, 2007.
11. Pavia D L, Lampman G M, Kriz G S and Vyvyan J R, Introduction to Spectroscopy, 5th Edition, Cengage Learning, Delhi, 2015.
12. Understanding Organic Reaction Mechanisms A. Jacobs, Cambridge Univ Press, 1998.
13. Organic Chemistry M. K. Jain, Nagin & Co., 1987.
14. A Guide to Mechanism in Organic Chemistry P. Sykes, Orient Longman, 2005.
15. Organic Spectroscopy V. R. Dani, Tata McGraw Hill, 1998.
16. Organic Spectroscopy W. Kemp, ELBS IV Edition, 1998.
17. Synthetic Drugs G. R. Chatwal, Himalaya Publications, 2000.
18. Stereochemistry of Organic Compounds, by Ernest L. Eliel, Samuel H. Wilen, Wiley India Edition,1994.

Physical Chemistry

1. Atkins P and Ronald Friedman, Molecular Quantum Mechanics, 5th Edition, Oxford University Press, New York, 2011.
2. Barrow, G.M. Physical Chemistry Tata McGraw-Hill (2007).
3. Castellan, G.W. Physical Chemistry 4th Ed. Narosa (2004).
4. Chandra, A. K. Introductory Quantum Chemistry Tata McGraw-Hill (2001). House, J. E. Fundamentals of Quantum Chemistry 2nd Ed. Elsevier: USA, 2004.
5. Towe, J. P. & Peterson, K. Quantum Chemistry, Academic Press (2005).
6. Callen, Herbert *Thermodynamics and an Introduction to Themostatistics*, 2nd edition, John Wiley & Sons, 1985.
7. V. S. Bagotsky, Fundamentals of Electrochemistry, John Wiley & Sons, Inc. 2006.
8. Samuel Glasstone, An Introduction to Electrochemistry, Read Book Publishers, 2008.
9. K. L. Kapoor, A Text Book of Physical Chemistry: Quantum Chemistry and Molecular Spectroscopy, 5th edition, McGraw Hill Education (India) Private Limited, 2014.
10. Colin.N. Banwell and Elaine M, Fundamentals of Molecular Spectroscopy, 4th edition, McGraw Hill Education,2017.
11. Puri, Sharma, Pathania, Principles of Physical Chemistry, 48th edition, Vishal Publishing company.
12. Kakkar, R. Atomic & Molecular Spectroscopy: Concepts & Applications, Cambridge University Press (2015).
13. Jeffery, G.H., Bassett, J., Mendham, J. & Denney, R.G. Vogel's Textbook of Quantitative Chemical Analysis, John Wiley & Sons, 1989.
14. John R. Dyer: Applications of Absorption Spectroscopy of Organic Compounds, Prentice Hall.
15. R.M. Silverstein, G.C. Bassler & T.C. Morill: Spectroscopic Identification of Organic Compounds, John Wiley &Sons

Recommended Practical Text Books

1. Jeffery G H, Bassett J, Mendham J and Denney R C, Vogel's Textbook of Quantitative Chemical Analysis, 5thEdition, Longman Scientific & Technical, Essex, England, 1989.
2. Vogel's Text book of Qualitative Chemical Analysis, J. Bassett, G. H. Jeffery and J. Mendham, ELBS (1986).
3. Vogel's text book of Quantitative Chemical Analysis, 5th Edition, J. Bassett, G. H. Jeffery and J. Mendham,
4. Inorganic Semi Micro Qualitative Analysis, V. V. Ramanujam; The National Pub. Co. (1974).
5. Skoog D A, West D M, Holler F J, and Crouch S R, Fundamentals of Analytical Chemistry, 9th Edition, Brooks/Cole Cengage Learning, Belmont, USA, (2014).
6. Practical Organic Chemistry - Mann and Saunders, Pearson Education Limited (Publisher) (2011).
7. Chemistry Analytical Chemistry / Organic & Industrial Chemistry Dsc-1 For 1 Sem B.Sc. & Chemistry In by Babu Giriya Gowda, Prajwal Lourdeslobo, Doddamani Hanumantanaik (Author), Sapna Book House (Publisher) (2022)
8. A Handbook of Organic Analysis 4th edition (2014) CBS Publishers & Distributors.
9. Comprehensive practical organic chemistry: Preparation, Quantitative and quantitative Analysis by Nandeshwarappa, B P (2017)
10. Advanced Practical Organic Chemistry, Second Edition June 1994 by John Leonard, Barry Lygo, Garry Procter
11. Experiments in Physical Chemistry, Sixth Edition (by David P. Shoemaker, Carl W. Garland, and Joseph W. Nibler), May 1997.

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